# PARAKRAM

## JEE MAIN

CURATED BY EXPERT FACULTY OF PW

# PHYSICS

**1500+**

**Selected MCQs**

**to Boost your Confidence**

**EDITION: First**

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# PREFACE

A highly skilled professional team of Physics Wallah (PW) works arduously to ensure that the students receive the best content for the **JEE** exam.

From the beginning, the whole content team comprising faculties, DTP operators, Proofreaders and others are involved in shaping the material to their best knowledge and experience to produce powerful content for the students.

Faculties have adopted a new style of presenting the content in easy-to-understand language and have provided the team with their guidance and supervision throughout the creation of this Study Material.

Physics Wallah (PW) strongly believes in conceptual and fun-based learning. PW provides highly exam-oriented content to bring quality and clarity to the students.

A plethora of **JEE Study Material** is available in the market but PW professionals are continuously working to provide the supreme Study Material for our **JEE** students.

This Study Material adopts a multi-faceted approach to master and understanding the concepts by having a rich diversity of questions asked in the examination and equip the students with the knowledge for the competitive exam.

The main objective of the study material is to provide a large number of quality problems with varying cognitive levels to facilitate the teaching-learning of concepts that are presented through the book.

It has become popular among aspirants because of its easy-to-understand language.

Students can benefit themselves by attempting the exercise given in this problem booklet.

The questions are strictly designed in accordance with the exam relevant topics that help to develop examination temperament within the students.

Mastering the Physics Wallah (PW) study material curated by the PW team, the students can easily qualify for the exam with a top Rank in the **JEE**.

In each chapter, for better understanding, questions have been classified according to the latest syllabus of **JEE Mains**.

- The nature and diversity of the equations help students to ace the examination.
- Quality questions to strengthen the concept of the topic at the zenith level.

## BOOK FEATURES

- Topic wise **MCQs** and Integer type questions
- Strictly as per the latest **NTA** syllabus
- Assertion Reason, Matrix match & Statement based questions also included in exercises.

# CONTENTS

CHAPTER

01

# MATHEMATICAL TOOLS, UNITS, DIMENSIONS AND ERRORS

## Single Option Correct Type Questions (01 to 60)

**1.** Which of the following sets cannot enter into the list of fundamental quantities in any system of units?

(1) length, mass and velocity
(2) length, time and velocity
(3) mass, time and velocity
(4) length, time and mass

**2.** A dimensionless quantity

(1) never has a unit
(2) always has a unit
(3) may have a unit
(4) does not exist

**3.** A unit less quantity

(1) never has a nonzero dimension
(2) always has a nonzero dimension
(3) may have a nonzero dimension
(4) does not exist

**4.** Which pair of following quantities has dimensions different from each other.

(1) Impulse and linear momentum
(2) Planck's constant and angular momentum
(3) Moment of inertia and moment of force
(4) Young's modulus and pressure

**5.** To find the distance d over which a signal can be seen clearly in foggy conditions, a railways engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency *f*. The engineer find that *d* is proportional to $S^{1/n}$. The value of *n* is:

(1) 2  (2) 4
(3) 3  (4) 5

**6.** The velocity of water waves ($v$) may depend on their wavelength ($\lambda$), the density of water ($\rho$) and the acceleration due to gravity ($g$). The method of dimensions gives the relation between these quantities as where $k$ is a dimensionless constant

(1) $v^2 = k\lambda^{-1} g^{-1} \rho^{-1}$  (2) $v^2 = k g \lambda$
(3) $v^2 = k g \lambda \rho$  (4) $v^2 = k \lambda^3 g^{-1} \rho^{-1}$

**7.** $\tan 15^\circ$ is equivalent to:

(1) $(2-\sqrt{3})$  (2) $(5+\sqrt{3})$
(3) $\left(\frac{5-\sqrt{3}}{2}\right)$  (4) $\left(\frac{5+\sqrt{3}}{2}\right)$

**8.** Force applied by water stream depends on density of water ($\rho$), velocity of the stream ($v$) and cross– sectional area of the stream (A). The expression of the force can be

(1) $\rho A v$
(2) $\rho A v^2$
(3) $\rho^2 A v$
(4) $\rho A^2 v$

**9.** $\sin\theta$ is equivalent to:

(1) $\cos\left(\frac{\pi}{2}+\theta\right)$  (2) $\cos\left(\frac{\pi}{2}-\theta\right)$
(3) $\sin(\theta-\pi)$  (4) $\sin(\pi+\theta)$

**10.** Match the following:

| Physical quantity | | Dimension | |
|---|---|---|---|
| I | Stefan's constant 'σ' | P | $M^1L^{-1}T^{-1}$ |
| II | Wien's constant 'b' | Q | $M^1L^0T^{-3}K^{-4}$ |
| III | Coefficient of viscosity 'η' | R | $M^1L^0T^{-3}$ |
| IV | Emissive power of radiation (Intensity emitted) | S | $M^0L^1T^0K^1$ |

(1) I-P; II-R; III-Q; IV-S
(2) I-Q; II-S; III-P; IV-R
(3) I-R; II-S; III-Q; IV-P
(4) I-P; II-S; III-Q; IV-R

**11.** Using the expression 2d sin θ = λ, one calculates the values of d by measuring the corresponding angles θ in the range 0 to 90º. The wavelength λ is exactly knowns and the error in θ is constant for all values of θ. As θ increases from 0º:
(1) the absolute error in d remains constant.
(2) the absolute error in d increases.
(3) the fractional error in d remains constant.
(4) the fractional error in d decreases.

**12.** Which of the following sets of displacements might be capable of bringing a car to its returning point?
(1) 5, 10, 30 and 50 km
(2) 5, 9, 9 and 16 km
(3) 40, 40, 90 and 200 km
(4) 10, 20, 40 and 90 km

**13.** Two full turns of the circular scale of a screw gauge cover a distance of 1mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of –0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm in the first turn the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is:
(1) 3.32 mm (2) 3.73 mm
(3) 3.67 mm (4) 3.38 mm

**14.** In an optics experiment, with the position of the object fixed, a student varies the position of the convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance *u* and the image distance *v*, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at *P*. The coordinates of *P* will be:
(1) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (2) $(f, f)$
(3) $(4f, 4f)$ (4) $(2f, 2f)$

**15.** The respective number of significant figures for the numbers 23.023, 0.0003 and $2.1 \times 10^{-3}$ are
(1) 5, 1, 2 (2) 5, 1, 5
(3) 5, 5, 2 (4) 4, 4, 2

**16.** A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?
(1) A meter scale.
(2) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm.
(3) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm.
(4) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.

**17.** The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of *L* is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90s using a wrist watch of 1s resolution. The accuracy in the determination of g is closest to:
(1) 2% (2) 3%
(3) 1% (4) 5%

**18.** A student measures the time period of 100 oscillations of a simple pendulum four times. That data set is 90 s, 91 s, 95 s and 92 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be:

(1) $92 \pm 5.0$ s (2) $92 \pm 1.8$ s

(3) $92 \pm 3$ s (4) $92 \pm 2$ s

**19.** The force is given in terms of time $t$ and displacement $x$ by the equation $F = A \cos Bx + C \sin Dt$. The dimensional formula of $AD/B$ is

(1) $[M^2L^2T^{-3}]$ (2) $[M^1L^1T^{-2}]$

(3) $[ML^2T^{-3}]$ (4) $[M^0LT^{-1}]$

**20.** $f(x) = \log x^3$ and $g(x) = \log x$

Which of the following statement is true-

(1) $f(x) = g(x)$ (2) $3f(x) = g(x)$

(3) $f(x) = 3g(x)$ (4) $f(x) = (g(x))^3$

**21.** The value of $G$ in MKS system is equal to $6.67 \times 10^{-11}$ Nm$^2$ (kg)$^{-2}$. Its numerical value in CGS system will be:

(1) $6.67 \times 10^{-8}$ (2) $6.67 \times 10^{-6}$

(3) 6.67 (4) $6.67 \times 10^{-5}$

**22.** If momentum ($P$), area ($A$) and time ($T$) are taken to be the fundamental quantities then the dimensional formula for energy is

(1) $\left[P^{\frac{1}{2}}AT^{-1}\right]$ (2) $[P^2AT^{-1}]$

(3) $\left[PA^{\frac{1}{2}}T^{-1}\right]$ (4) $[PA^{-1}T^{-2}]$

**23.** $\sin A \,.\, \sin(A + B)$ is equal to

(1) $\cos^2 A.\cos B + \sin A \sin^2 B$

(2) $\sin A \,.\, \frac{1}{2}\cos B + \cos 2A \,.\, \sin B$

(3) $\sin^2 A \,.\, \cos B + \frac{1}{2}\sin 2A \,.\, \sin B$

(4) $\sin^2 A \,.\, \sin B + \cos A \cos^2 B$

**24.** If unit of length and time is doubled, the numerical value of 'g' (acceleration due to gravity) will be :

(1) doubled (2) halved

(3) four times (4) remain same

**25.** The $x$ and $y$ components of a force are 2 N and – 3 N. The force is

(1) $2\hat{i} - 3\hat{j}$ (2) $2\hat{i} + 3\hat{j}$

(3) $-2\hat{i} - 3\hat{j}$ (4) $3\hat{i} + 2\hat{j}$

**26.** Some physical quantities are given in **Column I** and some possible SI units in which these quantities may be expressed are given in **Column II**. Match the physical quantities in **Column I** with the units in **Column II.**

| Column-I | | Column-II | |
|---|---|---|---|
| I | $GM_eM_s$<br>$G$ - universal gravitational constant,<br>$M_e$ - mass of the earth,<br>$Ms$ - mass of the Sun | P | (volt) (coulomb) (metre) |
| II | $\frac{3RT}{M}$<br>$R$ - universal gas constant,<br>$T$ - absolute temperature,<br>olar mass | Q | (kilogram) (metre)$^3$ (second)$^{-2}$ |
| III | $\frac{F^2}{q^2B^2} \lim_{x\to\infty}$<br>$F$ - force,<br>$q$ - charge,<br>$B$ - magnetic field | R | (metre)$^2$ (second)$^{-2}$ |
| IV | $\frac{GM_e}{R_e}$<br>$G$ - universal gravitational constant,<br>$M_e$ - mass of the earth<br>$R_e$ - radius of the earth | S | (farad) (volt)$^2$ (kg)$^{-1}$ |

(1) I-Q; II-R, S; III-R, S; IV-S
(2) I-P, Q; II-R, S; III-R, S; IV-R, S
(3) I-P, Q; II-S, R; III-R, S; IV-Q, S
(4) I-P, Q; II-R, S; III-Q, S; IV-P, S

**27.** $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ represents the equation of state of some gases. Where $P$ is the pressure, $V$ is the volume, $T$ is the temperature and $a$, $b$, $R$ are the constants. The physical quantity, which has dimensional formula as that of $\frac{b^2}{a}$, will be:
(1) Bulk modulus
(2) Modulus of rigidity
(3) Compressibility
(4) Energy density

**28.** If $y_1 = A\sin\theta_1$ and $y_2 = A\sin\theta_2$ then
(1) $y_1+y_2 = 2A\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$
(2) $y_1+y_2 = 2A\sin\theta_1\sin\theta_2$
(3) $y_1-y_2 = 2A\sin\left(\frac{\theta_1-\theta_2}{2}\right)\cos\left(\frac{\theta_1+\theta_2}{2}\right)$
(4) $y_1.y_2 = -2A^2\cos\left(\frac{\pi}{2}+\theta_1\right).\cos\left(\frac{\pi}{2}-\theta_2\right)$

**29.** If $R^2 = A^2+B^2+2AB\cos\theta$, if $|A| = |B|$ then value of magnitude of $R$ is equivalent to:
(1) $2A\cos\theta$
(2) $A\cos\frac{\theta}{2}$
(3) $2A\cos\frac{\theta}{2}$
(4) $2B\cos\frac{\theta}{2}$

**30.** The density of a material in SI units is 128 kg m$^{-3}$. In certain units in which the unit of length is 25 cm and the unit of mass 50 g, the numerical value of density of the material is
(1) 40
(2) 16
(3) 640
(4) 410

**31.** A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of time is $\delta T = 0.01$ seconds and he measures the depth of the well to be $L = 20$ meters. Take the acceleration due to gravity $g = 10$ ms$^{-2}$ and the velocity of sound is 300 ms$^{-1}$. Then the fractional error in the measurement $\frac{\delta L}{L}$, is closest to:
(1) 0.2%
(2) 3%
(3) 5%
(4) 1%

**32.** If the angle between two forces increases, the magnitude of their resultant
(1) decreases
(2) increases
(3) remains unchanged
(4) first decreases and then increases

**33.** A car is moving on a straight road due north with a uniform speed of 50 km/hr when it turns left through 90º. If the speed remains unchanged after turning, the change in the velocity of the car in the turning process is
(1) zero
(2) $50\sqrt{2}$ km h$^{-1}$ along S-W
(3) $50\sqrt{2}$ km h$^{-1}$ along N-W
(4) west. 50 km h$^{-1}$ along west

**34.** When two vector $\vec{a}$ and $\vec{b}$ are added, the magnitude of the resultant vector is always
(1) greater than $(a + b)$
(2) less than or equal to $(a + b)$
(3) less than $(a + b)$
(4) equal to $(a + b)$

**35.** Given $\vec{a}+\vec{b}+\vec{c}=0$. Out of the three vectors $\vec{a}, \vec{b}$ and $\vec{c}$ two are equal in magnitude. The magnitude of the third vector is $\sqrt{2}$ times that of either of the two having equal magnitude. The angles between the vectors are:
(1) 90º, 135º, 135º
(2) 30º, 60º, 90º
(3) 45º, 45º, 90º
(4) 45º, 60º, 90º

**36.** A vector $\vec{A}$ points vertically downward & $\vec{B}$ points towards east, then the vector product $\vec{A}\times\vec{B}$ is

(1) along west (2) along east
(3) zero (4) along south

**37.** Let $\vec{a}$ and $\vec{b}$ be two non-null vectors such that $|\vec{a}+\vec{b}|=|\vec{a}-2\vec{b}|$. Then the value of $\frac{|\vec{a}|}{|\vec{b}|}$ may be:

(1) $\frac{1}{4}$ (2) $\frac{1}{8}$
(3) 1 (4) $\frac{1}{3}$

**38.** Match the integrals (given in column - II) with the given functions (in column - I)

| Column-I | | Column-II | |
|---|---|---|---|
| I | $\int \sec x \tan x dx$ | P | $-\frac{\operatorname{cosec} kx}{k}+C$ |
| II | $\int \operatorname{cosec} kx \cot kx\, dx$ | Q | $-\frac{\cot kx}{k}+C$ |
| III | $\int \operatorname{cosec}^2 kx\, dx$ | R | $\sec x+C$ |
| IV | $\int \cos kx\, dx$ | S | $\frac{\sin kx}{k}+C$ |

(1) I–S; II–P; III–Q; IV–R
(2) I–S; II–P; III–R; IV–Q
(3) I–Q; II–R; III–P; IV–S
(4) I–R; II–P; III–Q; IV–S

**39.** Match the statements given in column-I with statements given in column - II

| Column - I | | Column - II | |
|---|---|---|---|
| I | if $\|\vec{A}\| = \|\vec{B}\|$ and $\|\vec{A}+\vec{B}\|=\|\vec{A}\|$ then angle between $\vec{A}$ and $\vec{B}$ is | P | 90° |
| II | Magnitude of resultant of two forces $\|\vec{F}_1\| = 8$N and $\|\vec{F}_2\| = 4$ N may be | Q | 120° |
| III | Angle between $\vec{A} = 2\hat{i} + 2\hat{j}$ & $\vec{B} = 3\hat{k}$ is | R | 12 N |
| IV | Magnitude of resultant of vectors $\vec{A} = 2\hat{i} + \hat{j}$ & $\vec{B} = 3\hat{k}$ is | S | $\sqrt{14}$ |

(1) I–S; II–P; III–Q; IV–R
(2) I–S; II–P; III–R; IV–Q
(3) I–Q; II–R; III–P; IV–S
(4) I–R; II–P; III–Q; IV–S

**40.** A particle is moving along positive x-axis. Its position varies as $x = t^3 - 3t^2 + 12t + 20$, where $x$ is in meters and $t$ is in seconds. Velocity of the particle when its acceleration is zero

(1) 1 m/s (2) 3 m/s
(3) 6 m/s (4) 9 m/s

**41.** **Statement-1 :** A vector is a quantity that has both magnitude and direction and obeys the triangle law of addition.

**Statement-2 :** The magnitude of the resultant vector of two given vectors can never be less than the magnitude of any of the given vector.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**42.** **Statement-1:** If the rectangular components of a force are 8 N and 6N, then the magnitude of the force is 10N.

**Statement-2:** If $|\vec{A}|=|\vec{B}|=1$ then $|\vec{A}\times\vec{B}|^2+|\vec{A}.\vec{B}|^2=1$.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**43.** **Statement-1 :** The angle between the two vectors $(\hat{i}+\hat{j})$ and $(\hat{k})$ is $\frac{\pi}{2}$ radian.

**Statement-2:** Angle between two vectors $(\hat{i}+\hat{j})$ and $(\hat{k})$ is given by $\theta = cos^{-1}\left(\frac{\vec{A}.\vec{B}}{AB}\right)$.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**44.** The vector joining the points *A* (1, 1, –1) and *B* (2, –3, 4) and pointing from *A* to *B* is -

(1) $-\hat{i}+4\hat{j}-5\hat{k}$ (2) $\hat{i}+4\hat{j}+5\hat{k}$
(3) $\hat{i}-4\hat{j}+5\hat{k}$ (4) $-\hat{i}-4\hat{j}-5\hat{k}$

**45.** Match List I with List II and select the correct answer using the codes given below the lists:

| List I | | List II | |
|---|---|---|---|
| I | Boltzmann constant | P | $[ML^2T^{-1}]$ |
| II | Coefficient of viscosity | Q | $[ML^{-1}T^{-1}]$ |
| III | Planck constant | R | $[MLT^{-3}K^{-1}]$ |
| IV | Thermal conductivity | S | $[ML^2T^{-2}K^{-1}]$ |

(1) I-R; II-P; III-Q; IV-S
(2) I-R; II-Q; III-P; IV-S
(3) I-S; II-Q; III-P; IV-R
(4) I-S; II-P; III-Q; IV-R

**46.** Electric field in a certain region is given by $\vec{E}=\left(\frac{A}{x^2}\hat{i}+\frac{B}{y^3}\hat{j}\right)$. The SI unit of *A* and *B* are:

(1) $Nm^3C^{-1}$; $Nm^2C^{-1}$
(2) $Nm^2C^{-1}$; $Nm^3C^{-1}$
(3) $Nm^3C$; $Nm^2C$
(4) $Nm^2C$; $Nm^3C$

**47.** Consider an expanding sphere of instantaneous radius R whose total mass remains constant. The expansion is such that the instantaneous density ρ remains uniform throughout the volume. The rate of fractional change in density $\left(\frac{1}{\rho}\frac{d\rho}{dt}\right)$ is constant. The velocity v of any point on the surface of the expanding sphere is proportional to

(1) $R^3$ (2) $R$
(3) $R^{2/3}$ (4) $\frac{1}{R}$

**48.** Which of the following units denotes the dimensions $ML^2/Q^2$, where Q denotes the electric charge? (M = Mass, L = Length)

(1) $H/m^2$ (2) Weber (Wb)
(3) $Wb/m^2$ (4) Henry (H)

**49.** The dimension of magnetic field in M, L, T and C (Coulomb) is given as

(1) $MT^2C^{-2}$ (2) $MT^{-1}C^{-1}$
(3) $MT^{-2}C^{-1}$ (4) $MLT^{-1}C^{-1}$

**50.** Let [ $\varepsilon_0$ ] denote the dimensional formula of the permittivity of vacuum. If $M$ = mass, $L$ = length, $T$ = time and $A$ = electric current, then:

(1) $[\varepsilon_0] = [M^{-1} L^{-3} T^2 A]$

(2) $[\varepsilon_0] = [M^{-1} L^{-3} T^4 A^2]$

(3) $[\varepsilon_0] = [M^{-1} L^2 T^{-1} A^{-2}]$

(4) $[\varepsilon_0] = [M^{-1} L^2 T^{-1} A]$

**51.** **Statement-1:** Distance is a scalar quantity.

**Statement-2:** Distance is the length of path transversed.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**52.** A vector is not changed if

(1) it is displaced parallel to itself

(2) it is rotated through an arbitrary angle

(3) it is cross-multiplied by a unit vector

(4) it is multiplied by an arbitrary scalar.

**53.** Match List-I with List-II

| **List-I** | | **List-II** | |
|---|---|---|---|
| I | Planck's constant ($h$) | P | $[M^1 L^2 T^{-2}]$ |
| II | Stopping potential (Vs) | Q | $[M^1 L^2 T^{-1}]$ |
| III | Work function ($\phi$) | R | $[M^1 L^2 T^{-1}]$ |
| IV | Momentum ($p$) | S | $[M^1 L^2 T^{-3} A^{-1}]$ |

(1) I-R; II-P; III-Q; IV-S

(2) I-R; II-S; III-P; IV-Q

(3) I-Q; II-S; III-R; IV-P

(4) I-R; II-P; III-Q; IV-S

**54.** Identify the pair of physical quantities that have same dimensions:

(1) Velocity gradient and decay constant

(2) Wien's constant and Stefan constant

(3) Angular frequency and angular momentum

(4) Wave number and Avogadro number

**55.** Identify the pair of physical quantities which have different dimensions:

(1) Wave number and Rydberg's constant.

(2) Stress and Coefficient of elasticity.

(3) Coercivity and Magnetisation.

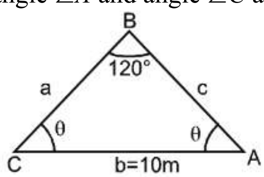
(4) Specific heat capacity and Latent heat.

**56.** Which of the following combinations has the dimension of electrical resistance ($\varepsilon_0$ is the permittivity of vacuum and $\mu_0$ is the permeability of vacuum)?

(1) $\sqrt{\dfrac{\varepsilon_0}{\mu_0}}$ (2) $\sqrt{\dfrac{\mu_0}{\varepsilon_0}}$

(3) $\sqrt{\dfrac{\varepsilon_0}{\mu_0}}$ (4) $\sqrt{\dfrac{\mu_0}{\varepsilon_0}}$

**57.** For a triangle shown in the figure, side $CA$ is 10 m, angle $\angle A$ and angle $\angle C$ are equal then:




(1) side $a$ = side $c$ = 10 m

(2) side $a \neq$ side $c$

(3) side $a$ = side $c$ = $\dfrac{10\sqrt{3}}{3}$ m

(4) side $a$ = side $c$ = $\dfrac{10}{\sqrt{2}}$ m

**58.** An expression of energy density is given by $u = \dfrac{\alpha}{\beta}\sin\left(\dfrac{\alpha x}{kt}\right)$ where $\alpha$, $\beta$ are constants, $x$ is displacement, $k$ is Boltzmann constant and t is the temperature. The dimensions of $\beta$ will be:

(1) $[ML^2T^{-2}\theta^{-1}]$ (2) $[M^0L^2T^{-2}]$

(3) $[M^0L^0T^0]$ (4) $[M^0L^2T^0]$

**59.** If e is the electronic charge, $c$ is the speed of light in free space and $h$ is Planck's constant, the quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e^2|}{hc}$ has dimensions of:

(1) $[MLT^0]$ (2) $[MLT^{-1}]$

(3) $[M^0L^0T^0]$ (4) $[LC^{-1}]$

**60.** $\sin^2\theta$ is equivalent to:

(1) $\left(\frac{1+\cos\theta}{2}\right)$ (2) $\left(\frac{1+\cos 2\theta}{2}\right)$

(3) $\left(\frac{1-\cos 2\theta}{2}\right)$ (4) $\left(\frac{\cos 2\theta-1}{2}\right)$

## *Integer Type Questions (61 to 75)*

**61.** A vernier calliper has 1 mm marks on the main scale. It has 20 equal division on the Vernier scale which match with 16 main scale divisions. For this Vernier calliper, the least count is $x$ mm then $\frac{x}{0.2}$ is:

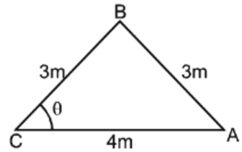
**62.** The energy of a system as a function of time $t$ is given as $E(t) = A^2\exp(-\alpha t)$, where $\alpha = 0.2s^{-1}$. The measurement of $A$ has an error of 1.25%. If the error in the measurement of time is 1.50%, the percentage error in the value of $E(t)$ at $t = 5$ s is

**63.** In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (0.5°), then the least count of the instrument is $n$ minute then $n$ is:

**64.** The Current voltage relation of diode is given by $I = (e^{1000V/T} - 1)$ mA, where the applied voltage $V$ is in volts and the temperature $T$ is in degree Kelvin. If a student makes an error measuring ±0.01 V while measuring the current of 5 mA at 300 K. The error in the value of current in mA is $n$ then $\frac{n}{0.2}$ is:

**65.** $f(x) = \cos x + \sin x$. Find $f(\pi/2)$

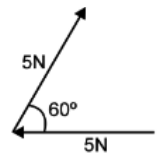
**66.** $\theta$ is angle between side $CA$ and $CB$ of triangle, shown in the figure then $\cos\theta = \frac{n}{3}$, here $n$ is:




**67.** Particle's position as a function of time is given by $x = -t^2 + 4t + 4$ find the maximum positive value of position co-ordinate of particle is:

**68.** The area of the region between the curve $y = \sin x$ and the $x$-axis in the interval $[0, \pi]$ is:

**69.** The forces, each numerically equal to 5 N, are acting as shown in the figure. The angle between forces is $x^{\circ}$ then $x$ is




**70.** A vector of magnitude 30 and direction eastwards is added with another vector of magnitude 40 and direction Northwards. The angle which resultant make with east is $y^{\circ}$ than $y$ is:

**71.** $\int_{\pi}^{2\pi}\theta\, d\theta = n$. The value of $n$ is: Take ($\pi^2 = 10$)

**72.** If $|\vec{A}+\vec{B}| = |\vec{A}| = |\vec{B}|$, then the angle between $\vec{A}$ and $\vec{B}$ is ( $\vec{A}$ and $\vec{B}$ are not null vectors). $n^{\circ}$ then $n$ is:

**73.** Vector $\vec{A}$ is of length 2 cm and is 60° above the $x$-axis in the first quadrant. Vector $\vec{B}$ is of length 2 cm and 60° below the x-axis in the fourth quadrant. The sum $\vec{A}+\vec{B}$ is a vector of magnitude-

**74.** Six forces, 9.81 N each, acting at a point are coplanar. If the angles between neighboring forces are equal, then the resultant is

**75.** The vector $\vec{A} = \hat{i} + \hat{j}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along $x$-axis and $y$-axis respectively, makes an angle of ............... degree with $x$-axis.

CHAPTER

02

# KINEMATICS

## Single Option Correct Type Questions (01 to 60)

**1.** A body covered some distance along a curved path of a quarter circle. The ratio of distance to displacement is

(1) $\frac{\pi}{2\sqrt{2}}$ (2) $\frac{2\sqrt{2}}{\pi}$

(3) $\frac{\pi}{\sqrt{2}}$ (4) $\frac{\sqrt{2}}{\pi}$

**2.** A motor car covers $\frac{1}{3}$rd part of total distance with $v_1$ = 10 km/hr, second $\frac{1}{3}$rd part with $v_2$ = 20 km/hr and rest $\frac{1}{3}$rd part with $v_3$ = 60 km/hr. What is the average speed of the car?

(1) 18 km/hr (2) 45km/hr

(3) 6 km/hr (4) 22.5 km/hr

**3.** A particle is moving with velocity 5 m/s towards east and its velocity changes to 5 m/s north in 10 sec. Find the acceleration of the particle?

(1) $\sqrt{2}\, m/s^2 N-W$

(2) $\frac{1}{\sqrt{2}} m/s^2 N-W$

(3) $\frac{1}{\sqrt{2}} m/s^2\ N-E$

(4) $\sqrt{2}\, m/s^2 N-E$

**4.** The displacement-time relationship for a particle is given by $x = a_0 + a_1t + a_2t^2$. The acceleration of the particle is

(1) $a_0$ (2) $a_1$

(3) $a_2$ (4) $2a_2$

**5.** A particle is moving so that its displacement is given as $s = t^3 - 6t^2 + 3t + 4$ meter. Its velocity at the instant when its acceleration is zero will be

(1) 3 m/s (2) –12 m/s

(3) 42 m/s (4) –9 m/s

**6.** If the displacement of a particle varies with time as $\sqrt{x} = t + 7$, the

(1) velocity of the particle is inversely proportional to $t$

(2) acceleration of the particle is directly proportional to $t$

(3) velocity of the particle is proportional to $\sqrt{t}$

(4) the particle moves with a constant acceleration

**7.** A body is thrown upward and reaches its maximum height. At that position

(1) Its velocity is zero and its acceleration is also zero

(2) Its velocity is zero but its acceleration is maximum

(3) Its acceleration is minimum

(4) Its velocity is zero and its acceleration is the acceleration due to gravity

**8.** A man standing on the edge of a cliff throws a stone straight up with initial speed $u$ and then throws another stone straight down with same initial speed $u$ from the same position. Find the ratio of speeds, the stones would have attained when they hit the ground at the base of the cliff?

(1) 2 : 1 (2) 1 : 2

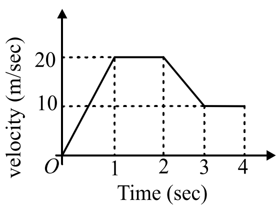
(3) 1 : 1 (4) 3 : 1

**9.** The displacement-time graph for the two particles $A$ and $B$ are straight lines inclined at angles $30^\circ$ and $60^\circ$ with the time axis. The ratio of the velocities of $A$ to $B$ will be

(1) 1 : 2 (2) $1:\sqrt{3}$

(3) $\sqrt{3}:1$ (4) 1 : 3

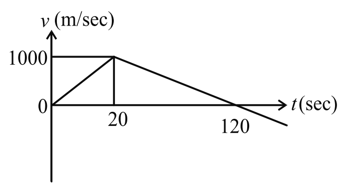
**10.** The variation of velocity of a particle moving along straight line is shown in figure. The distance traversed by the body in 4 seconds is




(1) 70 m (2) 60 m

(3) 40 m (4) 55 m

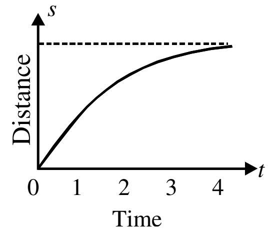
**11.** A rocket is projected vertically upwards and its velocity time graph is shown in the figure. The maximum height attained by the rocket is




(1) 1 km (2) 10 km

(3) 100 km (4) 60 km

**12.** The displacement of a particle as a function of time is shown in fig. The fig. indicates that



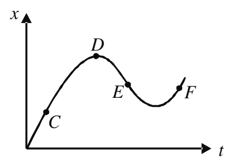

(1) the particle starts with a certain velocity, but the motion is retarded and finally the particle stops

(2) the velocity of particle is constant through

(3) the acceleration of the particle is constant throughout

(4) the particle starts with a constant velocity, the motion is accelerated and finally the particle moves with another constant velocity.

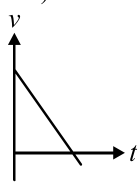
**13.** The displacement–time graph of a moving particle is shown below. The instantaneous velocity of the particle is negative at the point :

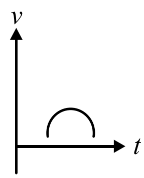


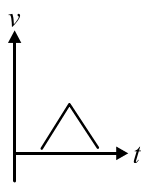

(1) C (2) D

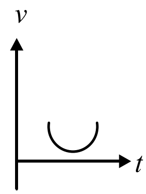
(3) E (4) F

**14.** A particle is thrown above, then correct $v$-$t$ graph will be (taking upward direction as positive)

(1) 


(2) 


(3) 


(4) 

**15.** Two balls are dropped from different heights. One ball is dropped 2 sec after the other but they both strike the ground at the same time, 3 sec after the first is dropped. The difference in the heights at which they were dropped is ($g = 9.8$ m/s$^2$)

(1) 7.8 m (2) 78 m
(3) 15.6 m (4) 39.2 m

**16.** Juggler keeps on moving four balls in the air continuously such that each ball attains 20 m height. When the first ball leaves his hand, the position of the other balls (in meter) will be

(1) 10, 20, 10 (2) 15, 20, 15
(3) 5, 51, 20 (4) 5, 10, 20

**17.** Mark the correct statements :

(1) The magnitude of the instantaneous velocity of a particle is equal to its instantaneous speed.
(2) The magnitude of average velocity in an interval is equal to its average speed in that interval.
(3) It is possible to have a situation in which the speed of a particle is always zero but the average speed is not zero
(4) It is possible to have a situation in which the speed of the particle is never zero but the average speed in an interval is zero.

**18.** A particle is thrown upwards from ground. It experiences a constant air resistance which can produce a retardation of 2 m/s$^2$ opposite to the direction of velocity of particle. The ratio of time of ascent to the time of descent is: [$g = 10$ m/s$^2$]

(1) 1 : 1
(2) $\sqrt{\frac{2}{3}}$
(3) $\frac{2}{3}$
(4) $\sqrt{\frac{3}{2}}$

**19.** A truck travelling towards North at 20 m/s turns East and travels at the same speed. The change in its velocity is

(1) $20\sqrt{2}$ m/s North-East
(2) $20\sqrt{2}$ m/s South-East
(3) $40\sqrt{2}$ m/s North-East
(4) $20\sqrt{2}$ m/s North-West

**20.** **STATEMENT-1 :** A particle having negative acceleration will slow down.

**STATEMENT-2:** Direction of the acceleration is not dependent upon direction of the velocity.

(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

**21.** **STATEMENT-1:** Magnitude of average velocity is equal to average speed.

**STATEMENT-2:** Magnitude of instantaneous velocity is equal to instantaneous speed.

(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

**22.** **STATEMENT-1:** A particle moves in a straight line with constant acceleration. The average velocity of this particle cannot be zero in any time interval

**STATEMENT-2:** For a particle moving in straight line with constant acceleration, the average velocity in a time interval is $\frac{u+v}{2}$, where u and v are initial and final velocity of the particle in the given time interval.

(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1

(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1

(3) STATEMENT-1 is true, STATEMENT-2 is false

(4) STATEMENT-1 is false, STATEMENT-2 is true

**23.** **STATEMENT-1:** For a particle moving in a straight line, velocity ($v$ in m/s) of the particle in terms of time ($t$ in sec) is given by $v = t^2 - 6t + 8$. Then the speed of the particle is minimum at $t = 2$ sec.

**STATEMENT-2:** For a particle moving in a straight line the velocity $v$ at any time $t$ may be minimum or may be maximum when $\frac{dv}{dt} = 0$.

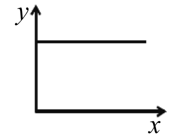
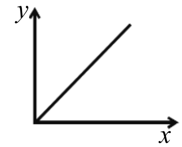
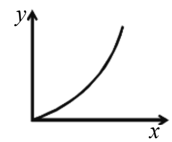
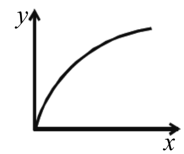
(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1

(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1

(3) STATEMENT-1 is true, STATEMENT-2 is false

(4) STATEMENT-1 is false, STATEMENT-2 is true

**24.** Match the following: A particle is moving along a straight line. Its velocity varies with time as $v = kt$, where $k$ is a positive constant and $t$ is the time. Match the graphs in Column II with the statements in Column I.

| | Column I | | Column II |
|---|---|---|---|
| A | Acceleration (along $y$-axis) versus time (along $x$-axis) curve | P |  |
| B | Acceleration (along $y$-axis) versus displacement (along $x$-axis) curve | Q |  |
| C | Velocity (along $y$-axis) versus time (along $x$- axis)curve | R |  |
| D | Displacement (along $y$-axis) versus velocity (along $x$-axis) curve | S |  |

(1) (A)-P; (B)-P; (C)-Q; (D)-R

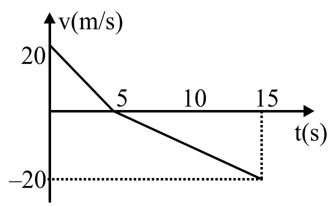
(2) (A)-P; (B)-P; (C)-Q; (D)-S

(3) (A)-Q; (B)-P; (C)-Q; (D)-S

(4) (A)-Q; (B)-P; (C)-Q; (D)-R

**25.** Match the following:

For the velocity–time graph shown in figure, in a time interval from $t = 0$ to $t = 15$ s, match the following:



| Column–I | | Column–II | |
|---|---|---|---|
| A | Change in velocity (in m/s) | P | –8/3 |
| B | Average acceleration (in m/s$^2$) | Q | –40 |
| C | Total displacement (in m) | R | –10 |
| D | Acceleration at $t$ = 7 s (in m/s$^2$) | S | – 2 |
| | | T | –50 |

(1) A-Q; B-P; C-T; D-S
(2) A-Q; B-P; C-S; D-T
(3) A-T; B-P; C-P; D-S
(4) A-P; B-Q; C-T; D-S

**26.** Speeds of two identical cars are $u$ and $4u$ at a specific instant. The ratio of the respective distances at which the two cars are stopped at the same instant is:
(1) 1 : 1 (2) 1 : 4
(3) 1 : 8 (4) 1 : 16

**27.** The coordinates of a moving particle at any time $t$ are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time $t$ is given by:
(1) $\sqrt{\alpha^2+\beta^2}$
(2) $3t^2\sqrt{\alpha^2+\beta^2}$
(3) $t^2\sqrt{\alpha^2+\beta^2}$
(4) $3t\sqrt{\alpha^2+\beta^2}$

**28.** An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20 m. If the car is going twice as fast, ie. 120 km/h, the stopping distance will be
(1) 20 m (2) 40 m
(3) 60 m (4) 80 m

**29.** The relation between time $t$ and distance $x$ is $t = ax^2 + bx$, where a and $b$ are constants. The acceleration is:
(1) $-2\,abv^2$ (2) $2\,bv^2$
(3) $-2\,av^3$ (4) $2\,av^3$

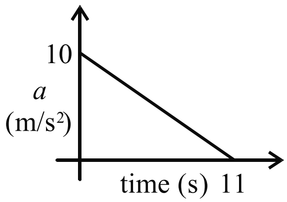
**30.** A particle located at $x = 0$ at time $t = 0$, starts moving along the positive $x$-direction with a velocity $v$ that varies as $v = \alpha\sqrt{x}$. The displacement of the particle varies with time as
(1) $t^{1/2}$ (2) $t^3$
(3) $t^2$ (4) $t$

**31.** An object moving with a speed of 6.25 m/s, is decelerated at a rate given by: $\frac{dv}{dt} = -2.5\sqrt{v}$ where $v$ is the instantaneous speed. The time taken by the object, to come to rest, would be:
(1) 1 s (2) 2 s
(3) 4 s (4) 8 s

**32.** From a tower of height $H$, a particle is thrown vertically upwards with a speed $u$. The time taken by the particle, to hit the ground, is a $n$ times that taken by it to reach the highest point of its path.
The relation between $H$, $u$ and $n$ is :
(1) $2\,gH = n^2u^2$ (2) $gH = (n-2)^2u^2$
(3) $2\,gH = nu^2\,(n-2)$ (4) $gH = (n-2)u^2$

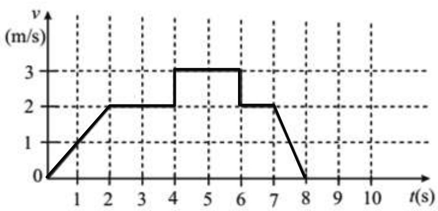
**33.** A block is moving down a smooth inclined plane starting from rest at time $t = 0$. Let $S_n$ be the distance travelled by the block in the interval $t = n - 1$ to $t = n$. The ratio $\frac{S_n}{S_{n+1}}$ is
(1) $\frac{2n-1}{2n}$
(2) $\frac{2n-1}{2n+1}$
(3) $\frac{2n+1}{2n-1}$
(4) $\frac{2n}{2n-1}$

**34.** A particle is initially at rest, It is subjected to a linear acceleration $a$, as shown in the figure. The maximum speed attained by the particle is




(1) 605 m/s (2) 110 m/s
(3) 55 m/s (4) 550 m/s

**35.** A particle starts from the origin at time $t = 0$ and moves along the positive $x$-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle at time $t = 5$s?




(1) 10 m (2) 6 m
(3) 3 m (4) 9 m

**36.** An object moves with speed $v_1$, $v_2$, and $v_3$ along a line segment $AB$, $BC$ and $CD$ respectively as shown in figure. Where $AB = BC$ and $AD = 3\ AB$, then average speed of the object will be:


(1) $\dfrac{(v_1 + v_2 + v_3)}{3}$

(2) $\dfrac{v_1 v_2 v_3}{3(v_1 v_2 + v_2 v_3 + v_3 v_1)}$

(3) $\dfrac{3 v_1 v_2 v_3}{v_1 v_2 + v_2 v_3 + v_3 v_1}$

(4) $\dfrac{(v_1 + v_2 + v_3)}{3 v_1 v_2 v_3}$

**37.** The position of a particle as a function of time $t$, is given by $x(t) = at + bt^2 - ct^3$ where $a$, $b$ and $c$ are constants. When the particle attains zero acceleration, then its velocity will be:

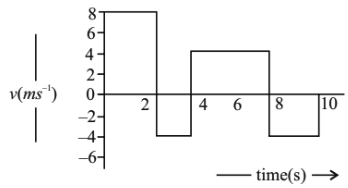
(1) $a + \dfrac{b^2}{4c}$ (2) $a + \dfrac{b^2}{c}$

(3) $a + \dfrac{b^2}{2c}$ (4) $a + \dfrac{b^2}{3c}$

**38.** A particle starts with an initial velocity of 10.0 $ms^{-1}$ along x-direction and accelerates uniformly at the rate of 2.0 $ms^{-2}$. The time taken by the particle to reach the velocity of 60.0 $ms^{-1}$ is

(1) 6s (2) 3s
(3) 30s (4) 25s

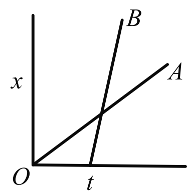
**39.** The velocity time graph of a body moving in a straight line is shown in figure.




The ratio of displacement to distance travelled by the body in time 0 to 10 s is

(1) 1 : 1 (2) 1 : 4
(3) 1 : 2 (4) 1 : 3

**40.** The position-time graphs for two students $A$ and $B$ returning from the school to their homes are shown in figure:

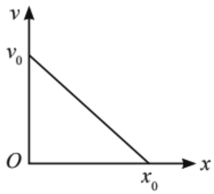



(A) $A$ lives closer to the school
(B) $B$ lives closer to the school
(C) $A$ takes lesser time to reach home
(D) $A$ travels faster than $B$
(E) $B$ travels faster than $A$

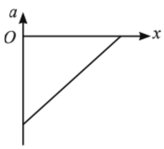
Choose the correct answer from the options given below:

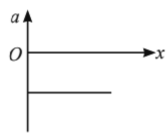
(1) (A) and (E) only
(2) (B) and (E) only
(3) (A), (C) and (E) only
(4) (A), (C) and (D) only

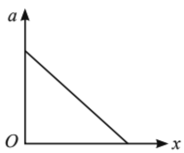
**41.** The velocity - displacement graph of a particle is shown in the figure.

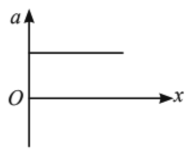



The acceleration - displacement graph of the same particle is represented by:

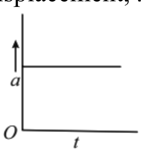
(1) 

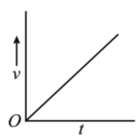

(2) 

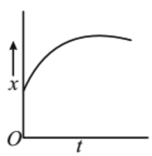

(3) 

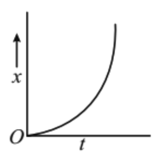

(4) 


**42.** A particle starts from origin $O$ from rest and moves with a uniform acceleration along the positive $x$-axis. Identify the figure that is not correctly representing the motion qualitatively.
($a$ = acceleration, $v$ = velocity,
$x$ = displacement, $t$ = time)

(A) 


(B) 


(C) 


(D) 


(1) (A), (B), (C)
(2) (A)
(3) (C)
(4) (B), (C)

**43.** The instantaneous velocity of a particle moving in a straight line is given as $v = \alpha t + \beta t^2$, where $\alpha$ and $\beta$ are constants. The distance travelled by the particle between 1s and 2s is:

(1) $\frac{\alpha}{2}+\frac{\beta}{3}$
(2) $\frac{3}{2}\alpha+\frac{7}{3}\beta$
(3) $\frac{3}{2}\alpha+\frac{7}{2}\beta$
(4) $3\alpha+7\beta$

**44.** A particle moves such that its position vector $\vec{r}(t)=\cos\omega t\,\hat{i}+\sin\omega t\,\hat{j}$ where $\omega$ is a constant and $t$ is time. Then which of the following statements is true for the velocity $\vec{v}(t)$ and acceleration a $\vec{a}(t)$ of the particle:

(1) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed towards the origin.
(2) $\vec{v}$ and $\vec{a}$ both are parallel to $\vec{r}$ .
(3) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed away from the origin.
(4) $\vec{v}$ and $\vec{a}$ both are perpendicular to $\vec{r}$ .

**45.** The range of the projectile projected at an angle of 15° with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be:

(1) 50 m
(2) $50\sqrt{2}$ m
(3) 100 m
(4) $100\sqrt{2}$ m

**46.** The initial speed of a projectile fired from ground is $u$. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}u$. The time of flight of the projectile is:

(1) $\frac{u}{2g}$
(2) $\frac{u}{g}$
(3) $\frac{2u}{g}$
(4) $\frac{\sqrt{3}u}{g}$

**47.** A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 $ms^{-1}$. Neglecting the air resistance, the speed with which the stone hits the ground will be $ms^{-1}$ (given, $g = 10\ ms^{-2}$).

(1) 20 (2) 15
(3) 30 (4) 25

**48.** A stone is projected at angle 30° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be

(1) 1 : 2 (2) 1 : 4
(3) 4 : 1 (4) 4 : 3

**49.** A passenger sitting in a train *A* moving at 90 km/h observes another train *B* moving in the opposite direction for 8 s. If the velocity of the train *B* is 54 km/h, then length of train *B* is:

(1) 80 m (2) 200 m
(3) 120 m (4) 320 m

**50.** A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when: (i) they are moving in the same direction, and (ii) in the opposite direction is:

(1) $\frac{11}{5}$ (2) $\frac{5}{2}$
(3) $\frac{3}{2}$ (4) $\frac{25}{11}$

**51.** A butterfly is flying with a velocity $4\sqrt{2}$ m/s in North – East direction. Wind is slowly blowing at 1 m/s from North to South. The resultant displacement of the butterfly in 3 seconds is:

(1) 15 m
(2) 20 m
(3) 3 m
(4) $12\sqrt{2}$ m

**52.** A particle is moving with a velocity $\vec{v} = k(y\hat{i} + x\hat{j})$, where k is a constant. The general equation for its path is:

(1) $y = x^2$ + constant
(2) $y^2 = x$ + constant
(3) $y^2 = x^2$ + constant
(4) $xy$ = constant

**53.** A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2}$ $kmh^{-1}$, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is:

(1) 30 $kmh^{-1}$ (2) $\frac{25}{\sqrt{2}}$ $kmh^{-1}$
(3) $\frac{30}{\sqrt{2}}$ $kmh^{-1}$ (4) 25 $kmh^{-1}$

**54.** Two projectiles *A* and *B* are thrown with initial velocities of 40 m/s and 60 m/s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is ($g$ =10 m/s$^2$)

(1) $\sqrt{3}:2$ (2) $2:\sqrt{3}$
(3) 1 : 1 (4) 4 : 9

**55.** Two projectiles thrown at 30° and 45° with the horizontal respectively, reach the maximum height in same time. The ratio of their initial velocities is.

(1) $1:\sqrt{2}$ (2) 2 : 1
(3) $\sqrt{2}:1$ (4) 1 : 2

**56.** An object is projected in the air with initial velocity $u$ at an angle θ from the horizontal. The projectile motion is such that the horizontal range *R*, is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be ________degree.

(Mark the smallest angle possible)

(1) 15 (2) 30
(3) 75 (4) 60

**57.** An object is thrown vertically upwards. At its maximum height, which of the following quantity becomes zero?

(1) Instantaneous Momentum

(2) Average velocity

(3) Acceleration

(4) Force

**58.** The position vector of a particle changes with time according to the relation $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$ m. What is the magnitude of the acceleration at $t = 1$sec.?

(1) 40 $m/s^2$ (2) 100 $m/s^2$

(3) 25 $m/s^2$ (4) 50 $m/s^2$

**59.** A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance $R$ form it. If $t_1$ and $t_2$ are the values of the time taken by it to hit the target in two possible ways, the product $t_1t_2$ is:

(1) $R/g$ (2) $R/4g$

(3) $2R/g$ (4) $R/2g$

**60.** A ball is project with kinetic energy 100 J, at an angle of 30° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become:

(1) 0 J (2) 75 J

(3) 50 J (4) 60 J

### *Integer Type Questions (61 to 75)*

**61.** A horse rider covers half the distance with 5 m/s speed. The remaining part of the distance was travelled with speed 10 m/s for half the time and with speed 15 m/s for other half of the time. The mean speed of the rider averaged over the whole time of motion is $p/7$ m/s. The value of $p$ is ———.

**62.** A car is moving with speed of 150 km/h and after applying the break it will move 27m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling ________ m distance.

**63.** For a train engine moving with speed of 20 $ms^{-1}$. the driver must apply brakes at a distance of 500m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}\ ms^{-1}$. The value of $x$ is:

(Assuming same retardation is produced by brakes)

**64.** A ball is thrown vertically upward with an initial velocity of 150 m/s. The ratio of velocity after 3s and 5s is $\frac{x+1}{x}$. The value of $x$ is ________. [Take $g = 10$ $m/s^2$]

**65.** A 0.4 kg mass takes 8s to reach ground when dropped from a certain height '$P$' above surface of earth. The loss of potential energy in the last second of fall is ________ J.

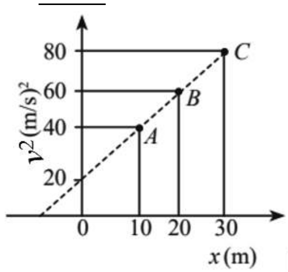
[Take $g = 10$ $m/s^2$]

**66.** A tennis ball is dropped on to the floor from a height of 9.8m. It rebounds to a height 5.0 $m$. Ball comes in contact with the floor for 0.2 s. The average acceleration during contact is________ $ms^{-2}$ [Given $g = 10$ $ms^{-1}$]

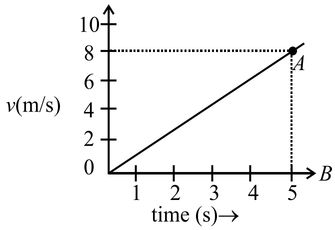
**67.** Two small spherical balls having equal masses each are thrown upwards along the same vertical direction at an interval of 3s with the same initial velocity of 35 m/s, then these balls collide at a height of ________ m.

(Take $g = 10$ $m/s^2$)

**68.** A particle is moving with constant acceleration '$a$'. Following graph shows $v^2$ versus $x$ (displacement) plot. The acceleration of the particle is _____$m/s^2$.



**69.** The speed versus time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval $t = 0$ to $t = 5$ s will be ______.




**70.** The distance $x$ covered by a particle in one dimensional motion varies with time $t$ as $x^2 = at^2 + 2bt + c$. If the acceleration of the particle depends on $x$ as $x^{-n}$, where $n$ is an integer, the value of $n$ is __________.

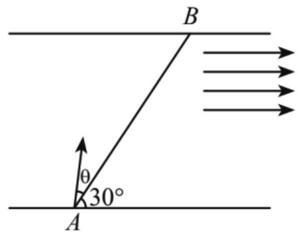
**71.** A projectile fired at 30º to the ground is observed to be at same height at time 3s and 5s after projection, during its flight. The speed of projection of the projectile is _________$ms^{-1}$ (Given $g = 10\ ms^{-2}$)

**72.** Two bodies are projected from ground with same speeds 40 $ms^{-1}$ at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60º, with horizontal then sum of the maximum heights, attained by the two projectiles, is______ m. (Given $g = 10\ ms^{-2}$)

**73.** If the initial velocity in horizontal direction of a projectile is unit vector $\hat{i}$ m/s and the equation of trajectory is $y = 5x(1 - x)$ where $x$ and $y$ are in meter. The $y$ component vector of the initial velocity is _________ $\hat{j}$ m/s.

(Take $g = 10\ m/s^2$)

**74.** A swimmer wants to cross a river from point $A$ to point $B$. Line $AB$ makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer with respect to river is same as that of the speed of the river. The angle θ with the line $AB$ should be _________°, so that the swimmer reaches point $B$.




**75.** A ball of mass $m$ is thrown vertically upward. Another ball of mass 2 $m$ is thrown an angle θ with the vertical. Both the balls stay in air for the same period of time. The ratio of the heights attained by the two balls respectively is $\frac{1}{x}$. The value of $x$ is ________.

# CHAPTER 03

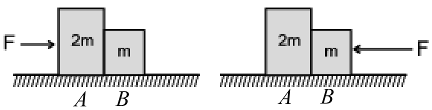
# LAWS OF MOTION

## *Single Option Correct Type Questions (01 to 60)*

**1.** In a tug of war each of the two teams apply 1000 Newton force at the ends of a rope, which is found to be in equilibrium, the tension in the rope is-

(1) 2000 newton (2) 1000 newton
(3) 500 newton (4) Zero

**2.** Two blocks are in contact on a frictionless table. One has mass $m$ and the other $2m$. A force $F$ is applied on $2m$ as shown in the figure. Now the same force $F$ is applied from the right on $m$. In the two cases respectively, the ratio of force of contact between the two blocks will be:




(1) 1 : 1 (2) 1 : 2
(3) 2 : 1 (4) 1 : 3

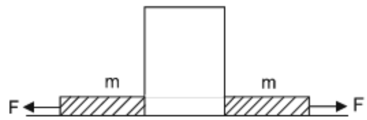
**3.** A force vector applied on a mass is represented as $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$ and accelerates with 1 m/s$^2$. What will be the mass of the body-

(1) $10\sqrt{2}$ kg (2) $2\sqrt{10}$ kg
(3) 10 kg (4) 20 kg

**4.** The engine of a car produces acceleration 4 m/s$^2$ in the car. If this car pulls another car of same mass. What will be the acceleration produced-

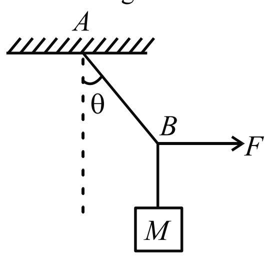
(1) 1 m/s$^2$ (2) 1.5 m/s$^2$
(3) 2 m/s$^2$ (4) 4 m/s$^2$

**5.** A heavy block kept on a frictionless surface and being pulled by two ropes of equal mass $m$ as shown in figure. At $t = 0$, the force on the left rope is withdrawn but the force on the right end continues to act. Let $F_1$ and $F_2$ be the magnitudes of the forces by the right rope and the left rope on the block respectively.




(1) $F_1 = F_2 = F$ for $t < 0$
(2) $F_1 = F_2 = F + mg$ for $t < 0$
(3) $F_1 = F$, $F_2 = F$ for $t > 0$
(4) $F_1 < F$, $F_2 = F$ for $t > 0$

**6.** A mass $M$ is suspended by a rope from a rigid support at $A$ as shown in figure. Another rope is tied at the end $B$, and it is pulled horizontally with a force $F$. If the rope $AB$ makes an angle $\theta$ with the vertical in equilibrium, then the tension in the string $AB$ is:

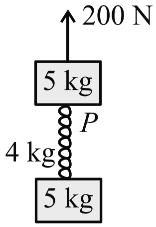



(1) $F \sin\theta$ (2) $F/\sin\theta$
(3) $F \cos\theta$ (4) $F/\cos\theta$

**7.** Two persons are holding a rope of negligible weight tightly at its ends so that it is horizontal. A 15 kg weight is attached to the rope at the midpoint which now no longer remains horizontal. The minimum tension required to completely straighten the rope is:

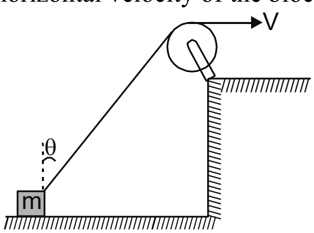
(1) 15 kg (2) $\frac{15}{2}$ kg
(3) 5 kg (4) Infinitely large

**8.** Two blocks of 7 kg and 5 kg are connected by a heavy rope of mass 4 kg. An upward force of 200N is applied as shown in the diagram. The tension at the top of heavy rope at point *P* is- ($g = 10$ m/s$^2$)



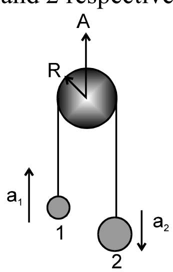

(1) 2.27 N (2) 112.5 N
(3) 87.5 N (4) 360 N

**9.** A block is dragged on smooth plane with the help of a rope which moves with velocity *v*. The horizontal velocity of the block is :




(1) $v$ (2) $\frac{v}{\sin\theta}$
(3) $v\sin\theta$ (4) $\frac{v}{\cos\theta}$

**10.** Two masses are connected by a string which passes over a pulley accelerating upward at a rate *A* as shown. If $a_1$ and $a_2$ be the acceleration of bodies 1 and 2 respectively then:




(1) $A = a_1 - a_2$ (2) $A = a_1 + a_2$
(3) $A = \frac{a_1 - a_2}{2}$ (4) $A = \frac{a_1 + a_2}{2}$

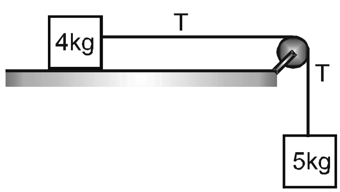
**11.** Newton's second law gives a measure of-
(1) acceleration
(2) force
(3) momentum
(4) angular momentum

**12.** When a constant force is applied to a body, it moves with uniform:
(1) acceleration
(2) velocity
(3) speed
(4) momentum

**13.** Two masses of 5 kg and 10 kg are connected to a pulley as shown. What will be the acceleration if the pulley is set free?
[$g$ = acceleration due to gravity]

(1) $g$ (2) $\frac{g}{2}$
(3) $\frac{g}{3}$ (4) $\frac{g}{4}$

**14.** bodies of 5 kg and 4 kg are tied to a string as shown in the fig. If the table and pulley both are smooth, acceleration of 5 kg body will be equal to-

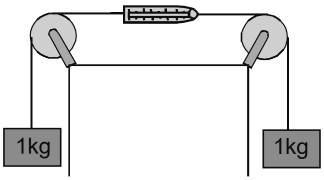



(1) g (2) $\frac{g}{4}$
(3) $\frac{4g}{9}$ (4) $\frac{5g}{9}$

**15.** A dynamometer $D$, is connected with two bodies of mass $M = 6$ kg and $m = 4$ kg. If two forces $F = 20$ N and $F = 10$ N are applied on masses according to figure then reading of the dynamometer will be (when acceleration of both blocks are same) -


(1) 10 N (2) 20 N
(3) 6 N (4) 14 N

**16.** In the given figure, what is the reading of the spring balance? (Take $g = 10$ m/s$^2$)




(1) 10 N (2) 20 N
(3) 5 N (4) Zero

**17.** The ratio of the weight of a man in a stationary lift & when it is moving downward with uniform acceleration '$a$' is 3 : 2 . The value of '$a$' is : ($g$ = acceleration. due to gravity)

(1) $(3/2)g$ (2) $g$
(3) $(2/3)g$ (4) $g/3$

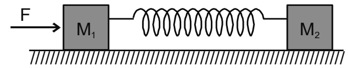
**18.** A body of mass 2 kg is hung on a spring balance mounted vertically in a lift. If the lift descends with an acceleration equal to the acceleration due to gravity 'g' the reading on the spring balance will be-

(1) 2 kg (2) 4g kg
(3) 2g kg (4) Zero

**19.** A lift is ascending with an acceleration of 2 m/sec$^2$, what will be the apparent weight of a person of 60 kg mass in it-

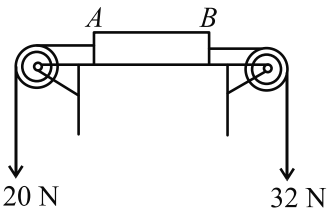
(1) 720N (2) 72N
(3) 48N (4) 480N

**20.** Two blocks of masses $M_1$ and $M_2$ are connected to each other through a light spring as shown in figure. If we push mass $M_1$ with force $F$ and cause acceleration $a_1$ in mass $M_1$, what will be the magnitude of acceleration in $M_2$?




(1) $F/M_2$ (2) $F/(M_1 + M_2)$
(3) $a_1$ (4) $(F - M_1a_1)/M_2$

**21.** Figure shows a uniform rod of mass 3 kg and of length 30 cm. The strings shown in figure are pulled by constant forces of 20 N and 32 N. The acceleration of the rod is-

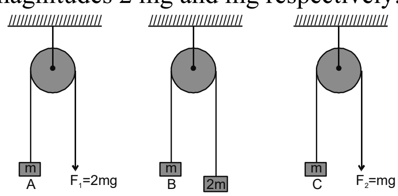



(1) 2 m/s² (2) 3m/s²
(3) 4m/s² (4) 6m/s²

**22.** A ball weighing 10 gm hits a hard surface vertically with a speed of 5m/s and rebounds with the same speed. The ball remain in contact with the surface for 0.01 sec. The average force exerted by the surface on the ball is:

(1) 100 N (2) 10 N
(3) 1 N (4) 150 N

**23.** In the figure , the blocks A , B and C of mass m each have acceleration $a_1$ , $a_2$ and $a_3$ respectively. $F_1$ and $F_2$ are external forces of magnitudes 2 mg and mg respectively.

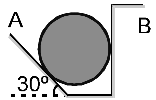



(1) $a_1 = a_2 = a_3$ (2) $a_1 > a_2 > a_3$
(3) $a_1 = a_2$ , $a_2 > a_3$ (4) $a_1 > a_2$ , $a_2 = a_3$

**24.** A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The force exerted by the wedge on the block has a magnitude.

(1) mg (2) mg/cos θ
(3) mg cosθ (4) mg tanθ

**25.** The 50 kg homogeneous smooth sphere rests on the 30º incline *A* and rests against the smooth vertical wall *B*. The contact forces at *A* and *B*. [Take $g = 10$ m/s$^2$]



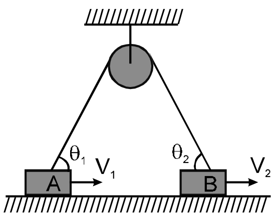

(1) $N_A = \frac{1000}{\sqrt{3}}$ N, $N_B = \frac{500}{\sqrt{3}}$ N

(2) $N_A = \frac{1000}{\sqrt{3}}$ N, $N_B = \frac{1000}{\sqrt{3}}$ N

(3) $N_A = \frac{500}{\sqrt{3}}$ N, $N_B = \frac{500}{\sqrt{3}}$ N

(4) $N_A = \frac{500}{\sqrt{3}}$ N, $N_B = \frac{400}{\sqrt{3}}$ N

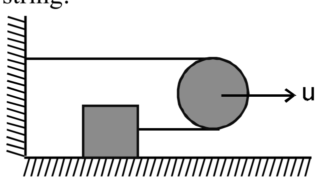
**26.** In the figure shown, blocks A and B move with velocities $v_1$ and $v_2$ along horizontal direction. The ratio of $\frac{v_1}{v_2}$




(1) $\frac{\sin\theta_2}{\sin\theta_1}$ (2) $\frac{\sin\theta_1}{\sin\theta_2}$

(3) $\frac{\cos\theta_2}{\cos\theta_1}$ (4) $\frac{\cos\theta_1}{\cos\theta_2}$

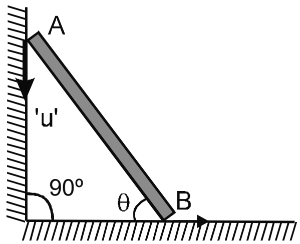
**27.** In the figure shown, the pulley is moving with velocity u. The velocity of the block attached with string:




(1) $4u$ (2) $3u$

(3) $u$ (4) $2u$

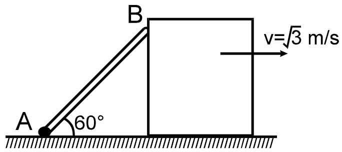
**28.** The velocity of end '*A*' of rigid rod placed between two smooth walls moves with velocity '*u*' along vertical direction. The velocity of end 'B' of that rod, rod always remains in contact with the vertical wall.




(1) $u \cot\theta$ (2) $u \tan\theta$

(3) $u \sin\theta$ (4) $u \cos\theta$

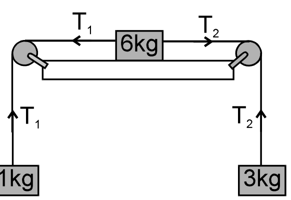
**29.** A rod AB is shown in figure. End A of the rod is fixed on the ground. Block is moving with velocity $\sqrt{3}$ m/s towards right. The velocity of end *B* of rod when rod makes an angle of 60º with the ground is:




(1) $\sqrt{3}$ m/s (2) 2 m/s

(3) $2\sqrt{3}$ m/s (4) 3 m/s

**30.** Three masses of 1 kg , 6 kg and 3 kg are connected to each other with threads and are placed on table as shown in figure. What is the acceleration with which the system is moving? Take g = 10m s$^{-2}$.



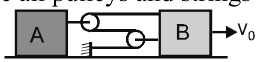

(1) Zero

(2) 1 m s$^{-2}$

(3) 2 m s$^{-2}$

(4) 3 m s$^{-2}$

**31.** Block $B$ is moving towards right with constant velocity $v_0$. Velocity of block $A$ with respect to block $B$ is-
(Assume all pulleys and strings are ideal)




(1) $\frac{v_0}{2}$ left (2) $\frac{v_0}{2}$ right

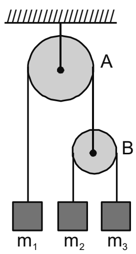
(3) $\frac{3v_0}{2}$ right (4) $\frac{3v_0}{2}$ left

**32.** Calculate the acceleration of the mass 12 kg shown in the set up of fig. Also calculate the tension in the string connecting the 12 kg mass. The string are weightless and inextensible, the pulleys are weightless and frictionless-

(1) $\frac{9}{10}, \frac{56g}{5} N$ (2) $\frac{2g}{7}, \frac{60g}{7} N$

(3) $\frac{10}{g}, \frac{5}{56g} N$ (4) $\frac{9}{14}, \frac{5}{56g} N$

**33.** In the arrangement shown in figure, pulleys are massless and frictionless and threads are inextensible. Block of mass $m_1$ will remain at rest if:



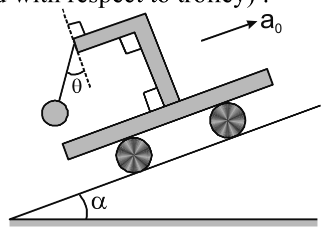

(1) $\frac{1}{m_1} = \frac{1}{m_2} + \frac{1}{m_3}$

(2) $\frac{4}{m_1} = \frac{1}{m_2} + \frac{1}{m_3}$

(3) $m_1 = m_2 + m_3$

(4) $\frac{1}{m_3} = \frac{2}{m_2} + \frac{3}{m_1}$

**34.** A pendulum of mass m hangs from a support fixed to a trolley. The direction of the string when the trolley rolls up a plane of inclination $\alpha$ with acceleration $a_0$ is (String and bob remain fixed with respect to trolley) :



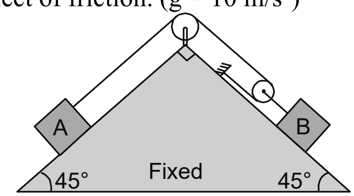

(1) $\theta = \tan^{-1} \alpha$

(2) $\theta = \tan^{-1}\left(\frac{a_0}{g}\right)$

(3) $\theta = \tan^{-1}\left(\frac{g}{a_0}\right)$

(4) $\theta = \tan^{-1}\left(\frac{a_0 + g\sin\alpha}{g\cos\alpha}\right)$

**35.** Two blocks A and B of masses 10 kg and 40 kg are connected by an ideal string as shown in the figure. Neglect the masses of the pulleys and effect of friction. ($g = 10$ m/s$^2$)



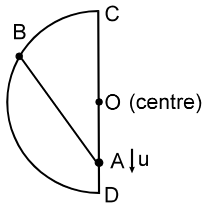

(1) The acceleration of block A is $\frac{5}{\sqrt{2}}$ ms$^{-2}$

(2) The acceleration of block B is $\frac{50}{2\sqrt{2}}$ ms$^{-2}$

(3) The tension in the string is $\frac{100}{\sqrt{2}}$ N

(4) The tension in the string is $\frac{1500}{\sqrt{2}}$ N

**36.** Two beads $A$ and $B$ move along a semicircular wire frame as shown in figure. The beads are connected by an inelastic string which always remains tight. At an instant the speed of $A$ is $u$, $\angle BAC = 45°$ and $\angle BOC = 75°$, where $O$ is the centre of the semicircular arc. The speed of bead $B$ at that instant is:




(1) $\sqrt{2}u$ (2) u

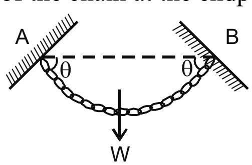
(3) $\dfrac{u}{2\sqrt{2}}$ (4) $\sqrt{\dfrac{2}{3}}u$

**37.** The acceleration of block B in the figure will be-

(1) $\dfrac{m_2 g}{(4m_1+m_2)}$ (2) $\dfrac{2m_2 g}{(4m_1+m_2)}$

(3) $\dfrac{2m_1 g}{(m_1+4m_2)}$ (4) $\dfrac{2m_1 g}{(m_1+m_2)}$

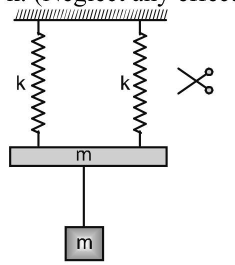
**38.** A flexible chain of weight W hangs between two fixed points A and B at the same level. The inclination of the chain with the horizontal at the two points of support is θ. What is the tension of the chain at the endpoint




(1) $\dfrac{W}{2}$ cosec θ (2) $\dfrac{W}{2}$ sec θ

(3) W cos θ (4) $\dfrac{W}{3}$ sin θ

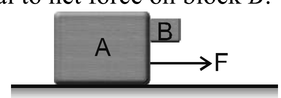
**39.** System shown in figure is in equilibrium. The magnitude of change in tension in the string just before and just after, when one of the spring is cut. Mass of both the blocks is same and equal to m and spring constant of both springs is k. (Neglect any effect of rotation)




(1) $\dfrac{mg}{2}$ (2) $\dfrac{mg}{4}$

(3) $\dfrac{3mg}{4}$ (4) $\dfrac{3mg}{2}$

**40.** **STATEMENT-1 :** Block $A$ is moving on horizontal surface towards right under action of force $F$. All surfaces are smooth. At the instant shown the force exerted by block $A$ on block $B$ is equal to net force on block $B$.




**STATEMENT-2 :** From Newton's third law, the force exerted by block $A$ on $B$ is equal in magnitude to force exerted by block $B$ on $A$.

(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1

(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1

(3) STATEMENT-1 is true, STATEMENT-2 is false

(4) STATEMENT-1 is false, STATEMENT-2 is true

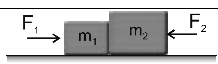
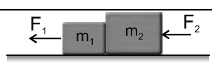
**41.** **STATEMENT–1 :** According to the Newton's third law of motion, the magnitude of the action and reaction force in an action reaction pair is same only in an inertial frame of reference.

**STATEMENT–2 :** Newton's laws of motion are applicable in every reference frame.

(1) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is correct explanation for STATEMENT-1

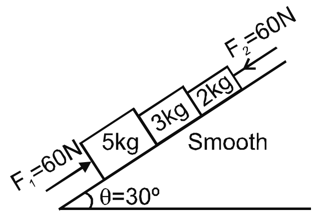
(2) STATEMENT-1 is true, STATEMENT-2 is true and STATEMENT-2 is not correct explanation for STATEMENT-1
(3) STATEMENT-1 is true, STATEMENT-2 is false
(4) STATEMENT-1 is false, STATEMENT-2 is true

**42.** Column-I gives four different situations involving two blocks of mass $m_1$ and $m_2$ placed in different ways on a smooth horizontal surface as shown. In each of the situations horizontal forces $F_1$ and $F_2$ are applied on blocks of mass $m_1$ and $m_2$ respectively and also $m_2 F_1 < m_1 F_2$. Match the statements in column I with corresponding results in column-II.

| | Column-I | | Column-II |
|---|---|---|---|
| A |  Both the blocks are connected by massless inelastic string. The magnitude of tension in the string is | p | $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_1}{m_1}-\frac{F_2}{m_2}\right)$ |
| B |  Both the blocks are connected by massless inelastic string. The magnitude of tension in the string is | q | $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_1}{m_1}+\frac{F_2}{m_2}\right)$ |
| C |  The magnitude of normal reaction between the blocks is | r | $\frac{m_1 m_2}{m_1+m_2}\left(\frac{F_2}{m_2}-\frac{F_1}{m_1}\right)$ |
| D |  The magnitude of normal reaction between the blocks is | s | $m_1 m_2\left(\frac{F_1+F_2}{m_1+m_2}\right)$ |

(1) A-p, B-q, C-r, D-s
(2) A-q, B-r, C-q, D-r
(3) A-s, B-r, C-q, D-s
(4) A-p, B-q, C-p, D-q

**43.** In the diagram shown in figure, match the following: ($g$ = 10 m/s$^2$)




| | Column-I | | Column-II |
|---|---|---|---|
| A | Acceleration of 2 kg block (in m/s$^2$) | p | 5 |
| B | Acceleration of 3 kg block (in m/s$^2$) | q | 50 |
| C | Normal reaction between 2 kg and 3 kg (in N) | r | 45 |
| D | Normal reaction between 3 kg and 5 kg (in N) | s | 60 |
| | | t | zero |

(1) (A) – p, (B) – p, (C) – s, (D) – s
(2) (A) – s, (B) – t, (C) – r, (D) – s
(3) (A) – p, (B) – q, (C) – r, (D) – s
(4) (A) – t, (B) – q, (C) – p, (D) – s

**44.** A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, When the lift is stationary. If the lift moves downward with an acceleration of 5 m/s$^2$ , the reading of the spring balance will be :
(1) 24 N  (2) 74 N
(3) 15 N  (4) 49 N

**45.** A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is :

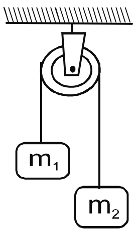
(1) $\frac{Pm}{M+m}$ (2) $\frac{Pm}{M-m}$

(3) $\frac{PM}{M-m}$ (4) $\frac{PM}{M+m}$

**46.** A light spring balance hangs from the hook of the other light spring balance and a block of mass M kg hangs from the former one. Then the true statement about the scale reading is:

(1) Both the scale read M kg each
(2) The scale of the lower one reads M kg and of the upper one zero
(3) The reading of the two scales can be anything but the sum of the reading will be M kg
(4) Both the scales read M/2 kg

**47.** Two masses $m_1 = 5$ kg and $m_2 = 4.8$ kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when system is free to move ? ($g = 9.8\ m/s^2$ )

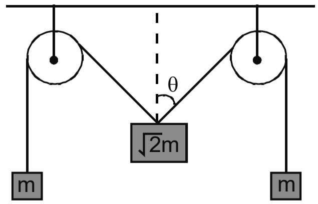



(1) $0.2\ m/s^2$ (2) $9.8\ m/s^2$
(3) $5\ m/s^2$ (4) $4.8\ m/s^2$

**48.** A ball of mass 0.2 kg is thrown vertically upwards by applying a constant force by hand. If the hand moves 0.2 m while applying the force and the ball goes upto 2m height further, find the magnitude of the force.
Consider $g = 10\ m/s^2$.

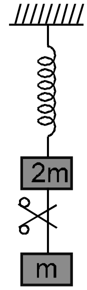
(1) 20 N (2) 22 N
(3) 4 N (4) 16 N

**49.** The pulleys and strings shown in the figure are smooth and of negligible mass for the system to remain in equilibrium, the angle θ should be



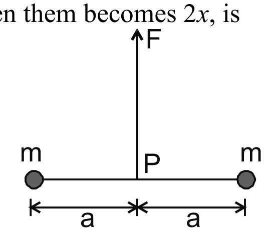

(1) 0º (2) 30º
(3) 45º (4) 60º

**50.** System shown in figure is in equilibrium and at rest. The spring and string are massless Now the string is cut. The acceleration of mass 2m and m just after the string is cut will be:




(1) g/2 upwards , g downwards
(2) g upwards, g/ 2 downwards
(3) g upwards , 2g downwards
(4) 2g upwards , g downwards

**51.** Two particles of mass $m$ each are tied at the ends of a light string of length $2a$. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance '$a$' from the centre $P$ (as shown in the figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force $F$. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes $2x$, is




(1) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ (2) $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$

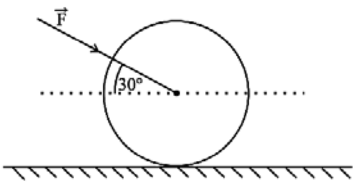
(3) $\frac{F}{2m}\frac{x}{a}$ (4) $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

**52.** A piece of wire is bent in the shape of a parabola $y = kx^2$ ($y$-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the $x$-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the $y$-axis is

(1) $\frac{a}{gk}$ (2) $\frac{a}{2gk}$

(3) $\frac{2a}{gk}$ (4) $\frac{a}{4gk}$

**53.** As shown in figure, $a$ 70kg garden roller is pushed with a force of $F = 200N$ at an angle of 30º with horizontal. The normal reaction on the roller is (Given $g = 10\ ms^{-2}$)




(1) $800\sqrt{2}\ N$ (2) $600\ N$

(3) $800\ N$ (4) $200\sqrt{3}\ N$

**54.** Given below are two statements:

**Statement-I**: An elevator can go up or down with a uniform speed when its weight is balanced with the tension of its cable.

**Statement-II**: Force exerted by the floor of an elevator on the foot of a person standing on it is more than his/ her weight when the elevator goes down with increasing speed. In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement-I and Statement-II are false
(2) Statement-I is true but Statement-II is false
(3) Both Statement-I and Statement-II are true
(4) Statement-I is false but Statement-II is true

**55.** A particle is projected with velocity $v_0$ along $x$-axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e. $F = -\alpha x^2$. The distance at which the particle stops:

(1) $\left(\frac{2v_0}{3\alpha}\right)^{\frac{1}{3}}$ (2) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{2}}$

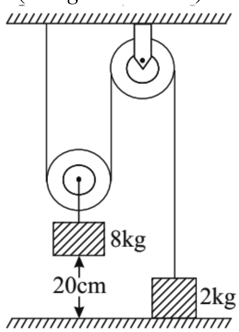
(3) $\left(\frac{2v_0^2}{3\alpha}\right)^{\frac{1}{2}}$ (4) $\left(\frac{3v_0^2 m}{2\alpha}\right)^{\frac{1}{3}}$

**56.** The time taken by an object to slide down a 45º rough inclined plane is n times as it takes to slide down a perfectly smooth 45º inclined plane. The coefficient of kinetic friction between the object and the incline plane is

(1) $\sqrt{\frac{1}{1-n^2}}$ (2) $\sqrt{1-\frac{1}{n^2}}$

(3) $1+\frac{1}{n^2}$ (4) $1-\frac{1}{n^2}$

**57.** The boxes of masses 2 $kg$ and 8 $kg$ are connected by a massless string passing over smooth pulleys. Calculate the time taken by box of mass 8 kg to strike the ground starting from rest. (use $g = 10\ m/s^2$ )



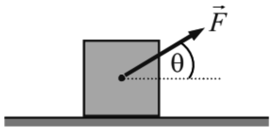

(1) 0.25 s (2) 0.4s
(3) 0.34 s (4) 0.2 s

**58.** A body of mass 10 kg is moving with an initial speed of 20 $m/s$. The body stops after 5$s$ due to friction between body and the floor. The value of the coefficient of friction is: (Take acceleration due to gravity $g = 10$ ms$^{-2}$)

(1) 0.2 (2) 0.3
(3) 0.5 (4) 0.4

**59.** A block of mass $M$ slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be:
(1) Mg
(2) $Mg\cos\theta$
(3) $\sqrt{Mg\sin\theta + Mg\cos\theta}$
(4) $Mg\sin\theta\sqrt{1+\mu}$

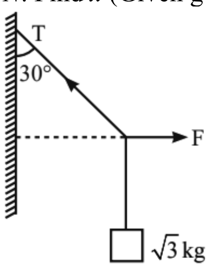
**60.** A block of mass m slides along a floor while a force of magnitude F is applied to it at an angle $\theta$ as shown in figure. The coefficient of kinetic friction is $\mu_k$. Then, the block's acceleration '$a$' is given by: ($g$ is acceleration due to gravity)




(1) $\frac{F}{m}\cos\theta + \mu_k\left(g - \frac{F}{m}\sin\theta\right)$
(2) $\frac{F}{m}\cos\theta + \mu_k\left(g + \frac{F}{m}\sin\theta\right)$
(3) $\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$
(4) $-\frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$

## *Integer Type Questions (61 to 73)*

**61.** A block of $\sqrt{3}\ kg$ is attached to a string whose other end is attached to the wall. An unknown force $F$ is applied so that the string makes an angle of 30° with the wall. The tension $T$ in the string is $x$ $N$. Find $x$ (Given g = 10 $ms^{-2}$)

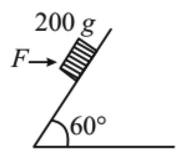



**62.** A balloon has mass of 10 $g$ in air. The air escapes from the balloon at a uniform rate with velocity 4.5 $cm/s$. If the balloon shrinks in 5 $s$ completely. Then, the average force acting on the balloon will be $x$. Find $x$ (in dyne).

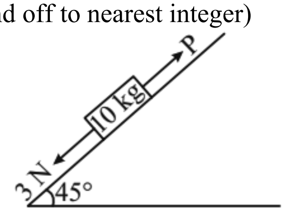
**63.** A mass of 10 kg is suspended by a rope of length 4m, from the ceiling. A force $F$ is applied horizontally at the mid-point of the rope such that the top half of the rope makes an angle of 45° with the vertical. Then $F$ equals $x$ N. (Take $g$ = 10 $ms^{-2}$ and the rope to be massless)

**64.** A body of mass '$m$' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is_________.

**65.** A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}N$ as shown in figure. The value of $x$ = ________. (Take $g$ = 10 m/s²)



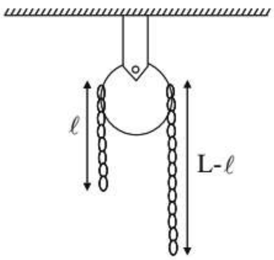

**66.** A block of mass 10 kg is kept on a rough inclined plane as shown in the figure. A force of 3 $N$ is applied on the block. The coefficient of static friction between the plane and the block is 0.6. What should be the minimum value of force $P$, (in N) such that the block does not move downward? (Take $g$ = 10 ms⁻²) (Round off to nearest integer)



**67.** A bag is gently dropped on a conveyor belt moving at a speed of 2 $m/s$. The coefficient of friction between the conveyor belt and bag is 0.4. Initially, the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion is $\frac{x}{10}$ Find $x$: [Take $g = 10\ m/s^{-2}$]

**68.** A block starts moving up an inclined plane of inclination 30º with an initial velocity of $v_0$. It comes back to its initial position with velocity $\frac{v_0}{2}$. The value of the coefficient of kinetic friction between the block and the inclined plane is close to $\frac{I}{1000}$. The nearest integer to $I$ is_______.

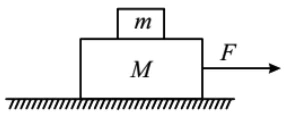
**69.** A uniform metal chain of mass m and length '$L$' passes over a massless and frictionless pulley. It is released from rest with a part of its length '$\ell$' is hanging on one side and rest of its length '$L-\ell$' is hanging on the other side of the pully. At a certain point of time, when $\ell = \frac{L}{x}$ the acceleration of the chain is $\frac{g}{2}$. The value of $x$ is_______.



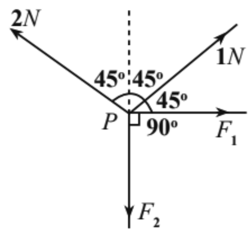

**70.** A uniform chain of 6 m length is placed on a table such that a part of its length is hanging over the edge of the table. The system is at rest. The co-efficient of static friction between the chain and the surface of the table is 0.5, the maximum length of the chain hanging from the table is _______$m$.

**71.** An insect is at the bottom of a hemispherical ditch of radius 1 m. It crawls up the ditch but starts slipping after it is at height $h$ from the bottom. If the coefficient of friction between the ground and the insect is 0.75, then $h$ is $\frac{x}{10}$ m Find $x$: ($g = 10\ ms^{-2}$)

**72.** Two blocks ($m = 0.5\ kg$ and $M = 4.5\ kg$) are arranged on a horizontal frictionless table as shown in figure. The coefficient of static friction between the two blocks is $\frac{3}{7}$. Then the maximum horizontal force that can be applied on the larger block so that the block move together is________ $N$. (Round off to the Nearest Integer) [Take $g$ as 9.8 $ms^{-2}$].




**73.** Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force $F_1$ to $F_2$ is 1 : $x$ where $x$ =__________.



# CHAPTER 04

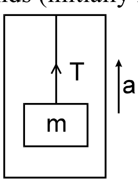
# WORK, ENERGY AND POWER

*Single Option Correct Type Questions (01 to 60)*

**1.** A man pushes wall and fails to displace it. He does
(1) Negative work
(2) Positive but not maximum work
(3) No work at all
(4) Maximum work

**2.** A rigid body of mass $m$ kg is lifted uniformly by a man to a height of one metre in 30 sec. Another man lifts the same mass uniformly to the same height in 60 sec. The work done on the body against gravitation by them are in ratio
(1) 1 : 2 (2) 1 : 1
(3) 2 : 1 (4) 4 : 1

**3.** A block of mass m is suspended by a light thread from an elevator. The elevator is accelerating upward with uniform acceleration a. The work done by tension on the block during $t$ seconds (initially lift is at rest):

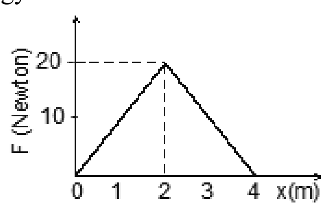



(1) $\frac{m}{2}(g+a)at^2$
(2) $\frac{m}{2}(g-a)at^2$
(3) $\frac{m}{2}gat^2$
(4) 0

**4.** Two springs have their force constant as $k_1$ and $k_2$ ($k_1 > k_2$). When they are stretched by the same force up to equilibrium -
(1) No work is done by this force in case of both the springs
(2) Equal work is done by this force in case of both the springs
(3) More work is done by this force in case of second spring
(4) More work is done by this force in case of first spring

**5.** A particle of mass $m$ at rest is acted upon by a constant force $F$ for a time $t$. Its kinetic energy after an interval $t$ is:
(1) $\frac{F^2t^2}{m}$ (2) $\frac{F^2t^2}{2m}$
(3) $\frac{F^2t^2}{3m}$ (4) $\frac{Ft}{2m}$

**6.** The graph between the resistive force $F$ acting on a body and the distance covered by the body is shown in the figure. The mass of the body is 25 kg and initial velocity is 2 m/s. When the distance covered by the body is 4 m, its kinetic energy would be




(1) 50 J (2) 40 J
(3) 20 J (4) 10 J

**7.** A heavy stone is thrown from a cliff of height $h$ with a speed $v$. The stone will hit the ground with maximum speed if it is thrown
(1) Vertically downward
(2) Vertically upward
(3) Horizontally
(4) The speed does not depend on the initial direction.

**8.** A body starts from rest with uniform acceleration and acquires a velocity $V$ in time $T$. The instantaneous kinetic energy of the body after any time $t$ is proportional to:
(1) $(v/T)\,t$ (2) $(v^2/T)t^2$
(3) $(v^2/T^2)\,t$ (4) $(v^2/T^2)t^2$

**9.** If $v$, $p$ and $E$ denote the velocity, momentum and kinetic energy of the particle, then:
(1) $p = dE/dv$ (2) $p = dE/dt$
(3) $p = dv/dt$ (4) None of these

**10.** The negative of the work done by the conservative internal forces on a system equals the change in
(1) total energy (2) kinetic energy
(3) potential energy (4) none of these

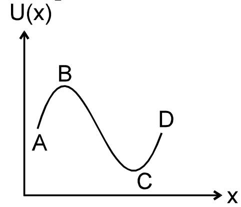
**11.** A body is dropped from a certain height. When it loses $U$ amount of its energy it acquires a velocity '$v$'. The mass of the body is:
(1) $2\,U/v^2$ (2) $2\,v/U^2$
(3) $2\,v/U$ (4) $U^2/2v$

**12.** The average power required to lift a 100 kg mass through a height of 50 metres in approximately 50 seconds would be (9.8 m/s$^2$)
(1) 50 J/s (2) 5000 J/s
(3) 100 J/s (4) 980 J/s

**13.** A block of mass $m$ is moving with a constant acceleration '$a$' on a rough horizontal plane. If the coefficient of friction between the block and plane is $\mu$. The power delivered by the external agent at $a$ time $t$ from the beginning is equal to:
(1) $ma^2t$
(2) $\mu mg\ at$
(3) $\mu m(a + \mu g)\ gt$
(4) $m(a + \mu g)\ at$

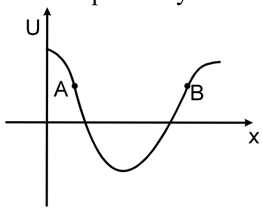
**14.** The potential energy of a particle in a field is $U = \frac{a}{r^2} - \frac{b}{r}$, where $a$ and $b$ are constant. The value of $r$ in terms of $a$ and $b$ where force on the particle is zero will be:
(1) $\frac{a}{b}$ (2) $\frac{b}{a}$
(3) $\frac{2a}{b}$ (4) $\frac{2b}{a}$

**15.** The potential energy of a particle varies with position $x$ as shown in the graph. The force acting on the particle is zero at:



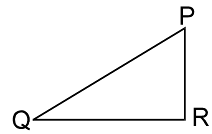

(1) $C$ only (2) $B$ only
(3) $B$ and $C$ (4) $A$ and $D$

**16.** Potential energy $v/s$ displacement curve for one dimensional conservative field is shown. Force at $A$ and $B$ is respectively.




(1) Positive, Positive
(2) Positive, Negative
(3) Negative, Positive
(4) Negative, Negative

**17.** For the path $PQR$ in a conservative force field (fig.), the amount of work done in carrying a body from $P$ to $Q$ & from $Q$ to $R$ are 5 J & 2 J respectively. The work done in carrying the body from $P$ to $R$ will be –




(1) 7 J (2) 3 J
(3) $\sqrt{21}$ J (4) Zero

**18.** The work done by the non-conservation forces only, on a system equals the change in
(1) total energy (2) kinetic energy
(3) potential energy (4) none of these

**19.** Work done by static friction on an object:
(1) may be positive (2) must be negative
(3) must be zero (4) none of these

**20.** A particle of mass $m$ is moving with speed $u$. It is stopped by a force F in distance $x$. If the stopping force is $4F$ then:
(1) work done by stopping force in second case will be same as that in first case.
(2) work done by stopping force in second case will be 2 times of that in first case.
(3) work done by stopping force in second case will be 1/2 of that in first case.
(4) work done by stopping force in second case will be 1/4 of that in first case.

**21.** Select the correct alternative.
(1) Work done by kinetic friction on a body always results in a loss of its kinetic energy.
(2) Work done on a body, in the motion of that body over a closed loop is zero for every force in nature.
(3) Total mechanical energy of a system is always conserved no matter what type of internal and external forces on the body are present.
(4) When total work done by a conservative force on the system is positive then the potential energy associated with this force decreases.

**22.** The potential energy of a particle varies with $x$ according to the relation $U(x) = x^2 - 4x$. The point $x = 2$ is a point of:
(1) stable equilibrium
(2) unstable equilibrium
(3) neutral equilibrium
(4) none of above

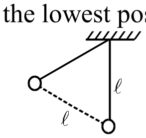
**23.** A rigid body of mass m is moving in a circle of radius r with a constant speed $v$. The force on the body is $\frac{mv^2}{r}$ and is directed towards the centre. What is the work done by this force in moving the body over half the circumference of the circle.
(1) $\frac{mv^2}{\pi r^2} J$ (2) Zero $J$
(3) $\frac{mv^2}{r^2} J$ (4) $\frac{\pi r^2}{mv^2} J$

**24.** The kinetic energy of a particle continuously increases with time
(1) the resultant force on the particle must be parallel to the velocity at all instants.
(2) the resultant force on the particle must be at an angle greater than 90° with the velocity all the time
(3) its height above the ground level must continuously decrease
(4) the magnitude of its linear momentum is increasing continuously

**25.** When total work done on a particle is positive
(1) $KE$ remains constant
(2) Momentum decreases
(3) $KE$ decreases
(4) $KE$ increases

**26.** One of the forces acting on a particle is conservative then which of the following statement(s) are true about this conservative force
(1) Its work is non zero when the particle moves exactly once around any closed path.
(2) Its work equals the change in the kinetic energy of the particle
(3) Then that particular force must be constant.
(4) Its work depends on the end points of the motion, not on the path between.

**27.** A bob hangs from a rigid support by an inextensible string of length $\ell$. If it is displaced through a distance $\ell$ (from the lowest position) keeping the string straight & then released. The speed of the bob at the lowest position is:




(1) $\sqrt{g\ell}$ m/sec (2) $\sqrt{3g\ell}$ m/sec
(3) $\sqrt{2g\ell}$ m/sec (4) $\sqrt{5g\ell}$ m/sec

**28.** Two springs $A$ and $B$ ($k_A = 2\ k_B$) are stretched by applying forces of equal magnitudes at the four ends. If the energy stored in $A$ is $E$ J that in $B$ is

(1) $E/2$ J (2) 2E J
(3) E J (4) E/4 J

**29.** **Statement-1:** A person walking on a horizontal road with a load on his head does no work on the load against gravity.

**Statement -2:** No work is said to be done, if directions of force and displacement of load are perpendicular to each other.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**30.** **Statement-1:** The instantaneous power of an agent is measured as the dot product of instantaneous velocity and the force (only one force applied by agent) acting on it at that instant.

**Statement-2:** The unit of instantaneous power is watt.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**31.** **Statement-1:** Water at the foot of the water fall is always at different temperature from that at the top.

**Statement-2:** The potential energy of water at the top is converted into heat energy (some or full part of energy) at the foot of the water fall.

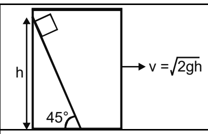
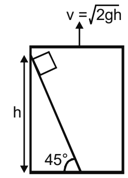
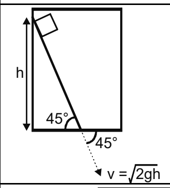
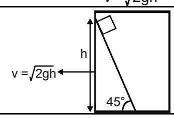
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**32.** **Statement-1:** Graph between potential energy of a spring versus the extension or compression of the spring is a straight line.

**Statement-2:** Potential energy of a stretched or compressed spring is proportional to square of extension or compression.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**33.** Figure shows four situations in which a small block of mass 'm' is released from rest (with respect to smooth fixed wedge) as shown in figure. Column-II shows work done by normal reaction on the block (with respect to an observer who is stationary on ground) till block reaches at the bottom of inclined wedge, match the appropriate column.

| **Column–I** | | **Column–II** | |
|---|---|---|---|
| I |   | P | Positive |
| II |   | Q | Negative |
| III |   | R | equal to *mgh* in magnitude |
| IV |   | S | equal to zero |

(1) I–P; II-P; III-S; IV-Q
(2) I–Q; II-P; III-S; IV-R
(3) I–Q; II-Q; III-S; IV-P
(4) I–S; II-P; III-Q; IV-R

**34.** A spring of force constant 800 N/m has an extension of 5 cm. The work done by external agent in extending it from 5 cm to 15 cm is
(1) 16 J (2) 8 J
(3) 32 J (4) 24 J

**35.** A spring of spring constant $5 \times 10^3$ N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5 cm is:
(1) 12.50 N-m (2) 18.75 N-m
(3) 25.00 N-m (4) 6.25 N-m

**36.** A uniform chain of length 2 m is kept on a table such that a length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg. What is the work done in pulling the entire chain on the table?
(1) 7.2 J (2) 3.6 J
(3) 120 J (4) 1200 J

**37.** A force $\vec{F} = (5\hat{i} + 3\hat{j} + 2\hat{k})$ N is applied over a particle which displaces it from origin to the point $\vec{r} = (2\hat{i} - \hat{j})m$. The work done on the particle in joules is:
(1) – 7 J (2) + 7 J
(3) + 10 J (4) + 13 J

**38.** A body of mass $m$ is accelerated uniformly from rest to a speed $v$ in a time $T$. The instantaneous power delivered to the body as a function of time, is given by:
(1) $\frac{mv^2}{T^2}.t$ (2) $\frac{mv^2}{T^2}.t^2$
(3) $\frac{1}{2}\frac{mv^2}{T^2}.t$ (4) $\frac{1}{2}\frac{mv^2}{T^2}.t^2$

**39.** A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. the work done by the force of gravity during the time the particle goes up is
(1) – 0.5 J (2) –1.25 J
(3) +1.25 J (4) 0.5 J

**40.** A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes upto 2 m height further, find the magnitude of the force. Consider $g = 10$ m/s$^2$
(1) 22 N (2) 4 N
(3) 16 N (4) 20 N

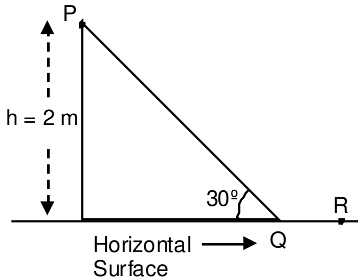
**41.** A particle is projected at 60º to the horizontal with a kinetic energy $K$. The kinetic energy at the highest point is
(1) KJ (2) Zero J
(3) K/4 J (4) K/2 J

**42.** An athlete in the Olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range (Assuming mass of athlete is between 40 kg to 100 kg)
(1) $2 \times 10^5$ J – $3 \times 10^5$ J
(2) 20,000 J – 50,000 J
(3) 2,000 J – 5,000 J
(4) 200 J – 500 J

**43.** At time $t = 0$ sec a particle starts moving along the $x$-axis. If its kinetic energy increases uniformly with time '$t$', the net force acting on it must be proportional to:
(1) Constant (2) $t$
(3) $\frac{1}{\sqrt{t}}$ (4) $\sqrt{t}$

**44.** When a rubber-band is stretched by a distance $x$, it exerts a restoring force of magnitude $F = ax + bx^2$ where $a$ and $b$ are constants. The work done in stretching the unstretched rubber-band by $L$ is:
(1) $aL^2 + bL^3$
(2) $\frac{1}{2}(aL^2 + bL^3)$
(3) $\frac{aL^2}{2} + \frac{bL^3}{3}$
(4) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

**45.** A point particle of mass $m$, moves along the uniformly rough track $PQR$ as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released, from rest, from the point $P$ and it comes to rest at a point $R$. The energies, lost by the ball, over the parts, $PQ$ and $QR$, of the track, are equal to each other, and no energy is lost when particle changes direction from $PQ$ to $QR$. The values of the coefficient of friction $\mu$ and the distance $x(= QR)$, are, respectively close to:




(1) 0.2 and 3.5 m (2) 0.29 and 3.5 m
(3) 0.29 and 6.5 m (4) 0.2 and 6.5 m

**46.** A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies $3.8 \times 10^7$ J of energy per kg which is converted to mechanical energy with a 20% efficiency rate. (Take $g = 9.8$ ms$^{-2}$)

(1) $6.45 \times 10^{-3}$ kg (2) $9.89 \times 10^{-3}$ kg
(3) $12.89 \times 10^{-3}$ kg (4) $2.45 \times 10^{-3}$ kg

**47.** A time dependent force $F = 6t$ acts on a particle of mass 1 kg. If the particle starts from rest, the work done by the force during the first 1 sec. will be:

(1) 18 J (2) 4.5 J
(3) 22 J (4) 9 J

**48.** A body of mass $m = 10^{-2}$ kg is moving in a medium and experiences a frictional force $F = -kv^2$. Its initial speed is $v_0 = 10$ ms$^{-1}$. If after 10s, its energy is $\frac{1}{8}mv_0^2$, the value of $k$ will be:

(1) $10^{-1}$ Kg m$^{-1}$s$^{-1}$
(2) $10^{-3}$ Kg m$^{-1}$
(3) $10^{-3}$ Kg s$^{-1}$
(4) $10^{-4}$ Kg m$^{-1}$

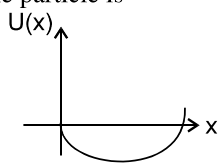
**49.** A force $\vec{F} = -K(y\hat{i} + x\hat{j})$ where $K$ is a positive constant, acts on a particle moving in the $x$-$y$ plane. Starting from the origin, the particle is taken along the positive $x$-axis to the point $(a, 0)$ and then parallel to the $y$-axis to the point $(a, a)$. The total work done by the force $\vec{F}$ on the particle is

(1) $-2Ka^2$ (2) $2Ka^2$
(3) $-Ka^2$ (4) $Ka^2$

**50.** An ideal spring with spring-constant $k$ is hung from the ceiling and a block of mass $M$ is attached to its lower end. The mass is released with the spring initially unstreched. Then the maximum extension in the spring is

(1) $4\,Mg/k$ (2) $2\,Mg/k$
(3) $Mg/k$ (4) $Mg/2k$

**51.** A particle, which is constrained to move along the $x$-axis, is subjected to a force in the same direction which varies with the distance $x$ of the particle from the origin as $F(x) = -kx + ax^3$. Here $k$ and $a$ are positive constants. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is

(1)
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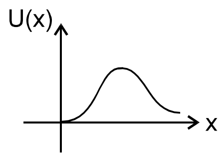


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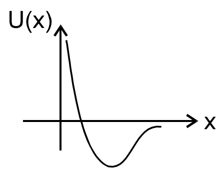


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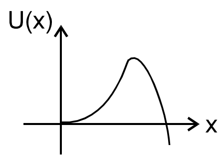
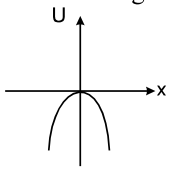
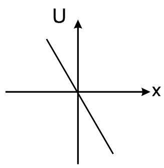
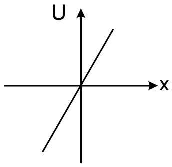
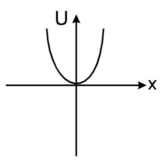


**52.** A particle moves under the influence of a force $F = kx$ in one dimensions ($k$ is a positive constant and $x$ is the distance of the particle from the origin). Assume that the potential energy of the particle at the origin is zero, the schematic diagram of the potential energy $U$ as a function of $x$ is given by

(1) 


(2) 


(3) 

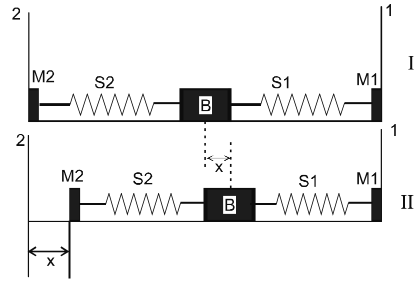

(4) 


**53.** **STATEMENT - 1:** A block of mass m starts moving on a rough horizontal surface with a velocity $v$. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of 30º with the horizontal and the same block is made to go up on the surface with the same initial velocity $v$. The decrease in the mechanical energy in the second situation is smaller than that in the first situation.

**STATEMENT-2:** The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

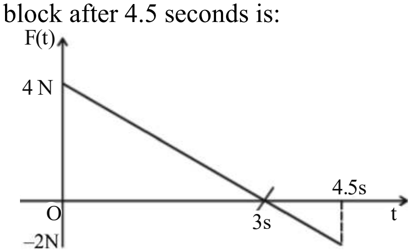
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**54.** A block (B) is attached to two unstretched springs S1 and S2 with spring constants k and 4 $k$, respectively (see figure I). The other ends are attached to identical supports M1 and M2 not attached to the walls. The springs and supports have negligible mass. There is no friction anywhere. The block B is displaced towards wall 1 by a small distance $x$ (figure II) and released. The block returns and moves a maximum distance $y$ towards wall 2. Displacements $x$ and $y$ are measured with respect to the equilibrium position of the block $B$. The ratio $\frac{y}{x}$ is




(1) 4 (2) 2
(3) $\frac{1}{2}$ (4) $\frac{1}{4}$

**55.** A block of mass 2 kg is free to move along the $x$-axis. It is at rest and from $t = 0$ onwards it is subjected to a time-dependent force $F(t)$ in the $x$-direction. The force $F(t)$ varies with $t$ as shown in the figure. The kinetic energy of the block after 4.5 seconds is:




(1) 4.50 J (2) 7.50 J
(3) 5.06 J (4) 14.06 J

**56.** The work done on a particle of mass m by a force, $K\left[\frac{x}{\left(x^2+y^2\right)^{3/2}}\hat{i}+\frac{y}{\left(x^2+y^2\right)^{3/2}}\hat{j}\right]$

($K$ being a constant of appropriate dimensions), when the particle is taken from the point $(a, 0)$ to the point $(0, a)$ along a circular path of radius a about the origin in the $x$-$y$ plane is:

(1) $\frac{2K\pi}{a}$ (2) $\frac{K\pi}{a}$
(3) $\frac{K\pi}{2a}$ (4) 0

**57.** As per the given figure, two blocks each of mass 250g are connected to a spring of spring constant 2 $Nm^{-1}$. If both are given velocity $v$ in opposite directions, then maximum elongation of the spring is:


(1) $\frac{v}{2\sqrt{2}}$ (2) $\frac{v}{2}$

(3) $\frac{v}{4}$ (4) $\frac{v}{\sqrt{2}}$

**58.** If momentum of a body is increased by 20%, then its kinetic energy increases by

(1) 36% (2) 40%

(3) 44% (4) 48%

**59.** The ratio of powers of two motors is $\frac{3\sqrt{x}}{\sqrt{x}+1}$, that are capable of raising 300 kg water in 5 minutes and 50 kg water in 2 minutes respectively from a well of 100 m deep. The value of $x$ will be:

(1) 2 (2) 4

(3) 2.4 (4) 16

**60.** An automobile of mass '$m$' accelerates starting from origin and initially at rest, while the engine supplies constant power $P$. The position is given as a function of time by:

(1) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$ (2) $\left(\frac{9P}{8m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

(3) $\left(\frac{9m}{8P}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$ (4) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{2}{3}}$

## *Integer Type Questions (61 to 75)*

**61.** If the unit of force and length each be increased by four times, then the unit of energy is increased by $n$ times, then $n$ is

**62.** A particle moves from position $\vec{r}_1 = 3\hat{i} + 2\hat{j} - 6\hat{k}$ to $\vec{r}_2 = 14\hat{i} + 13\hat{j} + 9\hat{k}$ under the action of force $4\hat{i} + \hat{j} + 3\hat{k}\,N$. The work done by this force will be $n$J then $n$ is

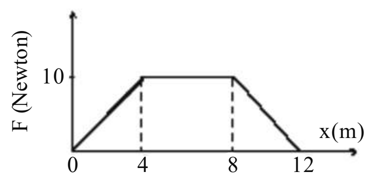
**63.** A particle moves under the effect of a force $F = Cx$ from $x = 0$ to $x = x_1$. The work done in the process is $\frac{Cx_1^2}{n}$ J then $n$ is

**64.** A force acting on a particle varies with the displacement $x$ as $F = ax - bx^2$. Where $a = 1$ N/m and $b = 1$ N/m$^2$. The work done by this force for the first one meter ($F$ is in newtons, $x$ is in meters) is $\frac{1}{n}$ J then $n$ is:

**65.** A position dependent force $F = 7 - 2x + 3x^2$ newton acts on a small body of mass 2 kg and displaces it from $x = 0$ to $x = 5$ m. The work done in joules is

**66.** The kinetic energy of a body of mass 2 kg and momentum of 2 Ns is $n$J then $n$ is:

**67.** A particle of mass 0.1 kg is subjected to a force which varies with distance as shown in figure. If it starts its journey from rest at $x = 0$, its velocity at $x = 12$ m (in m/sec) is:



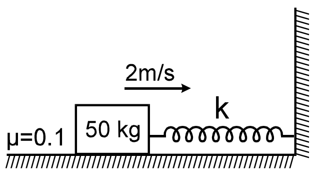

**68.** A spring when stretched by 2 mm its potential energy becomes 4 J. If it is stretched by 10 mm, its potential energy is equal to $n$J then $n$ is?

**69.** When a spring is stretched by 2 cm, it stores 100 J of energy. If it is stretched further by 2 cm, the stored energy will be increased by $n$J then $n$ is:

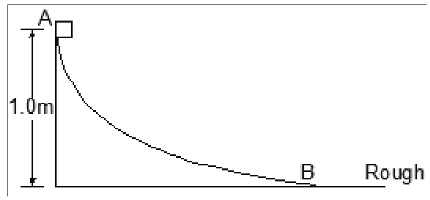
**70.** A particle moves with a velocity $\vec{v} = (5\hat{i} - 3\hat{j} + 6\hat{k})$ m/s under the influence of a constant force $\vec{F} = (10\hat{i} + 10\hat{j} + 20\hat{k})$N. The instantaneous power applied to the particle is: (in Joules)

**71.** The potential energy for a force field $\vec{F}$ is given by $U(x, y) = \sin(x + y)$. Magnitude of the force acting on the particle of mass $m$ at $\left(0, \frac{\pi}{4}\right)$ is

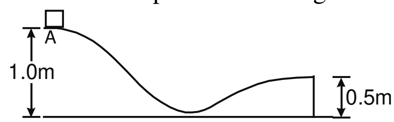
**72.** A block of mass 50 kg is projected horizontally on a rough horizontal floor. The coefficient of friction between the block and the floor is 0.1. The block strikes a light spring of stiffness $k$ = 100 N/m with a velocity 2m/s. The maximum compression of the spring is: (in $m$)




**73.** A block weighing 10 N travels down a smooth curved track $AB$ joined to a rough horizontal surface (figure). The rough surface has a friction coefficient of 0.20 with the block. If the block starts slipping on the track from a point 1.0 m above the horizontal surface, the distance it will move on the rough surface is (in meters)




**74.** Figure shows a particle sliding on a frictionless track which terminates in a straight horizontal section. If the particle starts slipping from the point $A$, how far (in meters) away from the track will the particle hit the ground?




**75.** If a body loses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate (in centimeter) more before coming to rest?

CHAPTER

05

# CIRCULAR MOTION

## Single Option Correct Type Questions (01 to 60)

**1.** Two racing cars of masses $m_1$ and $m_2$ are moving in circles of radii $r_1$ and $r_2$ respectively; their speeds are such that they each make a complete circle in the same time $t$. The ratio of the angular speed of the first to the second car is :

(1) $m_1 : m_2$ (2) $r_1 : r_2$

(3) 1 : 1 (4) $m_1r_1 : m_2r_2$

**2.** When a particle moves in a circle with a uniform speed

(1) It's velocity and acceleration are both constant

(2) It's velocity is constant but the acceleration changes

(3) It's acceleration is constant but the velocity changes

(4) It's velocity and acceleration both changes

**3.** The relation between an angular velocity, the position vector and linear velocity of a particle moving in a circular path is.

(1) $\vec{\omega}\times\vec{r}=\vec{v}$ (2) $\vec{v}\times\vec{r}=\vec{\omega}$

(3) $\vec{r}\times\vec{\omega}=\vec{v}$ (4) $\vec{\omega}\times\vec{v}=\vec{r}$

**4.** A wheel is of diameter 1m. If it makes 30 revolutions/sec., then the linear speed of a point on its circumference will be.

(1) 30π m/s (2) π m/s

(3) 60π m/s (4) π/2 m/s

**5.** A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the speed of the particle is 80 m/s at the end of the second revolution after motion has begun, the tangential acceleration is:

(1) 160 π m/s$^2$ (2) 40 π m/s$^2$

(3) 40 m/s$^2$ (4) 640 π m/s$^2$

**6.** The second's hand of a watch has length 6 cm. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be:

(1) 2π mm/s & 0 mm/s

(2) $2\sqrt{2}\pi$ mm/s & 4.44 mm/s

(3) $2\sqrt{2}\pi$ mm/s & 2π mm/s

(4) 2π mm/s & $2\sqrt{2}\pi$ mm/s

**7.** An aeroplane revolves in a circle above the surface of the earth at a fixed height with speed 100 km/hr. The magnitude of change in velocity after completing 1/2 revolution will be.

(1) 200 km/hr (2) 150 km/hr

(3) 300 km/hr (4) 400 km/hr

**8.** Two particles $P$ and $Q$ are located at distances $r_P$ and $r_Q$ respectively from the axis of a rotating disc such that $r_P > r_Q$ moving the constant angular velocity.

(1) Both $P$ and $Q$ have the same acceleration

(2) Both $P$ and $Q$ do not have any acceleration

(3) $P$ has greater acceleration than $Q$

(4) $Q$ has greater acceleration than $P$

**9.** Let $a_r$ and $a_t$ represent radial and tangential acceleration. The motion of a particle may be circular if:

(1) $a_r = 0, a_t = 0$ (2) $a_r = 0, a_t \neq 0$

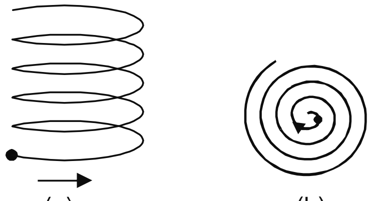
(3) $a_r \neq 0, a_t = 0$ (4) none of these

**10.** A particle of mass $m$ is executing a uniform motion along a circular path of radius $r$. If the magnitude of its linear momentum is $p$, the radial force acting on the particle will be.

(1) $pmr$ (2) $rm/p$

(3) $mp^2/r$ (4) $p^2/mr$

**11.** A particle is going in a uniform helical and spiral path separately as shown in figure with constant speed.




(1) The velocity of the particle is constant in both cases

(2) The acceleration of the particle is constant in both cases

(3) The magnitude of acceleration is constant in ($a$) and decreasing in ($b$)

(4) The magnitude of acceleration is decreasing continuously in both the cases

**12.** A car is travelling with linear velocity $v$ on a circular road of radius $r$. If the speed is increasing at the rate of '$a$' metre/sec$^2$, then the resultant acceleration will be -

(1) $\sqrt{\left[\frac{v^2}{r^2}-a^2\right]}$ m/s$^2$

(2) $\sqrt{\left[\frac{v^4}{r^2}+a^2\right]}$ m/s$^2$

(3) $\sqrt{\left[\frac{v^4}{r^2}-a^2\right]}$ m/s$^2$

(4) $\sqrt{\left[\frac{v^2}{r^2}+a^2\right]}$ m/s$^2$

**13.** A particle moving along a circular path due to a centripetal force having constant magnitude is an example of motion with:

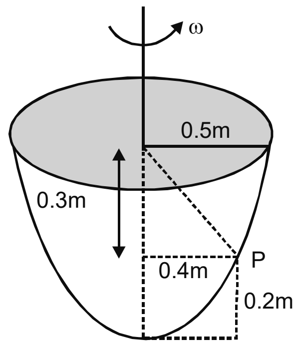
(1) constant speed and constant velocity

(2) variable speed and constant velocity

(3) variable speed and constant velocity

(4) constant speed and variable velocity.

**14.** A particle $P$ will be equilibrium inside a smooth hemispherical bowl of radius 0.5 m at a height 0.2 m from the bottom when the bowl is rotated at an angular speed ($g$ = 10 m/sec$^2$)-




(1) $10/\sqrt{3}$ rad/sec (2) $10\sqrt{3}$ rad/sec

(3) 10 rad/sec (4) $\sqrt{20}$ rad/sec

**15.** A mass is supported on a frictionless horizontal surface. It is attached to a string and rotates about a fixed centre at an angular velocity $\omega_0$. If the length of the string and angular velocity are doubled, the tension in the string which was initially $T_0$ is now -

(1) $T_0$ (2) $T_0/2$

(3) $4T_0$ (4) $8T_0$

**16.** A particle of mass $m$ is moving with constant velocity on smooth horizontal surface. A constant force $F$ starts acting on particle perpendicular to velocity $v$. Radius of curvature just after force $F$ start acting is:

(1) $\frac{mv^2}{F}$ (2) $\frac{mv^2}{F\cos\theta}$

(3) $\frac{mv^2}{F\sin\theta}$ (4) none of these

**17.** If the radii of circular paths of two particles of same masses are in the ratio of 1 : 2, then in order to have same centripetal force, their speeds should be in the ratio of :

(1) 1 : 4 (2) 4 : 1

(3) $1 : \sqrt{2}$ (4) $\sqrt{2} : 1$

**18.** A stone is projected in the vertical plane with speed $u$ and angle of projection is θ from horizontal. Find radius of curvature at $t = 0$.

(1) $\frac{u^2 \cos^2 \theta}{g}$ (2) $\frac{u^2}{g \sin \theta}$

(3) $\frac{u^2}{g \cos \theta}$ (4) $\frac{u^2 \sin^2 \theta}{g}$

**19.** A motorcycle is coming from an overbridge of radius $R$. The driver maintains a constant speed. As the motorcycle is descending on the overbridge, the normal force on it:

(1) increase

(2) decreases

(3) remains constant

(4) first increases then decreases

**20.** In a circus, stuntman rides a motorbike in a circular track of radius $R$ in the vertical plane. The minimum speed at highest point of track will be:

(1) $\sqrt{2gR}$ (2) $\sqrt{5gR}$

(3) $\sqrt{3gR}$ (4) $\sqrt{gR}$

**21.** A particle is moving in a vertical circle. The tensions in the light string when passing through two positions at angles 30° and 60° from vertical (lowest positions) are $T_1$ and $T_2$ respectively. Then

(1) $T_1 = T_2$

(2) $T_2 > T_1$

(3) $T_1 > T_2$

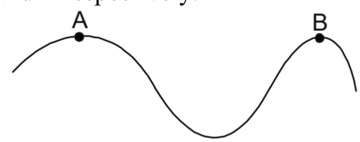
(4) Tension in the string always remains the same

**22.** A stone tied to a light string is rotated in a vertical plane. If mass of the stone is $m$, the length of the string is $r$ and the linear speed of the stone is $v$ when the stone is at its lowest point, then the tension in the string at the lowest point will be:

(1) $\frac{mv^2}{r} + mg$ (2) $\frac{mv^2}{r} - mg$

(3) $\frac{mv^2}{r}$ (4) mg

**23.** A car moves at a constant speed on a road as shown in figure. The normal force by the road on the car is $N_A$ and $N_B$ when it is at the points $A$ and $B$ respectively.




(1) $N_A = N_B$ (2) $N_A > N_B$

(3) $N_A < N_B$ (4) insufficient

**24.** A mass $m$ is revolving in a vertical circle at the end of a light string of length 20 cm. By how much times does the tension in the string at the lowest point exceed the tension at the topmost point -

(1) 2 $mg$ (2) 4 $mg$

(3) 6 $mg$ (4) 8 $mg$

**25.** A body is suspended from a smooth horizontal nail by a string of length 0.25 metre. What minimum horizontal velocity should be given to it in the lowest position so that it may move in a complete vertical circle with the nail at the centre ? (take $g = 10$ m/sec$^2$)

(1) $\sqrt{12.25}$ ms$^{-1}$ (2) 4.9 ms$^{-1}$

(3) $7\sqrt{2}$ ms$^{-1}$ (4) $\sqrt{9.8}$ ms$^{-1}$

**26.** The tension in the light string revolving in a vertical circle with a mass $m$, when it is at the highest position. (the particle just complete the circle with velocity $v$ at its lowest position)

(1) $\frac{mv^2}{r}$ (2) $\frac{mv^2}{r} - mg$

(3) $\frac{mv^2}{r} + mg$ (4) 0

**27.** A car moving on a horizontal road may be thrown out of the road in taking a turn:
(1) By the gravitational force
(2) Due to lack of sufficient centripetal force
(3) Due to normal between road and the tyre
(4) Due to reaction of earth

**28.** Centrifugal force is considered a force when observed by.
(1) An observer at the centre of circular motion
(2) An outside observer
(3) An observer who is moving with the particle which is experiencing the force
(4) none of the above

**29.** Water in a bucket is whirled in a vertical circle with a string attached to it. The water does not fall down even when the bucket is inverted at the top of its path. We conclude that in this position.
(1) $mg = \frac{mv^2}{r}$
(2) $mg$ is greater than $\frac{mv^2}{r}$
(3) $mg$ is not greater than $\frac{mv^2}{r}$
(4) $mg$ is not less than $\frac{mv^2}{r}$

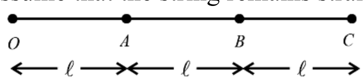
**30.** A train $A$ runs from east to west and another train $B$ of the same mass runs from west to east at the same speed along the equator. A presses the track with a force $F_1$ and $B$ presses the track with a force $F_2$.
(1) $F_1 > F_2$
(2) $F_1 < F_2$
(3) $F_1 = F_2$
(4) the information is insufficient to find the relation between $F_1$ and $F_2$.

**31.** A cyclist is moving on a circular track of radius 80 m with a velocity of constant magnitude of 72 km/hr. He has to lean from the vertical approximately through an angle.
(take $g$=10 m/s$^2$)
(1) $\tan^{-1}(1/4)$
(2) $\tan^{-1}(1)$
(3) $\tan^{-1}(1/2)$
(4) $\tan^{-1}(2)$

**32.** A car of mass $m$ is taking a circular turn of radius '$r$' on a frictional level road (coefficient friction between road and car is $\mu$) with a speed $v$. In order to that the car does not skid-
(1) $\frac{mv^2}{r} \geq \mu mg$
(2) $\frac{mv^2}{r} \leq \mu mg$
(3) $\frac{mv^2}{r} = \mu mg$
(4) $\frac{v}{r} = \mu mg$

**33.** A particle of mass $m$ is moving in a circular path of constant radius $r$ such that its centripetal acceleration $a_c$ is varying with time $t$ as $a_c = k^2 rt^2$ where $k$ is a constant. The power delivered to the particle by the force acting on it is-
(1) $2\pi mk^2 r^2$
(2) $mk^2 r^2 t$
(3) $\frac{(mk^4 r^2 t^5)}{3}$
(4) Zero

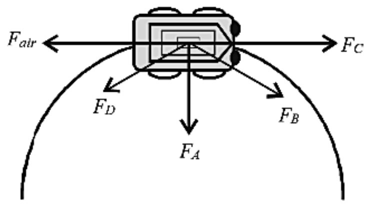
**34.** Three identical particles are joined together by a light thread as shown in figure. All the three particles are moving on a smooth horizontal plane about point $O$. If the speed of the outermost particle is $v_0$, then the ratio of tensions in the three sections of the string is: (Assume that the string remains straight)




(1) 3 : 5 : 7
(2) 3 : 4 : 5
(3) 7 : 11 : 6
(4) 3 : 5 : 6

**35.** A Toy cart attached to the end of an unstretched string of length $a$, when revolved moves on a smooth horizontal table in a circle of radius $2a$ with a time period $T$. Now the toy cart is speeded up until it moves in a circle of radius $3a$ with a period $T'$. If Hook's law holds then (Assume no friction):
(1) $T' = \sqrt{\frac{3}{2}}\,T$
(2) $T' = \left(\frac{\sqrt{3}}{2}\right)T$
(3) $T' = \left(\frac{3}{2}\right)T$
(4) $T' = T$

**36.** A car travels with constant speed on a circular road on level ground. In the figure shown, $F_{air}$ is the force of air resistance on the car. Which of the other forces best represents the horizontal force of the road on the car's tires?

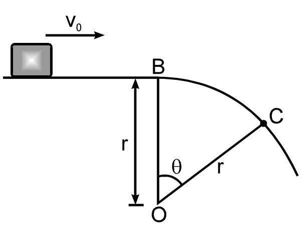



(1) $F_A$ (2) $F_B$
(3) $F_C$ (4) $F_D$

**37.** A particle is projected horizontally from the top of a tower with a velocity $v_0$. If $v$ be its velocity at any instant, then the radius of curvature of the path of the particle at that instant is directly proportional to:

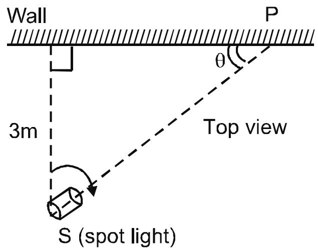
(1) $v^3$ (2) $v^2$
(3) $v$ (4) $1/v$

**38.** A small block slides with velocity $0.5\sqrt{gr}$ on the horizontal frictionless surface in the vertical plane as shown in the Figure. The block leaves the surface at point $C$. The angle θ in the Figure is:




(1) $\cos^{-1}(4/9)$
(2) $\cos^{-1}(3/4)$
(3) $\cos^{-1}(1/2)$
(4) none of the above

**39.** A spot light $S$ rotates in a horizontal plane with a constant angular velocity of 0.1 rad/s. The spot of light $P$ moves along the wall at a perpendicular distance 3 m. What is the velocity of the spot $P$ when $\theta = 45^0$?




(1) 0.6 m/s
(2) 0.5 m/s
(3) 0.4 m/s
(4) 0.3 m/s

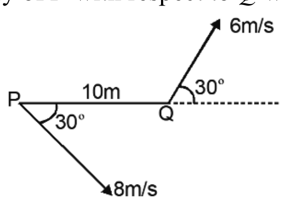
**40.** A grind-stone starts revolving from rest, if its angular acceleration is 4.0 rad/sec$^2$ (uniform) then after 4 sec. What is its angular displacement & angular velocity respectively -

(1) 32 rad, 16 rad/sec
(2) 16 rad, 32 rad/sec
(3) 64 rad, 32 rad/sec
(4) 32 rad, 64 rad/sec

**41.** A particle $P$ is moving at constant speed $v$ in a circular path of radius $a$. $C$ is the centre of circle, $AP$ is diameter then ratio of angular speed of particle $P$ with respect to $A$ and $C$ is-

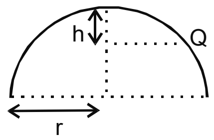
(1) 1 : 1 (2) 1 : 2
(3) 2 : 1 (4) 4 : 1

**42.** Two particles $P$ and $Q$ are at a distance of 10 m at any moment. Velocities of $P$ & $Q$ are 8 m/s and 6 m/s respectively. They make an angle of 30° with line $PQ$ as shown in fig. Angular velocity of $P$ with respect to $Q$ will be-




(1) 0 rad/s (2) 0.1 rad/s
(3) 0.4 rad/s (4) 0.7 rad/s

**43.** A small body of mass $m$ at rest, starts moving downwards from the hemisphere of radius $r$, it if leaves the hemisphere at a point that is at a distance $h$ below the vertex then-




(1) $h = r$ (2) $h = \frac{r}{3}$

(3) $h = \frac{r}{2}$ (4) $h = \frac{2r}{3}$

**44.** A gramophone recorder rotates at constant angular velocity of ω a coin is kept at a distance $r$ from its centre. If μ is static friction constant then coil will rotate with gramophone if -

(1) $r > \mu g \omega^2$ only (2) $r = \mu g/\omega^2$ only

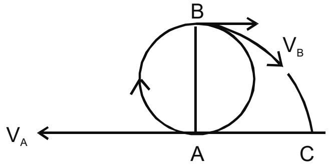
(3) $r < \mu g/\omega^2$ only (4) $r \leq \mu g/\omega^2$

**45.** A heavy & big sphere is hang with a string of length $\ell$, this sphere moves in a horizontal circular path making an angle θ with vertical then its time period is -

(1) $T = 2\pi\sqrt{\frac{\ell}{g}}$ (2) $T = 2\pi\sqrt{\frac{\ell \sin\theta}{g}}$

(3) $T = 2\pi\sqrt{\frac{\ell \cos\theta}{g}}$ (4) $T = 2\pi\sqrt{\frac{\ell}{g\cos\theta}}$

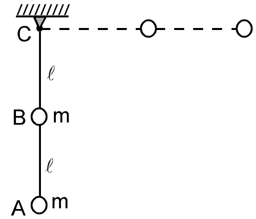
**46.** A body is tied up by a string of length $\ell$ and rotated in vertical circle at minimum speed. When it reaches at highest point, if the string being cut and the body moves on a parabolic path in presence of gravity according to fig. In the vertical plane of point $A$, value of horizontal range $AC$ will be -




(1) $x = \ell$ (2) $x = 2\ell$

(3) $x = \sqrt{2}\ell$ (4) $x = 2\sqrt{2}\,\ell$

**47.** A weightless rod of length $2\ell$ carries two equal masses '$m$', one tied at lower end $A$ and the other at the middle of the rod at $B$. The rod can rotate in vertical plane about a fixed horizontal axis passing through $C$. The rod is released from rest in horizontal position. The speed of the mass $B$ at the instant rod, become vertical is:




(1) $\sqrt{\frac{3g\ell}{5}}$ (2) $\sqrt{\frac{4g\ell}{5}}$

(3) $\sqrt{\frac{6g\ell}{5}}$ (4) $\sqrt{\frac{7g\ell}{5}}$

**48.** **STATEMENT-1:** Two small identical spheres are suspended from same point $O$ on roof with strings of different lengths. Both spheres move along horizontal circles as shown. Then both spheres may move along circles in same horizontal plane.

**STATEMENT-2:** For both spheres in Statement-1 to move in circular paths in same horizontal plane, their angular speeds must be same.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**49.** **STATEMENT-1:** A ball tied by thread is undergoing circular motion (of radius $R$) in a vertical plane. (Thread always remains in vertical plane). The difference of maximum and minimum tension in thread is independent of speed ($u$) of ball at the lowest position ($u > \sqrt{5gR}$)

**STATEMENT-2:** For a ball of mass $m$ tied by thread undergoing vertical circular motion (of radius $R$), difference in maximum and minimum kinetic energy of the ball is independent of speed ($u$) given to the ball at the lowest position ($u > \sqrt{5gR}$).

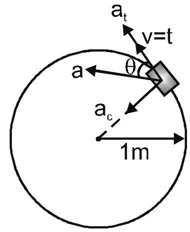
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**50.** **STATEMENT-1:** When a particle is projected at some angle ($\neq 90^\circ$) with horizontal, the radius of curvature of its path during the ascent decreases continuously.

**STATEMENT-2:** The radius of curvature is the ratio of square of magnitude of the velocity and the acceleration at that point.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**51.** A toy car is moving on a circular track of radius 1m. Speed of the car is given by $v = t$ m/s. Mass of the car is $\sqrt{2}$ kg. Match the column–I with column–II. ($g = 10$ m/s$^2$)




| Column-I | | Column-II | |
|---|---|---|---|
| I | Time (in sec.) at which resultant acceleration makes an angle of $\theta = \frac{\pi}{4}$ radian–with tangential acceleration | P | $\frac{1}{\sqrt{10}}$ |
| II | Rate of change of angle θ (shown in figure) at above instant in (A) (in rad/sec.) is. | Q | 2 |
| III | Friction force acting on the car at above instant in (A) (in newton) | R | 1 |
| IV | If car starts sliding at $t = \sqrt{3}$ sec then coefficient of friction is | S | $\sqrt{10}$ |
| | | T | $\sqrt{2}$ |

(1) I – R; II – R; III – Q; IV – P
(2) I – P; II – R; III – Q; IV – R
(3) I – R; II – P; III – Q; IV – R
(4) I – R; II – P; III – R; IV – Q

**52.** Which of the following quantities does not remain constant during the motion of an object along a curved path:
(1) speed
(2) velocity
(3) acceleration
(4) magnitude of acceleration

**53.** Assuming the motion of Earth around the Sun as a circular orbit with a constant speed of 30 km/s. (assume observation from sun).
(1) The average velocity of the earth during a period of 1 year is non-zero
(2) The average speed of the earth during a period of 1 year is zero.
(3) The average acceleration during first 6 months of the year is zero
(4) The instantaneous acceleration of the earth points towards the Sun.

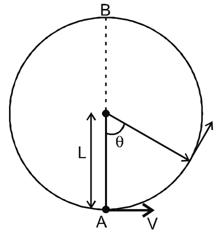
**54.** Which of the following statements is false for a particle moving in a circle with a constant angular speed?
(1) The velocity vector is tangent to the circle
(2) The acceleration vector is tangent to the circle
(3) The acceleration vector point to the center of the circle
(4) The velocity and acceleration vectors are perpendicular to each other

**55.** A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane, it follows that
(1) its velocity is constant
(2) its acceleration is constant
(3) its kinetic energy is constant
(4) it moves in a straight line

**56.** For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point $P(R, \theta)$ on the circle of radius $R$ is (Here θ is measured from the "+" $x$-axis)
(1) $-\frac{v^2}{R}\cos\theta\,\hat{i} + \frac{v^2}{R}\sin\theta\,\hat{j}$
(2) $-\frac{v^2}{R}\sin\theta\,\hat{i} + \frac{v^2}{R}\cos\theta\,\hat{j}$
(3) $-\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$
(4) $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

**57.** Two cars of masses $m_1$ and $m_2$ are moving in circles of radii $r_1$ and $r_2$, respectively. Their speeds are such that they make complete circles in the same time $t$. The ratio of their centripetal acceleration is:
(1) $m_1 r_1 : m_2 r_2$ (2) $m_1 : m_2$
(3) $r_1 : r_2$ (4) $1 : 1$

**58.** A bob of mass $M$ is suspended by a massless string of length $L$. The horizontal velocity $V$ at position $A$ is just sufficient to make it reach the point $B$. The angle θ at which the speed of the bob is half of that at $A$, satisfies




(1) $\theta = \frac{\pi}{4}$ (2) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$
(3) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ (4) $\frac{3\pi}{4} < \theta < \pi$

**59.** A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with a constant angular velocity of 0.2 rad/s. The centripetal force acting on the vehicle is:
(1) 560 N (2) 2800 N
(3) 14 N (4) 2240 N

**60.** A ball is spun with angular acceleration $\alpha = 6t^2 - 2t$ where $t$ is in second and α is in rad/s. At $t = 0$, the ball has angular velocity of 10 rad/s$^2$ and angular position of 4 rad. The most appropriate expression for the angular position of the ball is:
(1) $\frac{3}{2}t^4 - t^2 + 10t$ (2) $\frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$
(3) $\frac{2t^4}{3} - \frac{t^3}{6} + 10t + 12$ (4) $2t^4 - \frac{t^3}{2} + 5t + 4$

## *Integer Type Questions (61 to 75)*

**61.** A wheel is at rest. Its angular velocity increases uniformly and becomes 80 radian per second after 5 second. The total angular displacement is (in rad):

**62.** A stone is moved round a horizontal circle with a 20 cm long string tied to it. If centripetal acceleration is 9.8 m/sec$^2$, then its angular velocity will be (in rad/s)

**63.** A coin placed on a rotating turntable just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turntable is doubled, it will just slip at a distance of (in cm) from the centre

**64.** A stone of mass 0.5 kg tied with a string of length 1 metre is moving in a circular path with a speed of 4 m/sec. The tension acting on the string in newton is –

**65.** The breaking tension of a string is 10 N. A particle of mass 0.1 kg tied to it is rotated along a horizontal circle of radius 0.5 metre. The maximum speed (in m/s) with which the particle can be rotated without breaking the string is $x$ then $x^2$ is:

**66.** A stone of mass of 16 kg is attached to a string 144 m long and is whirled in a horizontal smooth surface. The maximum tension the string can withstand is 16 newtons. The maximum linear speed of the stone without breaking the string, will be (in m/s):

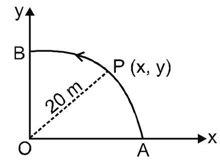
**67.** The velocity and acceleration vectors of a particle undergoing circular motion are $\vec{v} = 2\hat{i}$ m/s and $\vec{a} = 2\hat{i} + 4\hat{j}$ m/s$^2$ respectively at an instant of time. The radius of the circle is (in m)

**68.** Angular displacement (in radian) of any particle is given $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ where $\omega_0$ & $\alpha$ are constant if $\omega_0 = 1$ rad/sec, $\alpha = 1.5$ rad/sec$^2$ then in $t = 2$ sec. Angular velocity will be (in rad/sec)

**69.** A stone of 1 kg tied up with 10/3 metre long light string rotated in a vertical circle. If the ratio of maximum & minimum tension in string is 4 then speed of stone at highest point of circular path will be (in m/s)-
($g = 10$ m/s$^2$)

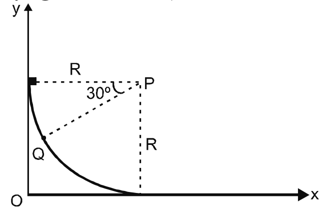
**70.** The maximum velocity (in ms$^{-1}$) with which a car driver can traverse a flat curve of radius 150 m and coefficient of friction 0.6 to avoid skidding is :

**71.** A point $P$ moves in counterclockwise direction on a circular path as shown in the figure. The movement of '$P$' is such that it sweeps out a length $s = t^3 + 5$, where $s$ is in metres and $t$ is in seconds. The radius of the path is 20 m. The acceleration of '$P$' (in m/s$^2$) at $t = 2s$. (to its nearest integer)




**72.** A ball of mass $m$ =0.5 kg is attached to the end of a string having length $L$=0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324 N. The maximum possible value of angular velocity of ball (in radian/s) is :

**73.** A small block of mass 1kg is released from rest at the top of a rough track. The track is a circular arc of radius 40m. The block slides along the track without toppling and a frictional force acts on it in the direction opposite to the instantaneous velocity. The work done by the friction up to the point $Q$, as shown in the figure below, is –150 J. (Take the acceleration due to gravity, $g = 10$ m s$^{-2}$)




The speed of the block when it reaches the point $Q$ is (in m/s) :

**74.** A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute. The magnitude of acceleration of stone is $\frac{1936}{x}$ ms$^{-2}$. The value of $x$______.
(take the value of $\pi = \frac{22}{7}$)

**75.** A body rotating with an angular speed of 600 rpm is uniformly accelerated to 1800 rpm in 10 sec. The number of rotations made in the process is______.

CHAPTER

06

# SYSTEM OF PARTICLES AND CENTRE OF MASS

*Single Option Correct Type Questions (01 to 60)*

**1.** The centre of mass of a body

(1) Lies always at the geometrical centre
(2) Lies always inside the body
(3) Lies always outside the body
(4) Lies within or outside the body

**2.** A uniform solid cone of height 40 cm is shown in figure. The distance of centre of mass of the cone from point *B* (centre of the base) is

(1) 20 cm (2) 10/3 cm
(3) 20/3 cm (4) 10 cm

**3.** If a ball is thrown upwards from the surface of earth and during upward motion

(1) The earth remains stationary while the ball moves upwards
(2) The ball remains stationary while the earth moves downwards
(3) The ball and earth both moves towards each other
(4) The ball and earth both move away from each other

**4.** Two balls are thrown in air. The acceleration of the centre of mass of the two balls while in air (neglect air resistance)

(1) depends on the direction of the motion of the balls
(2) depends on the masses of the two balls
(3) depends on the speeds of the two balls
(4) is equal to $g$

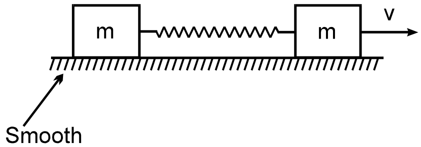
**5.** Two particles having mass ratio $n : 1$ are interconnected by a light inextensible string that passes over a smooth pulley. If the system is released, then the acceleration of the centre of mass of the system is :

(1) $(n-1)^2 g$ (2) $\left(\frac{n+1}{n-1}\right)^2 g$
(3) $\left(\frac{n-1}{n+1}\right)^2 g$ (4) $\left(\frac{n+1}{n-1}\right) g$

**6.** A man of mass '$m$' climbs on a rope of length $L$ suspended below a balloon of mass $M$. The balloon is stationary with respect to ground. If the man begins to climb up the rope at a speed $v_{rel}$ (relative to rope). In what direction and with what speed (relative to ground) will the balloon move?

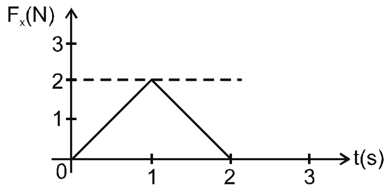
(1) downwards, $\frac{mv_{rel}}{m+M}$
(2) upwards, $\frac{Mv_{rel}}{m+M}$
(3) downwards, $\frac{mv_{rel}}{M}$
(4) downwards, $\frac{(M+m)v_{rel}}{M}$

**7.** Two masses are connected by a spring as shown in the figure. One of the masses was given velocity $v = 2k$, as shown in figure where '$k$' is the spring constant. Then maximum extension in the spring will be




(1) $2m$  (2) $m$
(3) $\sqrt{2mk}$  (4) $\sqrt{3mk}$

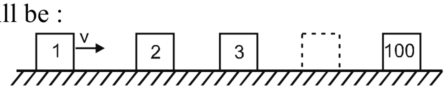
**8.** The given figure shows a plot of the time dependent force $F_x$ acting on a particle in motion along the $x$-axis. What is the total impulse delivered by this force to the particle from time $t = 0$ to $t = 2$ second?




(1) 0  (2) 1 kg-m/s
(3) 2 kg-m/s  (4) 3 kg-m/s

**9.** A block moving in air explodes in two parts then just after explosion
(1) the total momentum must be conserved
(2) the total kinetic energy of two parts must be same as that of block before explosion.
(3) the total momentum must change
(4) the total kinetic energy must not increase

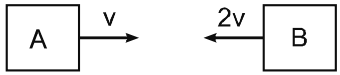
**10.** There are hundred identical sliders equally spaced on a frictionless track as shown in the figure. Initially all the sliders are at rest. Slider 1 is pushed with velocity $v$ towards slider 2. In a collision the sliders stick together. The final velocity of the set of hundred stucked sliders will be :




(1) $\frac{v}{99}$  (2) $\frac{v}{100}$
(3) zero  (4) $v$

**11.** During the head on collision of two masses 1 kg and 2 kg the maximum energy of deformation is $\frac{100}{3}J$. If before collision the masses are moving in the opposite direction, then their velocity of approach before the collision is :
(1) 10 m/sec.  (2) 5 m/sec.
(3) 20 m/sec.  (4) $10\sqrt{2}$ m/sec.

**12.** As shown a block $A$ of mass $m$ moving with a velocity '$v$' along a frictionless horizontal track and a block of mass $m/2$ moving with 2 $v$ collides with each other elastically. Final speed of the block $A$ is




(1) $\frac{5v}{3}$  (2) $v$
(3) $\frac{2v}{3}$  (4) none of these

**13.** A sphere of mass $m$ moving with a constant velocity hits another stationary sphere of the same mass. If $e$ is the coefficient of restitution, then ratio of speed of the first sphere to the speed of the second sphere after collision will be :
(1) $\left(\frac{1-e}{1+e}\right)$  (2) $\left(\frac{1+e}{1-e}\right)$
(3) $\left(\frac{e+1}{e-1}\right)$  (4) $\left(\frac{e-1}{e+1}\right)$

**14.** A skater of mass $m$ standing on ice throws a stone of mass $M$ with a velocity of $v$ in a horizontal direction. The distance over which the skater will move back (the coefficient of friction between the skater and the ice is $\mu$) :
(1) $\frac{M^2v^2}{2m\mu g}$  (2) $\frac{Mv^2}{2m^2\mu g}$
(3) $\frac{M^2v^2}{2m^2\mu g}$  (4) $\frac{M^2v^2}{2m^2\mu^2 g}$

**15.** A stationary body explodes into two fragments of masses $m_1$ and $m_2$. If momentum of one fragment is $p$, the minimum energy of explosion is

(1) $\frac{p^2}{2(m_1+m_2)}$ (2) $\frac{p^2}{2\sqrt{m_1 m_2}}$

(3) $\frac{p^2(m_1+m_2)}{2m_1 m_2}$ (4) $\frac{p^2}{2(m_1-m_2)}$

**16.** A train of mass $M$ is moving on a circular track of radius '$R$' with constant speed $V$. The length of the train is half of the perimeter of the track. The linear momentum of the train will be

(1) 0 (2) $\frac{2MV}{\pi}$

(3) $\frac{MV}{\pi}$ (4) $MV$

**17.** Two observers are situated in different inertial reference frames. Then:

(1) the momentum of a body by both observers may be same

(2) the momentum of a body measured by both observers must be same

(3) the kinetic energy measured by both observes must be same

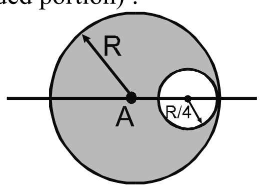
(4) none of the above

**18.** A shell is fired from a cannon with a velocity $v$ at an angle $\theta$ with the horizontal direction. At the highest point in its path, it explodes into two equal pieces, one retraces its path to the cannon and the speed of the other piece immediately after the explosion is

(1) $3v\cos\theta$ (2) $2v\cos\theta$

(3) $\left(\frac{3}{2}\right) v\cos\theta$ (4) $\frac{\sqrt{3}}{2} v\cos\theta$

**19.** The centre of mass of the shaded portion of the disc is : (The mass is uniformly distributed in the shaded portion) :




(1) $\frac{R}{20}$ to the left of $A$

(2) $\frac{R}{12}$ to the left of $A$

(3) $\frac{R}{20}$ to the right of $A$

(4) $\frac{R}{12}$ to the right of $A$

**20.** **STATEMENT-1 :** A sphere of mass $m$ moving with speed $u$ undergoes a perfectly elastic head on collision with another sphere of heavier mass $M$ at rest ($M > m$), then direction of velocity of sphere of mass $m$ is reversed due to collision [no external force acts on system of two spheres]

**STATEMENT-2:** During a collision of spheres of unequal masses, the heavier mass exerts more force on lighter mass in comparison to the force which lighter mass exerts on heavier mass.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**21.** **STATEMENT-1:** In a perfectly inelastic collision between two spheres, velocity of both spheres just after the collision are not always equal.

**STATEMENT-2:** For two spheres undergoing collision, component of velocities of both spheres along line of impact just after the collision will be equal if the collision is perfectly inelastic. The component of velocity of each sphere perpendicular to line of impact remains unchanged due to the impact.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**22.** Consider the following two statements :

A. Linear momentum of a system of particles is zero

B. Kinetic energy of a system of particles is zero, Then,

(1) A does not imply B and B does not imply A

(2) A implies B but B does not imply A

(3) A does not imply B but B implies A

(4) A implies B and B implies A

**23.** A rocket with a lift-off mass $3.5 \times 10^4$ kg is blasted upwards with an initial acceleration of 10 m/s$^2$. Then the initial thrust of the blast is: [Take $g = 10$ m/s$^2$]

(1) $3.5 \times 10^5$ N

(2) $7.0 \times 10^5$ N

(3) $14.0 \times 10^5$ N

(4) $1.75 \times 10^5$ N

**24.** A body $A$ of mass $M$ while falling vertically downwards under gravity breaks into two parts; a body $B$ of mass $\frac{1}{3}M$ and, a body $C$ of mass $\frac{2}{3}M$. The centre of mass of bodies $B$ and $C$ taken together shifts compared to projected centre of mass motion of body $A$ has it not broken apart towards

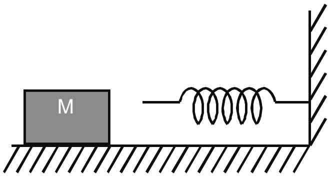
(1) depends on height of breaking

(2) does not shift

(3) shift towards body $C$

(4) shift towards body $B$

**25.** The block of mass $M$ moving on the frictionless horizontal surface collides with the spring of spring constant $k$ and compresses it by length $L$. The maximum momentum of the block after collision is




(1) $\sqrt{Mk}\,L$ (2) $\frac{kL^2}{2M}$

(3) zero (4) $\frac{ML^2}{k}$

**26.** A mass '$m$' moves with a velocity '$v$' and collides inelastically with another identical mass at rest. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion. Find the speed of the 2$^{nd}$ mass after collision :

(1) $v$ (2) $\sqrt{3}v$

(3) $\frac{2}{\sqrt{3}}v$ (4) $\frac{v}{\sqrt{3}}$

**27.** A bomb of mass 16 $kg$ at rest explodes into two pieces of masses of 4 $kg$ and 12 $kg$. The velocity of the 12 $kg$ mass is 4 $ms^{-1}$ . The kinetic energy of the other mass is

(1) 96 $J$ (2) 144 $J$

(3) 288 $J$ (4) 192 $J$

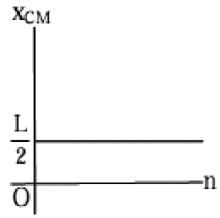
**28.** A circular disc of radius $R$ is removed from a bigger circular disc of radius $2R$ such that the circumferences of the discs coincide. The centre of mass of the new disc is $\alpha R$ from the centre of the bigger disc. The magnitude of value $\alpha$ is

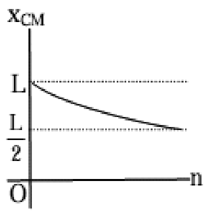
(1) 1/3 (2) 1/2

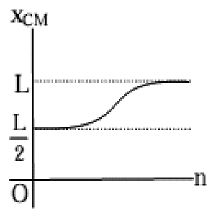
(3) 1/6 (4) 1/4

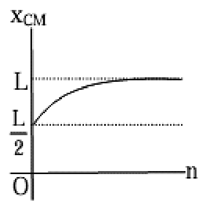
**29.** A thin rod of length '$L$' is lying along the $x$-axis with its ends at $x = 0$ and $x = L$. Its linear density (mass/length) varies with $x$ as $k\left(\frac{x}{L}\right)^n$, where $n$ can be zero or any positive number. If the position $x_{CM}$ of the centre of mass of the rod is plotted against '$n$', which of the following graphs best approximates the dependence of $x_{CM}$ on $n$?

(1)



(2) 


(3) 


(4) 


**30.** A particle of mass $m$ moving in the $x$ direction with speed $2v$ is hit by another particle of mass $2m$ moving in the $y$ direction with speed $v$. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

(1) 44% (2) 50%
(3) 56% (4) 62%

**31.** It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is $p_d$, while for its similar collision with carbon nucleus at rest, fractional loss of energy is $p_c$. The values of $p_d$ and $p_c$ are respectively:

(1) (0, 0) (2) (0, 1)
(3) (89, .28) (4) (28, .89)

**32.** The mass of a hydrogen molecule is $3.32 \times 10^{-27}$ kg. If $10^{23}$ hydrogen molecules strike, per second, a fixed wall of area 2 cm$^2$ at an angle of 45° to the normal, and rebound elastically with a speed of $10^3$ *m/s*, then the pressure on the wall is nearly

(1) $2.35 \times 10^2$ N/m$^2$
(2) $4.70 \times 10^2$ N/m$^2$
(3) $2.35 \times 10^3$ N/m$^2$
(4) $4.70 \times 10^3$ N/m$^2$

**33.** Two balls, having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p}'_1$ and $\vec{p}'_2$ be their final momenta. Which of the following option(s) is(are) **NOT ALLOWED** for any non-zero value of $p$, $a_1$, $a_2$, $b_1$, $b_2$, $c_1$ and $c_2$.

(A) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$, $\vec{p}'_2 = a_2\hat{i} + b_2\hat{j}$

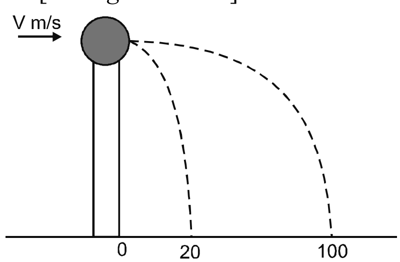
(B) $\vec{p}'_1 = c_1\hat{k}$, $\vec{p}'_2 = c_2\hat{k}$

(C) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$,
$\vec{p}'_2 = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(D) $\vec{p}'_1 = a_1\hat{i} + b_1\hat{j}$, $\vec{p}'_2 = a_2\hat{i} + b_1\hat{j}$

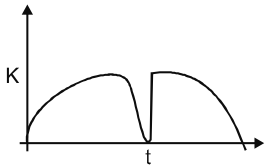
(1) (A, D) (2) (A, C)
(3) (B, C) (4) (A, B)

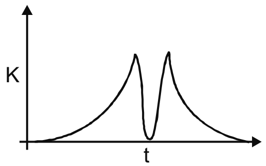
**34.** A ball of mass 0.2 *kg* rests on a vertical post of height 5 *m*. A bullet of mass 0.01 *kg*, traveling with a velocity *V m/s* in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 *m* and the bullet at a distance of 100 *m* from the foot of the post. The initial velocity *V* of the bullet is [Take $g = 10$ m/s$^2$]

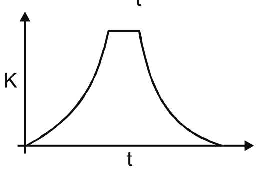


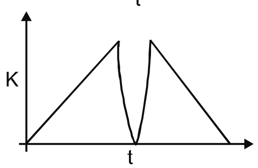

(1) 250 m/s
(2) $250\sqrt{2}$ m/s
(3) 400 m/s
(4) 500 m/s

**35.** A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy $K$ with time $t$ most appropriately? The figures are only illustrative and not to the scale.

(1) 


(2) 


(3) 


(4) 


**36.** A body has its centre of mass at the origin. The x-coordinates of the particles
(1) may be all positive
(2) may be all negative
(3) must be all non-negative
(4) may be positive for some particles and negative in other particles

**37.** A bomb travelling in a parabolic path under the effect of gravity, explodes in mid air. The centre of mass of fragments will:
(1) Move vertically upwards and then downwards
(2) Move vertically downwards
(3) Move in irregular path
(4) Move in the parabolic path which the unexploded bomb would have travelled.

**38.** Two particles $A$ and $B$ initially at rest move towards each other under a mutual force of attraction. The speed of centre of mass at the instant when the speed of $A$ is $v$ and the speed of $B$ is $2v$ is :
(1) v  (2) Zero
(3) $2v$  (4) $3v/2$

**39.** A ball of mass 50 gm is dropped from a height $h$ = 10 m. It rebounds losing 75 percent of its kinetic energy. If it remains in contact with the ground for $\Delta t$ = 0.01 sec., the impulse of the impact force is :
(1) 1.3 N–s  (2) 1.05 N-s
(3) 1300 N–s  (4) 105 N–s

**40.** A bullet of mass $m$ = 50 gm strikes a sand bag of mass $M$ = 5 kg hanging from a fixed point, with a horizontal velocity $\vec{v}_p$. If bullet sticks to the sand bag then the ratio of final & initial kinetic energy of the bullet is (approximately) :
(1) $10^{-2}$  (2) $10^{-3}$
(3) $10^{-6}$  (4) $10^{-4}$

**41.** A uniform thin rod of mass $M$ and Length $L$ is standing vertically along the y-axis on a smooth horizontal surface, with its lower end at the origin (0,0). A slight disturbance at t = 0 causes the lower end to slip on the smooth surface along the positive x-axis, and the rod starts falling. The acceleration vector of centre of mass of the rod during its fall is:
[ $\vec{R}$ is reaction from surface]
(1) $\vec{a}_{CM} = \dfrac{M\vec{g} + \vec{R}}{M}$
(2) $\vec{a}_{CM} = \dfrac{M\vec{g} - \vec{R}}{M}$
(3) $\vec{a}_{CM} = M\vec{g} - \vec{R}$
(4) None of these

**42.** A particle of mass '$m$' and velocity '$\vec{v}$' collides obliquely and elastically with a stationary particle of mass 'm'. The angle between the velocity vectors of the two particles after the collision is :
(1) 45°  (2) 30°
(3) 90°  (4) None of these

**43.** Internal forces can change :
(1) the linear momentum but not the kinetic energy of the system.
(2) the kinetic energy but not the linear momentum of the system.
(3) linear momentum as well as kinetic energy of the system.
(4) neither the linear momentum nor the kinetic energy of the system.

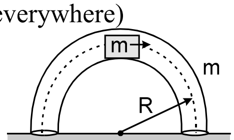
**44.** In a collision between two solid spheres, velocity of separation along the line of impact (assume no external forces act on the system of two spheres during impact) :
(1) cannot be greater than velocity of approach
(2) cannot be less than velocity of approach
(3) cannot be equal to velocity of approach
(4) none of these

**45.** Two homogenous spheres $A$ and $B$ of masses $m$ and $2m$ having radii $2a$ and $a$ respectively are placed in touch. The distance of centre of mass from centre of first sphere is :
(1) $a$ (2) $2a$
(3) $3a$ (4) none of these

**46.** If the $KE$ of a body becomes four times its initial value, then the new momentum will be more than its initial momentum by;
(1) 50% (2) 100%
(3) 125% (4) 150%

**47.** A massive ball moving with speed $v$ collides head-on with a tiny ball at rest having a mass very less than the mass of the first ball. If the collision is elastic, then immediately after the impact, the second ball will move with a speed approximately equal to:
(1) $v$ (2) $2v$
(3) $v/2$ (4) $\infty$

**48.** In a vertical plane inside a smooth hollow thin tube a block of same mass as that of tube is released as shown in figure. When it is slightly disturbed it moves towards right. By the time the block reaches the right end of the tube then magnitude of the displacement of the tube will be (where 'R' is mean radius of tube). Assume that the tube remains in vertical plane.(neglect friction everywhere)




(1) $\frac{2R}{\pi}$ (2) $\frac{4R}{\pi}$
(3) $\frac{R}{2}$ (4) $R$

**49.** A ball of mass '$m$', moving with uniform speed, collides elastically with another stationary ball. The incident ball will lose maximum kinetic energy when the mass of the stationary ball is
(1) $m$ (2) $2m$
(3) $4m$ (4) infinity

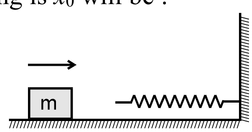
**50.** During a two body collision the area of $F$-$t$ curve is $A$, where '$F$' is the force on one mass due to the other. If one of the colliding bodies of mass $M$ is at rest initially, its speed just after the collision is :
(1) $A/M$ (2) $M/A$
(3) $AM$ (4) $\sqrt{\frac{2A}{M}}$

**51.** All the particles of a body are situated at a distance $R$ from the origin. The distance of the centre of mass of the body from the origin is
(1) $= R$ (2) $\leq R$
(3) $> R$ (4) $\geq R$

**52.** If the external forces acting on a system have zero resultant, the centre of mass
(1) must not move (2) must accelerate
(3) may move (4) may accelerate

**53.** A non–uniform thin rod of length $L$ is placed along x-axis as such its one of ends at the origin. The linear mass density of rod is $\lambda = \lambda_0 x$. The distance of centre of mass of rod from the origin is :
(1) $L/2$ (2) $2L/3$
(3) $L/4$ (4) $L/5$

**54.** In the figure shown the magnitude of change in momentum of the block when it comes to its initial position if the maximum compression of the spring is $x_0$ will be :



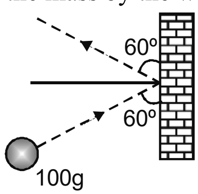

(1) $2\sqrt{km}\, x_0$ (2) $\sqrt{km}\, x_0$
(3) zero (4) none of these

**55.** A ball kept in a closed box moves in the box making collisions with the walls. The box is kept on a smooth surface. The velocity of centre of mass:
(1) of the box remains constant
(2) of the box plus the ball system remains constant
(3) of the ball remains constant
(4) of the ball relative to the box remains constant

**56.** A super-ball is to bounce elastically back and forth between two rigid walls at a distance d from each other. Neglecting gravity and assuming the velocity of super-ball to be $v_0$ horizontally, the average force being exerted by the super-ball on one wall is :
(1) $\frac{1}{2}\frac{mv_0^2}{d}$ (2) $\frac{mv_0^2}{d}$
(3) $\frac{2mv_0^2}{d}$ (4) $\frac{4mv_0^2}{d}$

**57.** Two particles of mass 1 kg and 0.5 kg are moving in the same direction with speed of 2m/s and 6m/s respectively on a smooth horizontal surface. The speed of centre of mass of the system is :
(1) $\frac{10}{3}$ m/s (2) $\frac{10}{7}$ m/s
(3) $\frac{11}{2}$ m/s (4) $\frac{12}{3}$ m/s

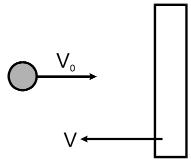
**58.** A mass of 100g strikes the wall with speed 5m/s at an angle as shown in figure and it rebounds with the same speed. If the contact time is $2 \times 10^{-3}$ sec., what is the average force applied on the mass by the wall :




(1) $250\sqrt{3}$ to right (2) 250 N to right
(3) $250\sqrt{3}$ N to left (4) 250 N to left

**59.** Two particles approach each other with different velocities. After collision, one of the particles has a momentum $\vec{p}$ in their center of mass frame. In the same frame, the momentum of the other particle is
(1) 0 (2) $-\vec{p}$
(3) $-\vec{p}/2$ (4) $-2\vec{p}$

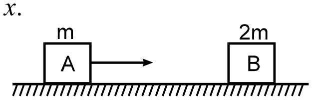
**60.** A particle of mass m moves with velocity $v_0$ = 20 m/sec towards a wall that is moving with velocity
$v$ = 5m/sec. If the particle collides with the wall elastically, the speed of the particle just after the collision is :




(1) 30 m/s (2) 20 m/s
(3) 25 m/s (4) 22 m/s

## Integer Type Questions (61 to 75)

**61.** In the figure shown the block $A$ collides head on with another block $B$ at rest. Mass of $B$ is twice the mass of $A$. The block $A$ stops after collision. The co-efficient of restitution is $\frac{1}{x}$. Find $x$.




**62.** If the force on a rocket which is ejecting gases with a relative velocity of 300 m/s, is 210 N. Then the rate of combustion of the fuel will be $\frac{x}{10}$ kg/sec. Find $x$.

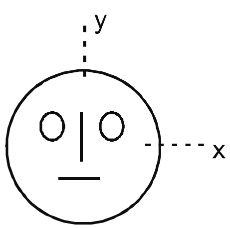
**63.** A man of mass $M$ stands at one end of a plank of length $L$ which lies at rest on a frictionless surface. The man walks to the other end of the plank. If the mass of plank is $M/3$, the distance that the plank moves relative to the ground is $\frac{xL}{4}$. Find $x$.

**64.** A block of mass 0.50 kg is moving with a speed of 2.00 $ms^{-1}$ on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is $\frac{x}{100}$ J. Find $x$ to the closed integer.

**65.** Distance of the centre of mass of a solid uniform cone from its vertex is $z_0$. If the radius of its base is $R$ and its height is h then $z_0$ is equal to $\frac{xh}{4}$. Find $x$.

**66.** In a collinear collision, a particle with an initial speed $v_0$ strikes a stationary particle of the same mass. Because of some internal source of energy if the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is $\sqrt{x}\, v_0$. Find $x$.

**67.** Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6m. The coordinates of the centres of the different parts are: outer circle (0, 0), left inner circle ($-a$, $a$), right inner circle ($a$, $a$), vertical line (0, 0) and horizontal line (0, $-a$). The y-coordinate of the centre of mass of the ink in this drawing is $\frac{a}{x}$. Find $x$.




**68.** The distance of centre of mass from end A of a one-dimensional rod ($AB$) having mass density $\lambda = \lambda_0\left(1-\frac{x^2}{L^2}\right)$ kg/m and length $L$ (in meter) is $\frac{3L}{\alpha}m$. The value of α is ________.

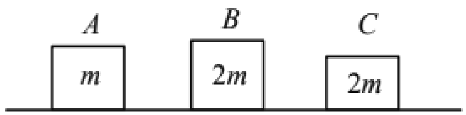
(where $x$ is the distance from end $A$)

**69.** A body $A$ of mass $m$ = 0.1 kg has an initial velocity of $3\hat{i}$ $ms^{-1}$. It collides elastically with another body $B$ of the same mass which has an initial velocity of $5\hat{j}$ $ms^{-1}$. After collision, A moves with a velocity $\vec{v} = 4(\hat{i}+\hat{j})$ m/s. The energy of $B$ after collision is written as $\frac{x}{10}J$. The value of $x$ is_____.

**70.** The position of the centre of mass of a uniform semi – circular wire of radius '$R$' placed in $x$ – $y$ plane with its centre at the origin and the line joining its ends as x-axis is given by $\left(0, \frac{xR}{\pi}\right)$. Then, the value of $|x|$ is ………..

**71.** A body of mass 2 kg moving with a speed of 4 m/s. makes an elastic collision with another body at rest and continues to move in the original direction but with one fourth of its initial speed. The speed of the centre of mass of two body is $\frac{x}{10}$ m/s. The value of $x$ is __________.

**72.** Three objects $A$, $B$ and $C$ are kept in a straight line on a frictionless horizontal surface. The masses of $A$, $B$ and $C$ are $m$, 2 $m$ and 2 $m$ respectively. A moves towards $B$ with a speed of 9 m/s and makes an elastic collision with it. Thereafter $B$ makes a completely inelastic collision with $C$. All motions occur along same straight line. The final speed of $C$ is $n$ m/s. Find $n$.



**73.** A body of mass 5 kg is moving with a momentum of 10 kg $ms^{-1}$. Now a force of 2 N acts on the body in the direction of its motion for 5s. The increase in the Kinetic energy of the body is _________J.

**74.** A man of 60 kg is running on the road and suddenly jumps into stationary trolly car of mass 120 kg. Then, the trolly car starts moving with velocity 2 $ms^{-1}$. The velocity of the running man was ____ $ms^{-1}$, when he jumps into the car: (Assume all velocities to be horizontal)

**75.** A body of mass 2 kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. The mass of the second body will be $x$ kg then find $10x$.

CHAPTER

07

# RIGID BODY MOTION

## Single Option Correct Type Questions (01 to 59)

**1.** If angular displacement of a particle moving on a curved path be given as, $\theta = 1.5t + 2t^2$, where $t$ is in sec, the angular velocity at $t = 2$ sec, will be

(1) 1.5 (2) 2.5

(3) 9.5 (4) 8.5

**2.** A wheel starts rotating from rest (with constant $\alpha$) and attains an angular velocity of 60 rad/sec in 5 seconds. The total angular displacement in radians will be

(1) 60 (2) 80

(3) 100 (4) 150

**3.** All the particles of a rigid body in a rotatory motion have:

(1) equal linear and angular velocity

(2) linear velocity equal, but angular velocity unequal

(3) equal angular velocity, but unequal linear velocity

(4) both linear and angular velocities unequal

**4.** A block hangs from a string wrapped on a disc of radius 20 cm free to rotate about its axis which is fixed in a horizontal position. If the angular speed of the disc is 10 rad/s at some instant, with what speed is the block going down at that instant?

(1) 4 m/s

(2) 3 m/s

(3) 2 m/s

(4) 5 m/s

**5.** A stone of mass 4 kg is whirled in a horizontal circle of radius 1m and makes 2 rev/sec. The moment of inertia of the stone about the axis of rotation is

(1) 64 kg $m^2$ (2) 4 kg $m^2$

(3) 16 kg $m^2$ (4) 1 kg $m^2$

**6.** Two solid spheres of same mass and radius are in contact with each other. If the moment of inertia of a sphere about its diameter is $I$, then the moment of inertia of both the spheres about the tangent at their common point would be

(1) 3 $I$ (2) 7 $I$

(3) 4 $I$ (4) 5 $I$

**7.** From the theorem of perpendicular axes. If the lamina is in $X$-$Y$ plane

(1) $I_x - I_y = I_z$

(2) $I_x + I_z = I_y$

(3) $I_x + I_y = I_z$

(4) $I_y + I_z = I_x$

**8.** A wheel of mass 10 kg has a moment of inertia of 160 kg $m^2$ about its own axis, the radius of gyration will be

(1) 10 m (2) 8 m

(3) 6 m (4) 4 m

**9.** Radius of gyration of a body depends on

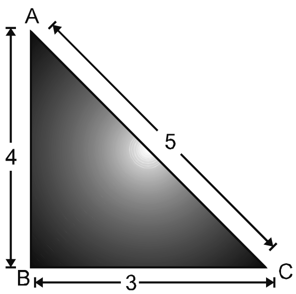
(1) Mass and size of body

(2) Mass distribution and axis of rotation

(3) Size of body

(4) Mass of body

**10.** *ABC* is a triangular plate of uniform thickness. The sides are in the ratio shown in the figure. $I_{AB}$, $I_{BC}$, $I_{CA}$ are the moments of inertia of the plate about *AB*, *BC*, *CA* respectively. Which one of the following relations is correct




(1) $I_{CA}$ is maximum (2) $I_{AB} > I_{BC}$

(3) $I_{BC} > I_{AB}$ (4) $I_{AB} + I_{BC} = I_{CA}$

**11.** The moment of inertia of a uniform semi-circular wire of mass *M* and radius *r* about a line perpendicular to the plane of the wire and passing through the centre of mass of the system is

(1) $Mr^2\left(1-\frac{4}{\pi^2}\right)$ (2) $Mr^2\left(1+\frac{4}{\pi^2}\right)$

(3) $Mr^2\left(1-\frac{\pi^2}{4}\right)$ (4) $Mr^2\left(1+\frac{\pi^2}{4}\right)$

**12.** Let $I_A$ and $I_B$ be moments of inertia of a body about two axes *A* and *B* respectively, The axis *A* passes through the centre of mass of the body but *B* does not, then

(1) $I_A < I_B$

(2) If $I_A < I_B$, the axes are parallel.

(3) If the axes are parallel, $I_A < I_B$

(4) If the axes are not parallel, $I_A \geq I_B$.

**13.** The moment of inertia of a uniform circular disc about its diameter is 200 gm cm$^2$. Then its moment of inertia about an axis passing through its center and perpendicular to its circular face is:

(1) 100 gm cm$^2$ (2) 200 gm cm$^2$

(3) 400 gm cm$^2$ (4) 1000 gm cm$^2$

**14.** A disc of radius 2m and mass 200 kg is acted upon by a torque 100 N-m about its central axis. Its angular acceleration would be

(1) 1 rad/sec$^2$

(2) 0.25 rad/sec$^2$

(3) 0.5 rad/sec$^2$

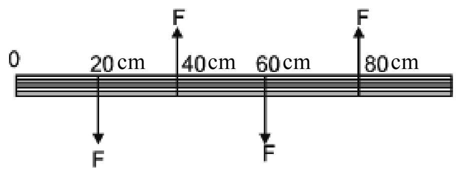
(4) 2 rad/sec$^2$

**15.** A force $F = 2\hat{i} + 3\hat{j} - \hat{k}$ acts at a point (2, –3, 1). Then magnitude of torque about point (0, 0, 2) will be:

(1) 6 (2) $3\sqrt{5}$

(3) $6\sqrt{5}$ (4) none of these

**16.** Four equal and parallel forces are acting on a rod (as shown in figure) at distances of 20 cm, 40 cm, 60 cm and 80 cm respectively from one end of the rod. Under the influence of these forces the rod:



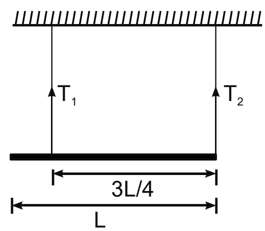

(1) Is at rest

(2) Experiences a torque

(3) Experiences a linear motion

(4) Experiences a torque and also a linear motion

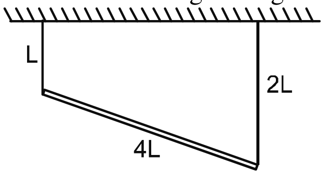
**17.** A uniform rod of mass m and length *L* is suspended with two massless strings as shown in the figure. If the rod is at rest in a horizontal position the ratio of tension in the two strings $T_1/T_2$ is:




(1) 1 : 1 (2) 1 : 2

(3) 2 : 1 (4) 4 : 3

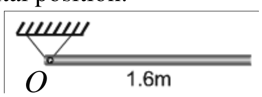
**18.** A uniform rod of length 4 $L$ and mass $M$ is suspended from a horizontal roof by two light strings of length $L$ and $2L$ as shown. Then the tension in the left string of length $L$ is




(1) $\frac{Mg}{2}$ (2) $\frac{Mg}{3}$

(3) $\frac{3}{5}$Mg (4) $\frac{Mg}{4}$

**19.** The uniform rod of mass 20 kg and length of 1.6 m is pivoted at its end and swings freely in the vertical plane. Angular acceleration of rod just after the rod is released from rest in the horizontal position.




(1) $\frac{15g}{16}$ (2) $\frac{17g}{16}$

(3) $\frac{16g}{15}$ (4) $\frac{g}{15}$

**20.** A body is rotating with constant angular velocity about a vertical axis fixed in an inertial frame. The resultant force on a particle of the body not on the axis is

(1) horizontal and skew with the axis
(2) vertical
(3) horizontal and intersecting the axis
(4) none of these.

**21.** One end of a uniform rod having mass $m$ and length $\ell$ is hinged. The rod is placed on a smooth horizontal surface and rotates on it about the hinged end at a uniform angular velocity ω. The force exerted by the hinge on the rod has a horizontal component

(1) $m\omega^2\ell$ (2) zero

(3) $mg$ (4) $\frac{1}{2}m\omega^2\ell$

**22.** A uniform metre stick is held vertically with one end on the floor hinged and is allowed to fall. The speed of the other end when it hits the floor assuming that the end at the floor does not slip:

(1) $\sqrt{4g}$ (2) $\sqrt{3g}$

(3) $\sqrt{5g}$ (4) $\sqrt{g}$

**23.** The moments of inertia of two rotating bodies $A$ and $B$ are $I_A$ and $I_B$ ($I_A > I_B$) and their angular momentum about fixed axes are equal. If their kinetic energies be $K_A$ and $K_B$, respectively, then

(1) $\frac{K_A}{K_B} > 1$ (2) $\frac{K_B}{K_A} > 1$

(3) $\frac{K_A}{K_B} = 1$ (4) $\frac{K_A}{K_B} = \frac{1}{2}$

**24.** The torque applied to a ring revolving about its own axis so as to change its angular momentum by 2 J-s. in 5 s, is

(1) 10 N-m (2) 2.5 N-m
(3) 0.1 N-m (4) 0.4 N-m

**25.** The angular speed of a body changes from $\omega_1$ to $\omega_2$ without applying a torque but due to change in its moment of inertia. The ratio of radii of gyration in the two cases is

(1) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (2) $\sqrt{\omega_1} : \sqrt{\omega_2}$

(3) $\omega_1 : \omega_2$ (4) $\omega_2 : \omega_1$

**26.** A thin circular ring of mass $M$ and radius $R$ is rotating about its axis with a constant angular velocity ω. Two objects each of mass $m$, are attached gently to the opposite ends of a diameter of the ring. The ring now rotates with an angular velocity

(1) $\frac{\omega M}{M+m}$ (2) $\frac{\omega(M-2m)}{M+2m}$

(3) $\frac{\omega M}{M+2m}$ (4) $\frac{\omega(M+2m)}{M}$

**27.** A constant torque acting on a uniform circular wheel changes its angular momentum from $A_0$ to $4A_0$ in 4 sec. the magnitude of this torque is:

(1) 4 $A_0$ (2) $A_0$
(3) $3A_0/4$ (4) $12A_0$

**28.** A particle moves with a constant velocity parallel to the $x$-axis. Its angular momentum with respect to the origin.

(1) is zero
(2) remains constant
(3) goes on increasing
(4) goes on decreasing

**29.** A particle performs uniform circular motion with an angular momentum $L$. If the frequency of particle's motion is doubled and its kinetic energy is halved, the angular momentum becomes:

(1) $2L$ (2) $4L$
(3) $L/2$ (4) $L/4$

**30.** A ring of mass 1 kg and diameter 1 m is rolling without slipping on a plane road with a speed 2m/s. Its kinetic energy would be

(1) 1 joule (2) 4 joule
(3) 2 joule (4) 0.5 joule

**31.** A solid cylinder starts rolling from a height h on an inclined plane. At some instant t, the ratio of its rotational $K.E.$ and the total $K.E.$ would be

(1) 1 : 2 (2) 1 : 3
(3) 2 : 3 (4) 1 : 1

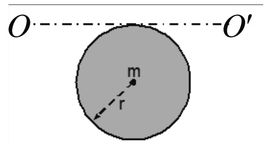
**32.** The centre of a wheel rolling without slipping in a plane surface moves with speed $V_0$. A particle on the rim of the wheel at the same level as the centre will be moving at speed

(1) zero (2) $V_0$
(3) $\sqrt{2}\, V_0$ (4) $2\, V_0$

**33.** A sphere is released on a smooth inclined plane from the top. When it moves down its angular momentum is:

(1) conserved about every point
(2) conserved about the point of contact only
(3) conserved about the centre of the sphere only
(4) conserved about any point on a fixed line parallel to the line of maximum inclination on plane and passing through the centre of the ball.

**34.** Moment of inertia of a uniform disc about $O\,O'$ is:

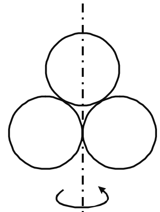



(1) $\dfrac{3\,m\,r^2}{2}$ (2) $\dfrac{m\,r^2}{2}$
(3) $\dfrac{5\,m\,r^2}{2}$ (4) $\dfrac{5\,m\,r^2}{4}$

**35.** Three identical rods, each of length $\ell$, are joined to form a rigid equilateral triangle. Its radius of gyration about an axis passing through a corner and perpendicular to the plane of the triangle is

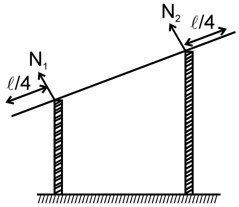
(1) $\dfrac{\ell}{\sqrt{3}}$ (2) $\dfrac{\ell}{\sqrt{2}}$
(3) $\dfrac{\ell}{\sqrt{5}}$ (4) $\dfrac{\ell}{\sqrt{7}}$

**36.** Three rings each of mass $m$ and radius $r$ are so placed that they touch each other. The radius of gyration of the system about the axis as shown in the figure is :



(1) $\sqrt{\dfrac{6}{5}}\,r$ (2) $\sqrt{\dfrac{5}{6}}\,r$
(3) $\sqrt{\dfrac{6}{7}}\,r$ (4) $\sqrt{\dfrac{7}{6}}\,r$

**37.** A uniform rod of length $\ell$ is placed symmetrically on two walls as shown in figure. The rod is in equilibrium. If $N_1$ and $N_2$ are the normal forces exerted by the walls on the rod then



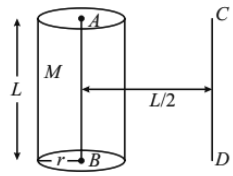

(1) $N_1 > N_2$
(2) $N_1 > N_2$
(3) $N_1 = N_2$
(4) $N_1$ and $N_2$ would be in the vertical directions

**38.** Match List–I with List–II

| List-I | | List-II | |
|---|---|---|---|
| I | Moment of inertia of solid sphere of mass M and of radius $R$ about any tangent. | P | $\frac{5}{3}MR^2$ |
| II | Moment of inertia of hollow sphere of mass M and of radius ($R$) about any tangent | Q | $\frac{7}{5}MR^2$ |
| III | Moment of inertia of circular ring of mass M and of radius ($R$) about its diameter. | R | $\frac{1}{4}MR^2$ |
| IV | Moment of inertia of circular disc of mass M and of radius ($R$) about any diameter. | S | $\frac{1}{2}MR^2$ |

Choose the correct answer from the options given below:
(1) I-Q, II-P, III-S, IV-R
(2) I-R, II-P, III-S, IV-Q
(3) I-Q, II-S, III-P, IV-R
(4) I-P, II-Q, III-S, IV-R

**39.** The solid cylinder of length 80 cm and mass M has a radius of 20 cm. Calculate the density of the material used if the moment of inertia of the cylinder about an axis CD parallel to AB as shown in figure is 2.7 kg m$^2$.




(1) $7.5 \times 10^1$ kg/m$^3$
(2) $1.49 \times 10^2$ kg/m$^3$
(3) 14.9 kg/m$^3$
(4) $7.5 \times 10^2$ kg/m$^3$

**40.** Math the following

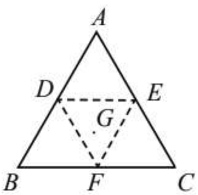
| List-I | | List-II | |
|---|---|---|---|
| I | Moment of Inertia of the rod (length $L$, Mass $M$, about an axis ⊥ to the rod Passing through the midpoint) | P | $8\,ML^2/3$ |
| II | Moment of Inertia of the rod (length $L$, Mass $2M$, about an axis ⊥ to the rod Passing through one of its end) | Q | $ML^2/12$ |
| III | Moment of Inertia of the rod (length $2L$, Mass M, about an axis ⊥ to the rod Passing through its midpoint) | R | $ML^2/12$ |
| IV | Moment of Inertia of the rod (length $2L$, Mass $2M$, about an axis ⊥ to the rod Passing through one of its end) | S | $2ML^2/3$ |

Choose the correct answer from the options given below:
(1) P-R, II - S, III-Q, IV-I
(2) I-R, II-Q, III-S, IV-P
(3) I-R, II- S, III-Q, IV-P
(4) P-R, II-Q, III-S, IV- I

**41.** A uniform sphere of mass 500 g rolls without slipping on a plane horizontal surface with its centre moving at a speed of 5.00 cm/s. Its kinetic energy is:

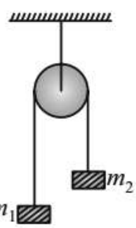
(1) $8.75 \times 10^{-4}$ J (2) $8.75 \times 10^{-3}$ J
(3) $6.25 \times 10^{-4}$ J (4) $1.13 \times 10^{-3}$ J

**42.** The equilateral triangle *ABC* is cut from a thin solid sheet of wood. (See figure) *D*, *E* and *F* are the mid points of its sides as shown and *G* is the centre of the triangle. The moment of inertia of the triangle about an axis passing through *G* and perpendicular to the plane of the triangle is $I_0$. If the smaller triangle *DEF* is removed from *ABC*, the moment of inertia of the remaining figure about the same axis is *I*. Then:




(1) $I = \frac{15}{16} I_0$ (2) $I = \frac{3}{4} I_0$
(3) $I = \frac{9}{16} I_0$ (4) $I = \frac{I_0}{4}$

**43.** A uniformly thick wheel with moment of inertia *I* and radius *R* is free to rotate about its centre of mass (see figure). A massless string is wrapped over its rim and two blocks of masses $m_1$ and $m_2$ ($m_1 > m_2$) are attached to the ends of the string. The system is released from rest. The angular speed of the wheel when $m_1$ descents by a distance *h* is:




(1) $\left[\frac{m_1 + m_2}{(m_1 + m_2)R^2 + I}\right]^{\frac{1}{2}} gh$

(2) $\left[\frac{2(m_1 - m_2)gh}{(m_1 + m_2)R^2 + I}\right]^{\frac{1}{2}}$

(3) $\left[\frac{2(m_1 + m_2)gh}{(m_1 + m_2)R^2 + I}\right]^{\frac{1}{2}}$

(4) $\left[\frac{(m_1 + m_2)gh}{(m_1 + m_2)R^2 + I}\right]^{\frac{1}{2}} gh$

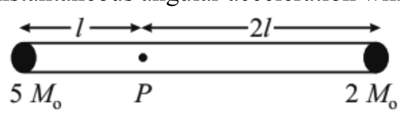
**44.** Consider a uniform wire of mass *M* and length *L*. It is bent into a semi-circle. Its moment of inertia about a line perpendicular to the plane of the wire passing through centre is:

(1) $\frac{ML^2}{\pi^2}$ (2) $\frac{2ML^2}{5\pi^2}$
(3) $\frac{ML^2}{2\pi^2}$ (4) $\frac{ML^2}{4\pi^2}$

**45.** Moment of inertia of a body about a given axis is 1.5 kg m$^2$. Initially the body is at rest. In order to produce a rotational kinetic energy of 1200 J, the angular acceleration of 20 rad/s$^2$ must be applied about the axis of rotation for a duration of:

(1) 2 s (2) 5 s
(3) 2.5 s (4) 3 s

**46.** A rigid massless road of length $3\ell$ has two masses attached at each end as shown in the figure. The rod is pivoted at point *P* on the horizontal axis (see figure). When released from initial horizontal position, its instantaneous angular acceleration will be:




(1) $\frac{g}{13l}$ (2) $\frac{g}{3l}$
(3) $\frac{g}{2l}$ (4) $\frac{7g}{3l}$

**47.** A thin circular ring of mass $M$ and radius $R$ is rotating with a constant angular velocity 2 rads$^{-1}$ in a horizontal plane about an axis vertical to its plane and passing through the centre of the ring. If two objects each of mass $m$ be attached gently to the opposite ends of a diameter of ring, the ring will then rotate with an angular velocity (in rads$^{-1}$).

(1) $\frac{M}{(M+m)}$ (2) $\frac{(M+2m)}{2M}$

(3) $\frac{2M}{(M+2m)}$ (4) $\frac{2(M+2m)}{M}$

**48.** Angular momentum of a single particle moving with constant speed along circular path:

(1) remains same in magnitude but changes in the direction

(2) changes in magnitude but remains same in the direction

(3) remains same in magnitude and direction

(4) is zero

**49.** A particle of mass $m$ is moving along a trajectory given by

$x = x_0 + a \cos \omega_1 t$

$y = y_0 + b \sin \omega_2 t$

The torque, acing on the particle about the origin, at $t = 0$ is:

(1) $my_0 a\omega_1^2 \hat{k}$

(2) $m(-x_0 b + y_0 a)\omega_1^2 \hat{k}$

(3) $-m(-x_0 b\omega_2^2 - y_0 a\omega_1^2)\hat{k}$

(4) Zero

**50.** A boy is rolling a 0.5 kg ball on the frictionless floor with the speed of 20 ms$^{-1}$. The ball gets deflected by an obstacle on the way. After deflection it moves with 5% of its initial kinetic energy. What is the speed of the ball now?

(1) 14.41 ms$^{-1}$ (2) 19.0 ms$^{-1}$

(3) 1.00 ms$^{-1}$ (4) 4.47 ms$^{-1}$

**51.** Mass per unit area of a circular disc of radius $a$ depends on the distance $r$ from its centre as $\sigma(r) = A + Br$. The moment of inertia of the disc about the axis, perpendicular to the plane passing through its centre is:

(1) $2\pi a^4\left(\frac{aA}{4}+\frac{B}{5}\right)$ (2) $2\pi a^4\left(\frac{A}{4}+\frac{aB}{5}\right)$

(3) $\pi a^4\left(\frac{A}{4}+\frac{aB}{5}\right)$ (4) $2\pi a^4\left(\frac{A}{4}+\frac{B}{5}\right)$

**52.** A thin smooth rod of length $L$ and mass $M$ is rotating freely with angular speed $\omega_0$ about an axis perpendicular to the rod and passing through its centre. Two beads of mass $m$ and negligible size are at the centre of the rod initially. The beads are free to slide along the rod. The angular speed of the system, when the beads reach the opposite ends of the rod, will be:

(1) $\frac{M\omega_0}{M+3m}$ (2) $\frac{M\omega_0}{M+m}$

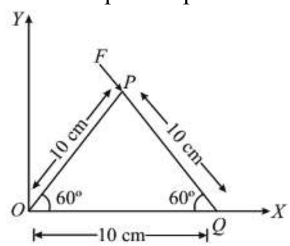
(3) $\frac{M\omega_0}{M+2m}$ (4) $\frac{M\omega_0}{M+6m}$

**53.** Let the moment of inertia of a hollow cylinder of length 30 cm (inner radius 10 cm and outer radius 20 cm), about its axis be $I$. The radius of a thin cylinder of the same mass such that its moment of inertia about its axis is also $I$, is:

(1) 12 cm (2) 15.8 cm

(3) 14 cm (4) 18 cm

**54.** A triangular plate is shown. A force $\vec{F} = 4\hat{i} - 3\hat{j}$ is applied at point $P$. The torque at point $P$ with respect to point '$O$' and '$Q$' are :




(1) $-15+20\sqrt{3},\ 15+20\sqrt{3}$

(2) $15-20\sqrt{3},\ 15+20\sqrt{3}$

(3) $15+20\sqrt{3},\ 15-20\sqrt{3}$

(4) $-15-20\sqrt{3},\ 15-20\sqrt{3}$

**55.** Four identical solid spheres each of mass '$m$' and radius '$a$' are placed with their centres on the four corners of a square of side '$b$'. The moment of inertia of the system about side of square where the axis of rotation is parallel to the plane of the square is:

(1) $\frac{4}{5}ma^2$  (2) $\frac{4}{5}ma^2 + 2mb^2$

(3) $\frac{8}{5}ma^2 + 2mb^2$  (4) $\frac{8}{5}ma^2 + mb^2$

**56.** A thin disc of mass $M$ and radius $R$ has mass per unit area $\sigma(r) = kr^2$ where $r$ is the distance from its centre. Its moment of inertia about an axis going through its centre of mass and perpendicular to its plane is:

(1) $\frac{MR^2}{2}$  (2) $\frac{MR^2}{3}$

(3) $\frac{MR^2}{6}$  (4) $\frac{2MR^2}{3}$

**57.** Two identical spherical balls of mass $M$ and radius $R$ each are stuck on two ends of a rod of length $2R$ and mass $M$ (see figure). The moment of inertia of the system about the axis passing perpendicularly through the centre of the rod is:

(1) $\frac{137}{15}MR^2$  (2) $\frac{17}{15}MR^2$

(3) $\frac{209}{15}MR^2$  (4) $\frac{152}{15}MR^2$

**58.** Two discs have moments of inertia $I_1$ and $I_2$ about their respective axes perpendicular to the plane and passing through the centre. They are rotating with angular speeds, $\omega_1$ and $\omega_2$ respectively and are brought into contact face to face with their axes of rotation coaxial having same sense of rotation. The loss in kinetic energy of the system in the process is given by:

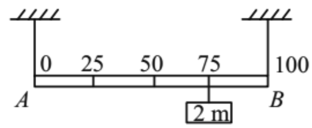
(1) $\frac{(I_1 - I_2)^2 \omega_1 \omega_2}{2(I_1 + I_2)}$

(2) $\frac{I_1 I_2}{(I_1 + I_2)}(\omega_1 - \omega_2)^2$

(3) $\frac{I_1 I_2}{2(I_1 + I_2)}(\omega_1 - \omega_2)^2$

(4) $\frac{(\omega_1 - \omega_2)^2}{2(I_1 + I_2)}$

**59.** Shown in the figure is rigid and uniform one meter long rod $AB$ held in horizontal position by two strings tied to its ends and attached to the ceiling. The rod is of mass '$m$' and has another weight of mass 2 $m$ hung at a distance of 75 cm from $A$. The tension in the string at $A$ is:




(1) 0.75 $mg$  (2) 1 $mg$

(3) 2 $mg$  (4) 0.5 $mg$

## *Integer Type Questions (60 to 74)*

**60.** The angular speed of truck wheel is increased from 900 rpm to 2460 rpm in 26 seconds. The number of revolutions by the truck engine during this time is ________ (Assuming the acceleration to be uniform).

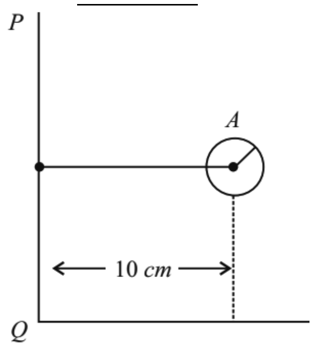
**61.** A uniform solid cylinder with radius R and length L has moment of inertia $I_1$, about the axis of cylinder. A concentric solid cylinder of radius $R' = \frac{R}{2}$ and length $L' = \frac{L}{2}$ is carved out of the original cylinder. If $I_2$ is the moment of inertia of the carved out portion of the cylinder then $\frac{I_1}{I_2}$ = (Both $I_1$ and $I_2$ are about the axis of the cylinder)

**62.** Moment of inertia of a disc of mass $M$ and radius '$R$' about any of its diameter is $\frac{MR^2}{4}$. The moment of inertia of this disc about an axis normal to the disc and passing through a point on its edge will be, $\frac{x}{2}MR^2$. The value of $x$ is ________.

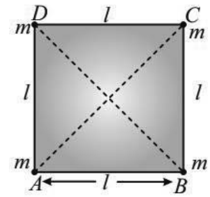
**63.** Two discs of same mass and different radii are made of different materials such that their thicknesses are 1 cm and 0.5 cm respectively. The densities of materials are in the ratio 3 : 5. The moment of inertia of these discs respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of $x$ is

**64.** A solid sphere and a solid cylinder of same mass and radius are rotating about their central axes respectively. The ratio of their radius of gyrations respectively $(K_{sph} : K_{cyl})$ is $2 : \sqrt{x}$, then value of $x$ is_______.

**65.** Solid sphere $A$ is rotating about an axis $PQ$. If the radius of the sphere is 5 cm then its radius of gyration about $PQ$ will be $\sqrt{x}$ cm. The value of $x$ is _________.




**66.** Four equal masses, $m$ each are placed at the corners of a square of length ($l$) as shown in the figure. The moment of inertia of the system about an axis passing through $A$ and parallel to $DB$ would be $x\,ml^2$. Value of $x$ is equal to



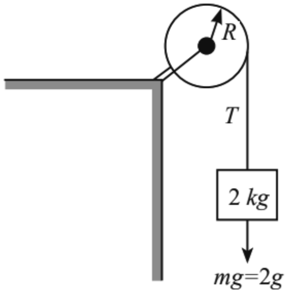

**67.** A circular disc of mass $M$ and radius $R$ is rotating about its axis with angular speed $\omega_1$. If another stationary disc having radius $\frac{R}{2}$ and same mass $M$ is dropped co-axially on to the rotating disc. Gradually both discs attain constant angular speed $\omega_2$. The energy lost in the process is $p$% of the initial energy. Value of $p$ is _______.

**68.** A cord is wound round the circumference of wheel of radius $r$. The axis of the wheel is horizontal and the moment of inertia about it is $I$. A weight mg is attached to the cord at the end. The weight falls from rest. After falling through a distance '$h$', the square of angular velocity of wheel is $\sqrt{\frac{n\,mgh}{I + mr^2}}$ then $n$ is:

**69.** A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is $7 \times 10^{-3}$ J. The speed of the centre of mass of the sphere is ________ cm s$^{-1}$.

**70.** A pulley of radius 1.5 m is rotated about its axis by a force $F = (12t - 3t^2)$ N applied tangentially (while $t$ is measured in seconds). If moment of inertia of the pulley about its axis of rotation is 4.5 kg m$^2$, the number of rotations made by the pulley before its direction of motion is reversed, will be $\frac{K}{\pi}$. The value of $K$ is

**71.** A uniform disc with mass $M = 4$ kg and radius $R = 10$ cm is mounted on a fixed horizontal axle as shown in figure. A block with mass $m = 2$ kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the block, the cord does not slip and there is no friction at the axle. The tension in the cord is _______N. (Take $g = 10$ ms$^{-2}$)




**72.** A particle of mass 'm' is moving in time '$t$' on a trajectory given by

$\vec{r} = 10\alpha t^2\hat{i} + 5\beta(t-5)\hat{j}$

Where $\alpha$ and $\beta$ are dimensional constants.

The angular momentum of the particle become the same as it was for $t = 0$ at time $t =$ _____ seconds.

**73.** A force of $-P\hat{k}$ acts on the origin of the coordinate system. The torque about the point $(2, -3)$ is $P(a\hat{i} + b\hat{j})$, the ratio of $\frac{a}{b}$ is $\frac{x}{2}$. The value of $x$ is

**74.** A light rope is wound around a hollow cylinder of mass 5 kg and radius 70 cm. The rope is pulled with a force of 52.5 N. The angular acceleration of the cylinder will be ________ rad $s^{-2}$.

CHAPTER

08

# GRAVITATION

## Single Option Correct Type Questions (01 to 58)

**1.** A mass $M$ splits into two parts $m$ and $(M - m)$, which are then separated by a certain distance. What ratio (M/m) maximise the gravitational force between the parts ?

(1) $\frac{2}{3}$ (2) $\frac{3}{4}$

(3) 2 (4) $\frac{1}{3}$

**2.** Two bodies of mass 100 kg and $10^4$ kg are lying one meter apart. At distance $x$ from 100 kg body will the intensity of gravitational field be zero. Find the value of $1/x$.

(1) $\frac{1}{9}$ m (2) $\frac{1}{10}$ m

(3) $\frac{1}{11}$ m (4) $\frac{10}{11}$ m

**3.** Two bodies of mass $10^2$ kg and $10^3$ kg are lying 1m apart. The gravitational potential at the mid-point of the line joining them is

(1) 0

(2) –1.47 J/kg

(3) 1.47 J/kg

(4) $-147 \times 10^{-9}$ J/kg

**4.** An object is placed at a distance of $R/2$ from the centre of earth. Knowing mass is distributed uniformly, acceleration of that object due to gravity at that point is: (g = acceleration due to gravity on the surface of earth and $R$ is the radius of earth)

(1) $g$ (2) $2g$

(3) $g/2$ (4) none of these

**5.** On a planet (whose size is the same as that of earth and mass 4 times to the earth) the energy needed to lift a 2kg mass vertically upwards through 2m distance on the planet is (g = 10m/sec$^2$ on surface of earth)

(1) 16 J (2) 32 J

(3) 160 J (4) 320 J

**6.** If g is the acceleration due to gravity on the earth's surface, the gain in P.E. of an object of mass m raised from the surface of the earth to a height of the radius $R$ of the earth is

(1) $mgR$ (2) $2mgR$

(3) $\frac{1}{2}mgR$ (4) $\frac{1}{4}mgR$

**7.** A satellite is in a circular orbit around the earth has kinetic energy $E_k$. Minimum amount of energy that is added so that it escapes the earth's gravitational field is:

(1) $E_k$ (2) $E_k/$

(3) $E_k/4$ (4) $2E_k$

**8.** Two satellites $S_1$ and $S_2$ revolve round a planet in the same direction in circular orbits. Their period of revolution are 1 hour and 8 hour respectively. The radius of $S_1$ is $10^4$ km. The velocity of $S_2$ with respect to $S_1$ will be

(1) $\pi \times 10^4$ km/hr

(2) $\pi/3 \times 10^4$ km/hr

(3) $2\pi \times 10^4$ km/hr

(4) $\pi/2 \times 10^4$ km/hr

**9.** In the above example the angular speed of $S_2$ as actually observed by an astronaut in $S_1$ is

(1) $\pi/3$ rad/hr (2) $\pi/3$ rad/sec

(3) $\pi/6$ rad/hr (4) $2\pi/7$ rad/hr

**10.** The mass and radius of earth and moon are $M_1$, $R_1$ and $M_2$, $R_2$ respectively. Their centres are $d$ distance apart. With what velocity should a particle of mass $m$ be projected from the midpoint of their centres so that it may escape out to infinity.

(1) $\sqrt{\dfrac{G(M_1+M_2)}{d}}$

(2) $\sqrt{\dfrac{2G(M_1+M_2)}{d}}$

(3) $\sqrt{\dfrac{4G(M_1+M_2)}{d}}$

(4) $\sqrt{\dfrac{GM_1M_2}{d}}$

**11.** A satellite is moving round the earth. In order to make it move to infinity, its velocity must be increased by

(1) 20%

(2) it is impossible to do so

(3) 82.8%

(4) 41.4%

**12.** Let gravitation field in a space be given as $E = -(k/r)$. If the reference point is at $d_i$ where potential is $V_i$ then relation for potential is:

(1) $V = k \log \dfrac{1}{V_i} + 0$

(2) $V = k \log \dfrac{r}{d_i} + V_i$

(3) $V = \log \dfrac{r}{d_i} + kV_i$

(4) $V = \log \dfrac{r}{d_i} + \dfrac{V_i}{k}$

**13.** A very large number of particles of same mass $M$ are kept at horizontal distances of 1m, 2m, 4m, 8m and so on from (0,0) point. The total gravitational potential at this point is :

(1) $-8GM$

(2) $-3G$M

(3) $-4GM$

(4) $-2GM$

**14.** Which of the following quantity is conserved for a satellite revolving around the earth in particular orbit?

(1) Angular velocity about earth

(2) Force

(3) angular momentum about earth

(4) Velocity

**15.** Acceleration due to gravity on a planet is 10 times the value on the earth. Escape velocity for the planet and the earth are $v_p$ and $v_e$ respectively Assuming that the radii of the planet and the earth are the same, then

(1) $v_P = 10\, v_e$

(2) $v_P = \sqrt{10}\, v_e$

(3) $v_P = \dfrac{v_e}{\sqrt{10}}$

(4) $v_P = \dfrac{v_e}{10}$

**16.** The escape velocity from a planet is $v_0$. The escape velocity from a planet having twice the radius but same density will be

(1) $0.5\, v_0$

(2) $v_0$

(3) $2v_0$

(4) $4v_0$

**17.** A body starts from rest at a point, distance $R_0$ from the centre of the earth of mass $M$, radius $R$. The velocity acquired by the body when it reaches the surface of the earth will be

(1) $GM\left(\dfrac{1}{R}-\dfrac{1}{R_0}\right)$

(2) $2\,GM\left(\dfrac{1}{R}-\dfrac{1}{R_0}\right)$

(3) $\sqrt{2GM\left(\dfrac{1}{R}-\dfrac{1}{R_0}\right)}$

(4) $2GM\sqrt{\left(\dfrac{1}{R}-\dfrac{1}{R_0}\right)}$

**18.** Three equal masses each of mass '$m$' are placed at the three-corners of an equilateral triangle of side '$a$'. If a fourth particle of equal mass is placed at the centre of triangle, then net force acting on it, is equal to :

(1) $\dfrac{Gm^2}{a^2}$

(2) $\dfrac{4Gm^2}{3a^2}$

(3) $\dfrac{3Gm^2}{a^2}$

(4) zero

**19.** Periodic-time of satellite revolving around the earth is - (ρ is density of earth)

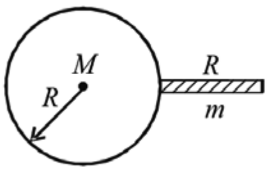
(1) Proportional to $\frac{1}{\rho}$

(2) Proportional to $\frac{1}{\sqrt{\rho}}$

(3) Proportional ρ

(4) does not depend on ρ.

**20.** A uniform thin rod of mass m and length $R$ is placed normally on surface of earth as shown. The mass of earth is $M$ and its radius is $R$. Then the magnitude of gravitational force exerted by earth on the rod is η find η.




(1) $\frac{GMm}{2R^2}$ (2) $\frac{GMm}{4R^2}$

(3) $\frac{4GMm}{9R^2}$ (4) $\frac{GMm}{8R^2}$

**21.** Altitude at which acceleration due to gravity decreases by 0.1% approximately: (Radius of earth = 6400 km)

(1) 3.2 km (2) 6.4 km

(3) 2.4 km (4) 1.6 km

**22.** An object is projected vertically up from the earth's surface with velocity $\sqrt{Rg}$ where $R$ is the radius of the earth and '$g$' is the acceleration due to earth on the surface of earth. The maximum height reached by the object.

(1) $R$ (2) $2R$

(3) $3R$ (4) $4R$

**23.** Time period of a simple pendulum on the equator is $T_1$ and at the pole is $T_2$. Then:

(1) $T_2 < T_1$ (2) $T_1 < T_2$

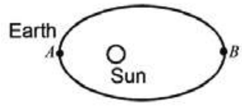
(3) $T_1 = T_2$ (4) none of these

**24.** A satellite is seen after every 6 hours over the equator. It is known that it rotates opposite to that of earth's direction. Then the angular velocity (in radians per hour) of the satellite about the centre of earth will be:

(1) π/2 (2) π/3

(3) π/4 (4) π/8

**25.** The earth is moving around the sun in an elliptical orbit. Point A is the closest and point B is the farthest point in the orbit, as shown. In comparison to the situation when the earth passes through point B**:**




(1) total energy of the earth-sun system is greater when the earth passes through point A.

(2) magnitude of gravitational potential energy of the earth-sun system is smaller when the earth passes through point A.

(3) kinetic energy of the earth due to the motion around the sun is smaller when it passes through the point A.

(4) magnitude of angular momentum of the earth about the sun is greater when the earth passes through point A.

**26.** A satellite of mass $m$ initially at rest on earth surface is launched into a circular orbit of double the radius of earth. The radius of earth is $R_e$. The minimum energy required to do so is

(1) $mgR_e$ (2) $\frac{mgR_e}{4}$

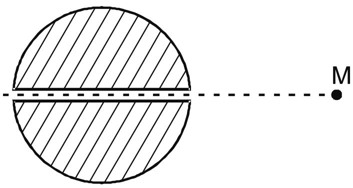
(3) $-\frac{3mgR_e}{4}$ (4) $\frac{3}{4}mgR_e$.

**27.** Assuming that the law of gravitation is of the form $F = \frac{GMm}{r^3}$ and attractive. A body of mass $m$ revolves in a circular path of radius $r$ around a fixed body of mass $M$. Find on what power of $r$ will the square of time period depend.

(1) 1 (2) 2

(3) 3 (4) 4

**28.** **STATEMENT-1 :** In free space a uniform spherical planet of mass M has a smooth narrow tunnel along the its diameter. This planet and another superdense small particle of mass M start approaching towards each other from rest under action of their gravitational forces. When the particle passes through the centre of the planet, sum of kinetic energies of both the bodies is maximum.




**STATEMENT-2:** When the resultant of all forces acting on a particle or a particle like object (initially at rest) is constant in direction, the kinetic energy of the particle keeps on increasing.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**29.** Consider an isolated system of earth and a satellite such that the satellite revolves about stationary earth in a circular orbit. Neglect rotation of earth about its axis and assume both earth and satellite to be solid spherical bodies with uniform mass distribution. For the given system, match the statements in Column-I with the statements in Column-II.

| **Column-I** | | **Column-II** | |
|---|---|---|---|
| I | Time period of revolution of satellite around | P | Independent of mass of satellite the earth is |
| II | Orbital speed of satellite is | Q | Independent of radius of orbit |
| III | Total mechanical energy of system of earth | R | Dependent on mass of earth and satellite is |
| IV | Magnitude of gravitation field at centre of satellite is | S | Independent of mass of earth |

(1) I-P,R; II-P,R; III-R; IV-P,R
(2) I- P,S; II-P,R; III-R; IV-P,S
(3) I-P,R; II-P; III-R; IV-P,S
(4) I-P,S; II-P,R; III-S; IV-P,R

**30.** Inside an isolated uniform spherical shell. Which of the following is false statement.
(1) The gravitation potential is not zero
(2) The gravitational field is not zero
(3) The gravitational potential is same everywhere
(4) The gravitational field is same everywhere.

**31.** Which of the following statements is **incorrect** about a planet rotating around the sun in an elliptic orbit:
(1) its mechanical energy is constant
(2) its angular momentum about the sun is constant
(3) its areal velocity about the sun is constant
(4) its time period is proportional to $r^3$

**32.** A satellite of the earth is revolving in a circular orbit with a uniform speed v. If the gravitational force suddenly disappears, the satellite will.
(1) Continue to move with velocity $v$ along the original orbit
(2) Move with a velocity $v$, tangentially to the original orbit
(3) Fall down with increasing velocity
(4) Ultimately come to rest somewhere on the original orbit

**33.** The time period of a satellite of earth is 5 hours. If the separation between the earth centre and the satellite is increased to 4 times the previous value, the new time period becomes.

(1) 10 hour (2) 80 hour
(3) 40 hour (4) 20 hour

**34.** The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/s. If the body is projected at an angle of 45° with the vertical, the escape velocity will be:

(1) $11\sqrt{2}$ km/s (2) 22 km/s
(3) 11 km/s (4) $11/\sqrt{2}$ m/s

**35.** A satellite of mass $m$ revolves around earth of radius $R$ at a height $x$ from its surface. If $g$ is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is:

(1) $gx$ (2) $\frac{gR}{R-x}$
(3) $\frac{gR^2}{R+x}$ (4) $\left(\frac{gR^2}{R+x}\right)^{1/2}$

**36.** The time period of an earth satellite in circular orbit is independent of:

(1) the mass of the satellite
(2) radius of its orbit
(3) both the mass and radius of the orbit
(4) neither the mass of the satellite nor the radius of its orbit

**37.** If $g$ is the acceleration due to gravity on the earth's surface, the gain in the potential energy of an object of mass $m$ raised from the surface of the earth to a height equal to the radius $R$ of the earth, is:

(1) $2mgR$
(2) $\frac{1}{2}mgR$
(3) $\frac{1}{4}mgR$
(4) $mgR$

**38.** The change in the value of '$g$' at a height '$h$' above the surface of the earth is the same as at a depth '$d$' below the surface of earth. When both '$d$' and '$h$' are much smaller than the radius of earth, then, which one of the following is correct?

(1) $d = \frac{h}{2}$ (2) $d = \frac{3h}{2}$
(3) $d = 2h$ (4) $d = h$

**39.** A particle of mass 10 kg is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them, to take the particle far away from the sphere (you may take $G = 6.67 \times 10^{-11}$ Nm$^2$/kg$^2$)

(1) $13.34 \times 10^{-10}$ J (2) $3.33 \times 10^{-10}$ J
(3) $6.67 \times 10^{-9}$ J (4) $6.67 \times 10^{-7}$ J

**40.** Two planets $A$ and $B$ of radii $R$ and $1.5R$ have densities $\rho$ and $\rho/2$ respectively. The ratio of acceleration due to gravity at the surface of $B$ to that $A$ is:

(1) 2 : 3 (2) 2 : 1
(3) 3 : 4 (4) 4 : 3

**41.** A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km s$^{-1}$, the escape velocity from the surface of the planet would be

(1) 11 km s$^{-1}$ (2) 110 km s$^{-}$
(3) 0.11 km s$^{-1}$ (4) 1.1 km s$^{-1}$

**42.** The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where g = the acceleration due to gravity on the surface of the earth) in terms of $R$, the radius of the earth is

(1) $\frac{R}{\sqrt{2}}$
(2) $\frac{R}{2}$
(3) $\sqrt{2}\,R$
(4) $2R$

**43.** Two bodies of masses $m$ and 4 $m$ are placed at a distance $r$. The gravitational potential at a point on the line joining them where the gravitational field is zero is :

(1) zero (2) $-\frac{4Gm}{r}$

(3) $-\frac{6Gm}{r}$ (4) $-\frac{9Gm}{r}$

**44.** Two particles of equal mass '$m$' go around a circle of radius $R$ under the action of their mutual gravitational attraction. The speed of each particle is:

(1) $\sqrt{\frac{Gm}{4R}}$ (2) $\sqrt{\frac{Gm}{3R}}$

(3) $\sqrt{\frac{Gm}{2R}}$ (4) $\sqrt{\frac{Gm}{R}}$

**45.** The mass of a spaceship is 1000 kg. It is to be launched from the earth's surface out into free space. The value of '$g$' and '$R$' (radius of earth) are 10 m/s$^2$ and 6400 km respectively. The required energy for this work will be :

(1) $6.4 \times 10^{11}$ Joules (2) $6.4 \times 10^{8}$ Joules

(3) $6.4 \times 10^{9}$ Joules (4) $6.4 \times 10^{10}$ Joules

**46.** What is the minimum energy required to launch a satellite of mass $m$ from the surface of a planet of mass $M$ and radius $R$ in a circular orbit at an altitude of $2R$?

(1) $\frac{5GmM}{6R}$ (2) $\frac{2GmM}{3R}$

(3) $\frac{GmM}{2R}$ (4) $\frac{GmM}{3R}$

**47.** Four particles, each of mass $M$ and equidistant from each other, move along a circle of radius $R$ under the action of their mutual gravitational attraction. the speed of each particle is

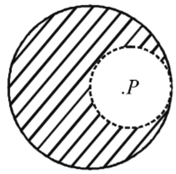
(1) $\sqrt{\frac{GM}{R}}$

(2) $\sqrt{2\sqrt{2}\frac{GM}{R}}$

(3) $\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$

(4) $\frac{1}{2}\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$

**48.** From a solid sphere of mass $M$ and radius $R$, a spherical portion of radius $R/2$ is removed, as shown in the figure. Taking gravitational potential $V = 0$ at $r = \infty$, the potential at the centre of the cavity thus formed is ($G$ = gravitational constant)




(1) $\frac{-GM}{2R}$ (2) $\frac{-GM}{R}$

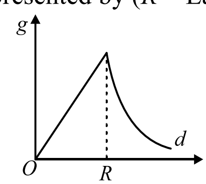
(3) $\frac{-2GM}{3R}$ (4) $\frac{-2GM}{R}$

**49.** A satellite is revolving in a circular orbit at a height '$h$' from the earth's surface (radius of earth $R$;$h<<R$). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to : (Neglect the effect of atmosphere.)

(1) $\sqrt{gR}$ (2) $\sqrt{\frac{gR}{2}}$

(3) $\sqrt{gR}\left(\sqrt{2}-1\right)$ (4) $\sqrt{2gR}$

**50.** The variation of acceleration due to gravity $g$ with distance $d$ from centre of the earth is best represented by ($R$ = Earth's radius)

(1)
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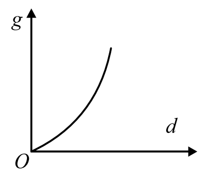
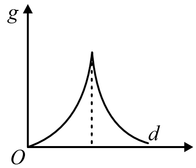
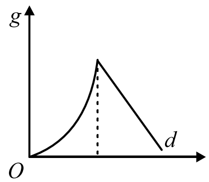
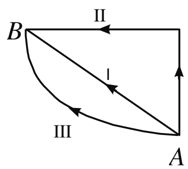


(3) 


(4) 


**51.** A particle of mass $m$ is taken through the gravitational field produced by a source $S$, from $A$ to $B$, along the three paths as shown in figure. If the work done along the paths I, II and III is $W_{I}$, $W_{II}$ and $W_{III}$ respectively, then




(1) $W_{I} = W_{II} = W_{III}$

(2) $W_{II} > W_{III} = W_{II}$

(3) $W_{III} = W_{II} > W_{I}$

(4) $W_{I} > W_{u} > W_{III}$

**52.** A double star system consists of two stars $A$ and $B$ which have time period $T_A$ and $T_B$. Radius $R_A$ and $R_B$ and mass $M_A$ and $M_B$. Choose the correct option.

(1) If $T_A > T_B$ then $R_A > R_B$

(2) If $T_A > T_B$ then $M_A > M_B$

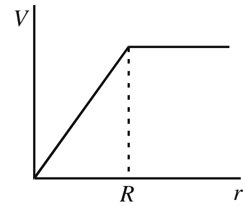
(3) $\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{R_A}{R_B}\right)^3$

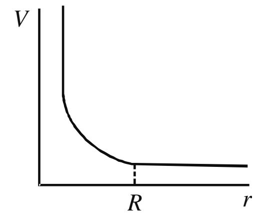
(4) $T_A = T_B$

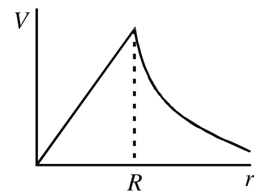
**53.** A spherically symmetric gravitational system of particles has a mass density

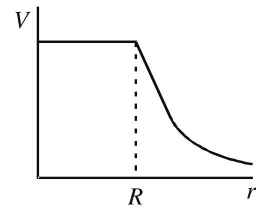
$$\rho = \begin{cases} \rho_0 & for \quad r \le R \\ 0 & for \quad r > R \end{cases}$$

where $\rho_0$ is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed $V$ as a function of distance $r$ $(0 < r < \infty)$ from the centre of the system is represented by

(1) 


(2) 


(3) 


(4) 


**54.** A satellite is moving with a constant speed '$v$' in a circular orbit about the earth. An object of mass '$m$' is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of its ejection, the kinetic energy of the object is

(1) $\frac{1}{2}mv^2$

(2) $mv^2$

(3) $\frac{3}{2}mv^2$

(4) $2mv^2$

**55.** Two spherical planets $P$ and $Q$ have the same uniform density ρ, masses $M_P$ and $M_Q$, with surface areas $A$ and $4A$, respectively. A spherical planet $R$ also has uniform density ρ and its mass is $(M_P + M_Q)$. The escape velocities from the planets $P$, $Q$ and R, are $V_P$, $V_Q$ and $V_R$ respectively. Then

(1) $V_Q > V_R > V_P$ (2) $V_R > V_Q > V_P$

(3) $V_R/V_P = 3$ (4) $V_P/V_Q = \frac{1}{4}$

**56.** Two bodies, each of mass $M$, are kept fixed with a separation $2L$. A particle of mass $m$ is projected from the midpoint of the line joining their centres, perpendicular to the line. The gravitational constant is $G$. The correct statement is:

(1) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $4\sqrt{\frac{GM}{L}}$.

(2) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $2\sqrt{\frac{GM}{L}}$.

(3) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $\sqrt{\frac{2GM}{L}}$.

(4) None of the above

**57.** Two objects of equal masses placed at certain distance from each other attract each other with a force $F$. If one-third mass of one object transferred to the other, then the new force will be:

(1) 2/9 $F$ (2) 16/9 $F$

(3) 8/9 $F$ (4) $F$

**58.** The acceleration due to gravity at height $h$ above the earth if $h << R$ (radius of earth) is given by

(1) $g' = g\left(1 - \frac{2h}{R}\right)$

(2) $g' = g\left(1 - \frac{2h^2}{R^2}\right)$

(3) $g' = g\left(1 - \frac{h}{2R}\right)$

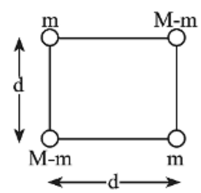
(4) $g' = g\left(1 - \frac{h^2}{2R^2}\right)$

## *Integer Type Questions (59 to 73)*

**59.** The elongation of a wire on the surface of the earth is $10^{-4}$ m. The same wire of same dimensions is elongated by $6 \times 10^{-5}$ m on another planet. The acceleration due to gravity on the planet will be ________ $ms^{-2}$.
(Take acceleration due to gravity on the surface of earth = 10 $ms^{-2}$)

**60.** The radius in kilometer to which the present radius of earth ($R$ = 6400 km) to be compressed so that the escape velocity is increased 10 times is:

**61.** A body of mass $(2M)$ splits into four masses $\{m, M-m, m, M-m\}$, which are rearranged to form a square as shown in the figure. The ratio of $\frac{M}{m}$ for which, the gravitational potential energy of the system becomes maximum is $x$ : 1. The value of $x$ is:




**62.** If one wants to remove all the mass of the earth to infinity in order to break it up completely. The amount of energy that needs to be supplied will be $\frac{x}{5}\frac{GM^2}{R}$, where $x$ is _______. (Round off to the Nearest Integer)
($M$ is the mass of earth, $R$ is the radius of earth, $G$ is the gravitational constant)

**63**. An asteroid is moving directly towards the centre of the earth. When at a distance of $10R$ ($R$ is the radius of the earth) from the earths centre, it has a speed of 12 km/s. Neglecting the effect of earth atmosphere, what will be the speed of the asteroid when it hits the surface of the earth (escape velocity from the earth is 11.2 km/s)?

Give your answer to the nearest integer in kilometer/s__________.

**64**. The initial velocity $v_i$ required to project a body vertically upward from the surface of the earth to reach a height of $10R$, where $R$ is the radius of the earth, may be described in terms of escape $v_e$ velocity such that $v_i = \sqrt{\frac{x}{y}} \times v_e$. The value of $x$ will be_____.

**65**. The distance between two stars of masses $3M_s$ and $6M_s$ is $9\ R$. Here $R$ is the mean distance between the centers of the Earth and the Sun, and $M_s$ is the mass of the Sun. The two stars orbit around their common center of mass in circular orbits with period $n\ T$, where $T$ is the period of Earth's revolution around the Sun. The value of $n$ is _______.

**66**. The satellites revolve around a planet in coplanar circular orbits in anticlockwise direction. Their period of revolutions are 1 hour and 8 hours respectively. The radius of the orbit of nearer satellite is $2 \times 10^3$ km. The angular speed of the farther satellite as observed from the nearer satellite at the instant when both the satellites are closest is $\frac{\pi}{x}$ rad $h^{-1}$ where $x$ is ___.

**67.** The weight of a body on the earth is 400 N. Then weight of the body when taken to a depth half of the radius of the earth will be:

**68**. Assuming the earth to be a sphere of uniform mass density, the weight of a body at a height $d = \frac{R}{200}$ from the surface of earth, if its weight on the surface of earth is 200 N, will be: (Given $R$ = Radius of earth)

**69**. The weight of a body at the surface of earth is 18 N. The weight of the body at an altitude of 3200 km above the earth's surface is (given, radius of earth $R_e$ = 6400 km)

**70**. $T$ is the time period of a simple pendulum on the earth's surface. Its time period becomes $xT$ when taken to a height $R$ (equal to earth's radius) above the surface of earth. Then, the value of $x$ will be:

**71**. The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth, equal to one-fourth the radius of the earth is:

**72**. At a certain depth '$d$' below surface of earth. value of acceleration due to gravity becomes four times that of its value at a height $3R$ above earth surface. Where $R$ is Radius of earth (Take $R$ = 6400 km). The depth $d$ is equal to $100\ x$. Find $x$.

**73.** Assume there are two identical simple pendulum clocks. Clock –1 is placed on the earth and Clock –2 is placed on a space station located at a height $h$ above the earth surface. Clock –1 and Clock –2 operate at time periods 4s and 6s respectively. Then the value of $h$ is $100\ x$. Find $x$. (consider radius of earth $R_E$ = 6400 km and $g$ on earth 10 m/s$^2$)

CHAPTER

09

# PROPERTIES OF MATTER - SOLIDS

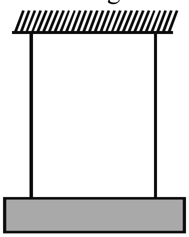
### *Single Option Correct Type Questions (01 to 45)*

**1.** The diameter of a brass rod is 4 mm and Young's modulus of brass is $9 \times 10^{10}$ N/m$^2$. The force required to stretch by 0.1% of its length is:

(1) $360\,\pi$ N (2) 36 N

(3) $144\,\pi \times 10^3$ N (4) $36\,\pi \times 10^5$ N

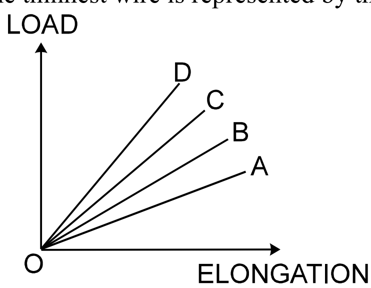
**2.** Two wires of equal length and cross-section area suspended as shown in figure. Their Young's modulus are $Y_1$ and $Y_2$ respectively. The equivalent Young's modulus will be



(1) $Y_1 + Y_2$ (2) $\frac{Y_1 + Y_2}{2}$

(3) $\frac{Y_1 Y_2}{Y_1 + Y_2}$ (4) $\sqrt{Y_1 Y_2}$

**3.** The load versus elongation graph for four wires of the same materials is shown in the figure. The thinnest wire is represented by the line:




(1) $OC$ (2) $OD$

(3) $OA$ (4) $OB$

**4.** A square brass plate of side 1.0 m and thickness 0.005 m is subjected to two force each of magnitude $F$ on its two smaller opposite faces, causing a relative displacement of one face with respect to other 0.02 cm. If the shear modulus of brass is $0.4 \times 10^{11}$ N/m$^2$, the value of the force $F$ is

(1) $4 \times 10^3$ N (2) 400 N

(3) $4 \times 10^4$ N (4) 1000 N

**5.** A metal block is experiencing an atmospheric pressure of $1 \times 10^5$ N/m$^2$, when the same block is placed in a vacuum chamber, the fractional change in its volume is (the bulk modulus of metal is $1.25 \times 10^{11}$ N/m$^2$)

(1) $4 \times 10^{-7}$ (2) $2 \times 10^{-7}$

(3) $8 \times 10^{-7}$ (4) $1 \times 10^{-7}$

**6.** If the potential energy of a spring is $V$ on stretching it by 2 cm, then its potential energy when it is stretched by 10 cm will be:

(1) $V/25$ (2) $5\,V$

(3) $V/5$ (4) $25\,V$

**7.** If work done in stretching a wire by 1 mm is 2 J, the work necessary for stretching another wire of same material, but with double the radius and half the length by 1mm in joule is:

(1) 1/4

(2) 4

(3) 8

(4) 16

**8.** A force $F$ is needed to break a copper wire having radius $R$. The force needed to break a copper wire of radius 2 $R$ will be:

(1) $F/2$ (2) $2F$

(3) $4F$ (4) $F/4$

**9.** Two hail stones with radii in the ratio of 1 : 2 fall from a great height through the atmosphere. Then the ratio of their momenta after they have attained terminal velocity is

(1) 1 : 1 (2) 1 : 4

(3) 1 : 16 (4) 1 : 32

**10.** The compressibility of water is $46.4 \times 10^{-6}$/atm. This means that

(1) The bulk modulus of water is $46.4 \times 10^6$ atm

(2) Volume of water decreases by 46.4 one-millionths of the original volume for each atmosphere increase in pressure

(3) when water is subjected to an additional pressure of one atmosphere, its volume decreases by 46.4%

(4) When water is subjected to an additional pressure of one atmosphere, its volume is reduced to $10^{-6}$ of its original volume.

**11.** If a rubber ball is taken to the depth of 200 m in a pool its volume decreases by 0.1%. If the density of the water is $1 \times 10^3$ kg/m$^3$ and $g = 10$ m/s$^2$, then the volume elasticity in N/m$^2$ will be:

(1) $10^8$ (2) $2 \times 10^8$

(3) $10^9$ (4) $2 \times 10^9$

**12.** A ball of mass $m$ and radius $r$ is released in a viscous liquid. The value of its terminal velocity is proportional to:

(1) $\frac{1}{r}$

(2) $\frac{m}{r}$

(3) $\sqrt{\frac{m}{r}}$

(4) $m$ only

**13.** Two wires of the same material and length but diameter in the ratio 1 : 2 are stretched by the same force. The ratio of potential energy per unit volume for the two wires when stretched will be:

(1) 1 : 1

(2) 2 : 1

(3) 4 : 1

(4) 16 : 1

**14.** A steel wire is suspended vertically from a rigid support. When loaded with a weight in air, it expands by $L_a$ and when the weight is immersed completely in water, the extension is reduced to $L_w$. Then relative density of the material of the weight is

(1) $\frac{L_a}{L_a - L_w}$ (2) $\frac{L_w}{L_a}$

(3) $\frac{L_a}{L_w}$ (4) $\frac{L_w}{L_a - L_w}$

**15.** An oil drop falls through air with a terminal velocity of $5 \times 10^{-4}$ m/s. [Take $g = 10$ m/s$^2$] the radius of the drop will be :

(1) $2.5 \times 10^{-6}$ m (2) $2 \times 10^{-6}$ m

(3) $3 \times 10^{-6}$ m (4) $4 \times 10^{-6}$ m

(Viscosity of air = $\frac{18 \times 10^{-5}}{5}$ N-s/m$^2$. density of oil = 900 Kg/m$^3$. Neglect density of air as compared to that of oil)

**16.** **Statement-1:** Steel is more elastic than rubber.
**Statement-2:** Under a given deforming force, steel deforms less than rubber.

(1) If both assertion and reason are true and reason is the correct explanation of assertion.

(2) If both assertion and reason are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false

(4) If assertion is false but reason is true.

17. **Statement-1:** Bulk modulus of incompressible fluid is zero.
**Statement-2:** Bulk modulus of elasticity ($B$) = $-\frac{\Delta p}{\Delta V / V}$ where symbols have their standard meaning.
(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If assertion is true but reason is false
(4) If assertion is false but reason is true.

18. A metal wire of length $L$ is suspended vertically from a rigid support. When a bob of mass $M$ is attached to the lower end of wire, the elongation of the wire is $\ell$:

| | Column-I | | Column-II |
|---|---|---|---|
| 1 | The loss in gravitational potential energy of mass $M$ is equal to | p | $Mg\ell$ |
| 2 | The elastic potential energy stored in the wire is equal to | q | $\frac{1}{2}Mg\ell$ |
| 3 | The elastic constant of the wire is equal to | r | $Mg/\ell$ |
| 4 | Heat produced during extension is equal to | s | $\frac{1}{4}Mg\ell$ |

(1) (1 – p); (2 – q); (3 – r); (4 – q)
(2) (1 – p); (2 – q); (3 – r); (4 – s)
(3) (1 – r); (2 – s); (3 – p); (4 – q)
(4) (1 – q); (2 – r); (3 – s); (4 – p)

19. A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the wire by 1 mm. The elastic energy stored in the wire is:
(1) 0.2 J (2) 10 J
(3) 20 J (4) 0.1 J

20. If '$S$' is stress and '$Y$' is Young's modulus of material of a wire, the energy stored in the wire per unit volume is:
(1) $2S^2Y$
(2) $\frac{S^2}{2Y}$
(3) $\frac{2Y}{S^2}$
(4) $\frac{S}{2Y}$

21. A wire elongates by $\ell$ mm when a load $W$ is hanged from it. If the wire goes over a pulley and two weights $W$ each are hung at the two ends, the elongation of the wire will be (in mm)
(1) $\ell/2$ (2) $\ell$
(3) $2\ell$ (4) Zero

22. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area $A$ and wire 2 has cross-sectional area $3A$. If the length of wire 1 increases by $\Delta x$ on applying force $F$, how much force is needed to stretch wire 2 by the same amount?
(1) 4 $F$
(2) 6 $F$
(3) 9 $F$
(4) $F$

23. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is:
(For steel, Young's modulus is $2 \times 10^{11}$ N m$^{-2}$ and coefficient of thermal expansion is $1.1 \times 10^{-5}\ K^{-1}$)
(1) $2.2 \times 10^8$ Pa
(2) $2.2 \times 10^9$ Pa
(3) $2.2 \times 10^7$ Pa
(4) $2.2 \times 10^6$ Pa

**24.** A pendulum made of a uniform wire of cross sectional area $A$ has time period $T$. When an additional mass $M$ is added to its bob, the time period changes to $T_M$. If the Young's modulus of the material of the wire is $Y$, then $\frac{1}{Y}$ is equal to: ($g$ = gravitational acceleration)

(1) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{A}{Mg}$

(2) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{Mg}{A}$

(3) $\left[1 - \left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$

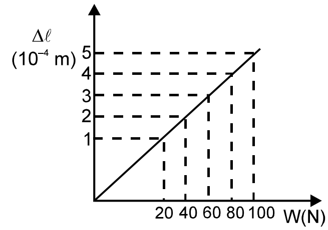
(4) $\left[1 - \left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

**25.** A solid sphere of radius $r$ made of a soft material of bulk modulus $K$ is surrounded by a liquid in a cylindrical container. A massless piston of area $a$ floats on the surface of the liquid, covering entire cross-section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$ is:

(1) $\frac{mg}{3Ka}$ (2) $\frac{mg}{Ka}$

(3) $\frac{Ka}{mg}$ (4) $\frac{Ka}{3mg}$

**26.** A 1m long metal wire of cross sectional area $10^{-6}$ m$^2$ is fixed at one end from a rigid support and a weight $W$ is hanging at its other end. The graph shows the observed extension of length $\Delta\ell$ of the wire as a function of $W$. Young's modulus of material of the wire in SI units is




(1) $5 \times 10^4$ (2) $2 \times 10^5$

(3) $2 \times 10^{11}$ (4) $5 \times 10^{11}$

**27.** One end of a horizontal thick copper wire of length $2L$ and radius $2R$ is welded to an end of another horizontal thin copper wire of length $L$ and radius $R$. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is:

(1) 0.25 (2) 0.50

(3) 2.00 (4) 4.00

**28.** An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}$ N/m$^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:

(1) 5600 (2) 8400

(3) 2800 (4) 11200

**29.** In an experiment, brass and steel wires of length 1 m each with areas of cross section 1 mm$^2$ are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2 mm is:
(Given, the Young's Modulus for steel and brass are respectively, $120 \times 10^9$ N/m$^2$ and $60 \times 10^9$ N/m$^2$)

(1) $0.2 \times 10^6$ N/m$^2$ (2) $8.0 \times 10^6$ N/m$^2$

(3) $1.8 \times 10^6$ N/m$^2$ (4) $1.2 \times 10^6$ N/m$^2$

**30.** The bulk modulus of a liquid is $3 \times 10^{10}$ Nm$^{-2}$. The pressure required to reduce the volume of liquid by 2% is:

(1) $3 \times 10^8$ Nm$^{-2}$ (2) $9 \times 10^8$ Nm$^{-2}$

(3) $6 \times 10^8$ Nm$^{-2}$ (4) $12 \times 10^8$ Nm$^{-2}$

**31.** A uniform heavy rod of weight 10 kg $ms^{-2}$, cross-sectional area 100 $cm^2$ and length 20 cm is hanging from a fixed support. Young modulus of the material of the rod is $2\times10^{11}$ $Nm^{-2}$. Neglecting the lateral contraction, find the elongation of rod due to its own weight:
(1) $2 \times 10^{-9}$ m (2) $5 \times 10^{-10}$ m
(3) $4 \times 10^{-8}$ m (4) $5 \times 10^{-8}$ m

**32.** A wire of length $L$ is hanging from a fixed support. The length changes to $L_1$ and $L_2$ when masses 1 kg and 2 kg are suspended respectively from its free end. Then the value of $L$ is equal to:
(1) $\sqrt{L_1L_2}$ (2) $\frac{L_1+L_2}{2}$
(3) $2L_1-L_2$ (4) $3L_1-2L_2$

**33.** Two steel wires having same length are suspended from a ceiling under the same load. If the ratio of their energy stored per unit volume is 1 : 4, the ratio of their diameters is:
(1) 1 : 1 (2) $1:\sqrt{2}$
(3) 2 : 1 (4) $\sqrt{2}:1$

**34.** If the length of a wire is made double and radius is halved of its respective values. Then, the Young's modulus of the material of wire will:
(1) remain same
(2) become 8 times its initial value
(3) become $1/4^{th}$ of its initial value
(4) become 4 times its initial value

**35.** The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit?
(1) 1.16 mm (2) 0.90 mm
(3) 1.36 mm (4) 1.00 mm

**36.** An object is located at 2 km beneath the surface of the water. If the fractional compression $\frac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be
[Given: density of water is 1000 $kgm^{-3}$ and g = 9.8 $ms^{-2}$.]
(1) $1.44 \times 10^7$ $Nm^{-2}$ (2) 1.96 $10^7$ $Nm^{-2}$
(3) $2.26 \times 10^9$ $Nm^{-2}$ (4) $1.44 \times 10^9$ $Nm^{-2}$

**37.** A steel wire having a radius of 2.0 mm, carrying a load of 4 kg, is hanging from a ceiling. Given that $g = 3.1\,\pi$ $ms^{-2}$, what will be the tensile stress that would be developed in the wire?
(1) $4.8 \times 10^6$ $Nm^{-2}$ (2) $5.2 \times 10^6$ $Nm^{-2}$
(3) $6.2 \times 10^6$ $Nm^{-2}$ (4) $3.1 \times 10^6$ $Nm^{-2}$

**38.** The area of cross section of the rope used to lift a load by a crane is $2.5 \times 10^{-4}$ $m^2$. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, the required area of cross section of the rope should be:
(take $g = 10$ $ms^{-2}$)
(1) $6.25 \times 10^{-4}$ $m^2$ (2) $10 \times 10^{-4}$ $m^2$
(3) $1 \times 10^{-4}$ $m^2$ (4) $1.67 \times 10^{-4}$ $m^2$

**39.** A cube of metal is subjected to a hydrostatic pressure of 4 GPa. The percentage change in the length of the side of the cube is close to (Given bulk modulus of metal, $B = 8 \times 10^{10}$ Pa)
(1) 0.6 (2) 20
(3) 1.67 (4) 5

**40.** A boy's catapult is made of rubber cord which is 42 cm long, with 6 mm diameter of cross-section and of negligible mass. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm by applying a constant force. When released, the stone flies off with a velocity of 20 $ms^{-1}$. Neglect the change in the area of cross-section of the cord while stretched. The Young's modulus of rubber is closest to:
(1) $10^4$ $Nm^{-2}$ (2) $10^8$ $Nm^{-2}$
(3) $3 \times 10^6$ $Nm^{-2}$ (4) $10^3$ $Nm^{-2}$

**41.** The value of tension in a long thin metal wire has been changed from $T_1$ to $T_2$. The lengths of the metal wire at two different values of tension $T_1$ and $T_2$ are $\ell_1$ and $\ell_2$ respectively. The actual length of the metal wire is:
(1) $\frac{T_1\ell_2-T_2\ell_1}{T_1-T_2}$ (2) $\sqrt{T_1T_2\ell_1\ell_2}$
(3) $\frac{\ell_1+\ell_2}{2}$ (4) $\frac{T_1\ell_1+T_2\ell_2}{T_1-T_2}$

**42.** The normal density of a material its ρ and its bulk modulus of elasticity is $K$. The magnitude of increase in density of material, when a pressure $P$ is applied uniformly on all sides, will be:

(1) $\frac{K}{\rho P}$

(2) $\frac{PK}{\rho}$

(3) $\frac{\rho K}{P}$

(4) $\frac{\rho P}{K}$

**43.** Four identical hollow cylindrical columns of mild steel support a big structure of mass $50 \times 10^3$ kg, The inner and outer radii of each column are 50 cm and 100 cm respectively. Assuming uniform local distribution, calculate the compression strain of each column
[Use $Y = 2.0 \times 10^{11}$ Pa, $g = 9.8$ m/s$^2$]

(1) $3.60 \times 10^{-8}$

(2) $2.60 \times 10^{-7}$

(3) $1.87 \times 10^{-3}$

(4) $7.07 \times 10^{-4}$

**44.** The force required to stretch a wire of cross-section 1 cm$^2$ to double its length will be: (Given Young's modulus of the wire = $2 \times 10^{11}$ N/m$^2$)

(1) $1 \times 10^7$ N

(2) $1.5 \times 10^7$ N

(3) $2 \times 10^7$ N

(4) $2.5 \times 10^7$ N

**45.** The elastic potential energy stored in a steel wire of length 20 m stretched through 2 cm is 80 J. The cross sectional area of the wire is: (Given: $Y = 2.0 \times 10^{11}$ Nm$^{-2}$)

(1) 20 mm$^2$ (2) 30 mm$^2$

(3) 40 mm$^2$ (4) 60 mm$^2$

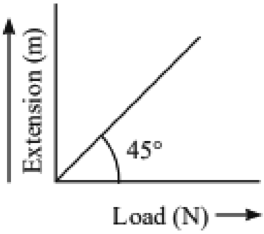
## *Integer Type Questions (46 to 59)*

**46.** A thin rod having a length of 1m and area of cross-section $3\times10^{-6}$ m$^2$ is suspended vertically from one end. The rod is cooled from 210ºC to 160ºC. After cooling, a mass $M$ is attached at the lower end of the rod such that the length of rod again becomes 1m. Young's modulus and coefficient of linear expansion of the rod are $2 \times 10^{11}$ Nm$^{-2}$ and $2 \times 10^{-5}$ $K^{-1}$, respectively. The value of $M$ is _______ kg.
(Take $g = 10$ ms$^{-2}$)

**47.** The length of wire becomes $l_1$ and $l_2$ when 100 N and 120 N tensions are applied respectively. If $10\, l_2 = 11\, l_1$, the natural length of wire will be $\frac{1}{x} l_1$. Here the value of $x$ is _______.

**48.** A stone of mass 20 g is projected from a rubber catapult of total length 0.1 m and area of cross section $10^{-6}$ m$^2$ stretched by a total length amount 0.04 m. The velocity of the projected stone is ___ m /s. (Young's modulus of rubber = $0.5 \times 10^9$ N/m$^2$)

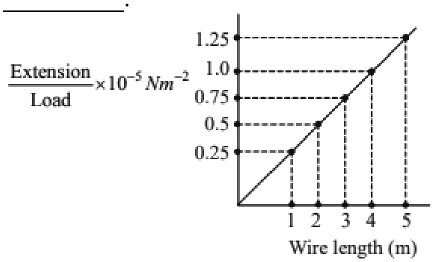
**49.** As shown in the figure, in an experiment to determine Young's modulus of a wire, the extension-load curve is plotted. The curve is a straight line passing through the origin and makes an angle of 45º with the load axis. The length of the wire is 62.8 cm and its diameter is 4 mm. The Young's modulus is found to be $x \times 10^4$ Nm$^{-2}$. The value of $x$ is______




**50.** A uniform metallic wire is elongated by 0.04 m when subjected to a linear force $F$. The elongation, if its length and diameter is doubled and subjected to the same force will be __________ cm.

**51.** A steel rod has a radius of 20 mm and a length of 20m. A force of 62.8 kN stretches it along its length. Young's modulus of steel is $2.0 \times 10^{11}$ $N/m^2$ . The longitudinal strain produced in the wire is ____ $\times 10^{-5}$

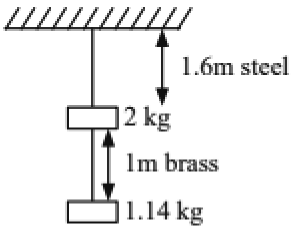
**52.** In an experiment to determine the Young's modulus, steel wires of five different lengths (1, 2, 3, 4, and 5 m) but of same cross section ($2\ mm^2$) were taken and curves between extension and load were obtained. The slope (extension / load) of the curves were plotted with the wire length and the following graph is obtained. If the Young's modulus of given steel wires is $x \times 10^{11}$ $Nm^{-2}$, then the value of $x$ is _________.




**53.** A square aluminium (shear modulus is $25 \times 10^9$ $Nm^{-2}$) slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of $18.0 \times 10^4$ N. The lower edge is riveted to the floor. The displacement of the upper edge is _________ μm.

**54.** When a rubber ball is taken to a depth of __________m in deep sea, its volume decreases by 0.5%. (The bulk modulus of rubber = $9.8 \times 10^8$ $Nm^{-2}$ and Density of sea water = $10^3$ $kgm^{-3}$, $g = 9.8\ m/s^2$)

**55.** Two wires each of radius 0.2 cm and negligible mass, one made of steel and other made of brass are loaded as shown in the figure. The elongation of the steel wire is ______ $\times 10^{-6}$ m. [Young's modulus for steel = $2 \times 10^{11}$ $Nm^{-2}$ and $g = 10\ ms^{-2}$]




**56.** The speed of a transverse wave passing through a string of length 50 cm and mass 10 g is $60\ ms^{-1}$. The area of cross section of the wire is $2.0\ mm^2$ and its Young's modulus is $1.2 \times 10^{11}$ $Nm^{-2}$. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}$ m. The value of $x$ is ________ .

**57.** A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is $7 \times 10^5$ $Nm^{-2}$. The value of mass m is __________ kg.

(Take, $g = 9.8\ ms^{-2}$ and $\pi = \frac{22}{7}$)

**58.** A certain pressure '$P$' is applied to 1 litre of water and 2 litre of a liquid separately. Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03%. The ratio of Bulk modulus of water to that of the liquid is $\frac{3}{x}$ . The value of $x$ is_______.

**59.** A steel rod of length 1 m and cross sectional area $10^{-4}\ m^2$ is heated from 0°C to 200°C without being allowed to extend or bend. The compressive tension produced in the rod is ______$\times 10^4$ N (Given Young's modulus of steel = $2 \times 10^{11}$ $Nm^{-2}$, coefficient of linear expansion = $10^{-5}K^{-1}$.

CHAPTER

10

# PROPERTIES OF MATTER- FLUIDS

*Single Option Correct Type Questions (01 to 58)*

**1.** A ball of mass $m$ and radius $r$ is released in a viscous liquid. The value of its terminal velocity is proportional to:

(1) $\frac{1}{r}$ (2) $\frac{m}{r}$

(3) $\sqrt{\frac{m}{r}}$ (4) $m$ only

**2.** Spherical balls of radius $R$ are falling in a viscous fluid of viscosity $\eta$ with a velocity $v$. The retarding viscous force acting on the spherical ball is:

(1) Directly proportional to $R$ but inversely proportional to $v$

(2) Directly proportional to both radius $R$ and velocity $v$

(3) Inversely proportional to both radius $R$ and velocity $v$

(4) Inversely proportional to $R$ but directly proportional to $v$

**3.** If the terminal speed of a sphere of gold (Density = 19.5 kg/m$^3$) is 0.2 m/s in a viscous liquid then find the terminal speed of sphere of silver (density = 10.5 kg/m$^3$) of the same size in the same liquid (density = 1.5 kg/m$^3$).

(1) 0.2 m/s (2) 0.4 m/s

(3) 0.133 m/s (4) 0.1 m/s

**4.** If a ball of steel (density $\rho = 7.8$ g cm$^{-3}$) attains a terminal velocity of 10 cm s$^{-1}$ when falling in a water (Coefficient of Viscosity $\eta_{water} = 8.5 \times 10^{-4}$ Pa.s) then its terminal velocity in glycerine ($\rho$ = 1.2 g cm$^{-3}$, $\eta$= 13.2 Pa.s.) would be, nearly:

(1) $6.25 \times 10^{-4}$ cm s$^{-1}$

(2) $6.45 \times 10^{-4}$ cm s$^{-1}$

(3) $1.5 \times 10^{-5}$ cm s$^{-1}$

(4) $1.6 \times 10^{-5}$ cm s$^{-1}$

**5.** A tiny spherical oil drop carrying a net charge $q$ is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5$ Vm$^{-1}$. When the field is switched off, the drop is observed to fall with terminal velocity $2 \times 10^{-3}$ ms$^{-1}$. Given $g = 9.8$ m s$^{-2}$, viscosity of the air = $1.8 \times 10^{-5}$ Ns m$^{-2}$ and the density of oil = 900 kg m$^{-3}$, the magnitude of $q$ is:

(1) $1.6 \times 10^{-19}$ C

(2) $3.2 \times 10^{-19}$ C

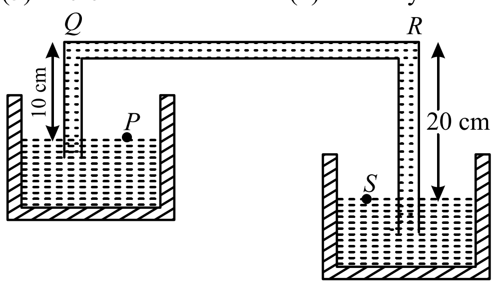
(3) $4.8 \times 10^{-19}$ C

(4) $8.0 \times 10^{-19}$ C

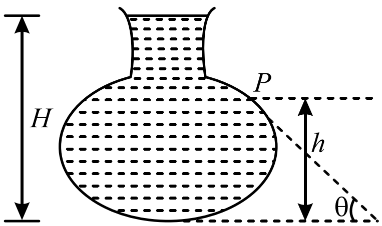
**6.** A siphon in use is demonstrated in the following figure. The density of the liquid flowing in siphon is 1.5 gm/cc. The pressure difference between the point $P$ and $S$ will be:

(1) $10^5$ N/m (2) $2 \times 10^5$ N/m

(3) Zero (4) Infinity



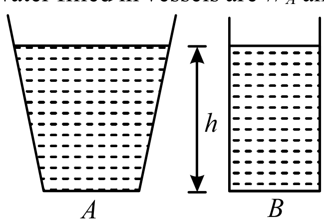
**7.** Figure here shows the vertical cross-section of a vessel filled with a liquid of density ρ. The normal thrust per unit area on the walls of the vessel at point. P, as shown, will be: (Neglect atmospheric pressure)




(1) $h\rho g$
(2) $H\rho g$
(3) $(H-h)\rho g$
(4) $(H-h)\rho g \cos\theta$

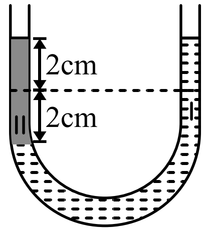
**8.** In a hydraulic lift, used at a service station the radius of the large and small piston are in the ratio of 20 : 1. What weight placed on the small piston will be sufficient to lift a car of mass 1500 kg?
(1) 3.75 kg
(2) 37.5 kg
(3) 7.5 kg
(4) 75 kg.

**9.** Two vessels $A$ and $B$ of different shapes have the same base area and are filled with water up to the same height $h$ (see figure). The force exerted by water on the base is $F_A$ for vessel $A$ and $F_B$ for vessel $B$. The respective weights of the water filled in vessels are $W_A$ and $W_B$. Then:



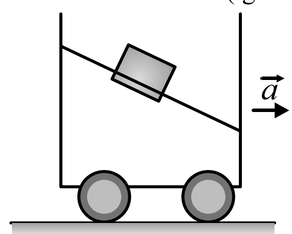

(1) $F_A > F_B$; $W_A > W_B$
(2) $F_A = F_B$; $W_A > W_B$
(3) $F_A = F_B$; $W_A < W_B$
(4) $F_A > F_B$; $W_A = W_B$

**10.** A $U$-tube of uniform cross-section as shown in figure is partially filled with a liquid I. Another liquid II which does not mix with liquid I is poured into one side. It is found that the liquid levels of the two sides of the tube are the same, while the level of liquid I has risen by 2 cm. If the specific gravity of liquid I is 1.1, the specific gravity of liquid II must be:




(1) 1.12 (2) 1.1
(3) 1.05 (4) 1.0

**11.** An open water tanker moving on a horizontal straight road has a cubical block of cork floating over its surface. If the tanker has an acceleration of $a$ as shown, the acceleration of the cork w.r.t. container is (ignore viscosity):




(1) Zero (2) $\frac{a^2}{g}$
(3) $\frac{a}{y}\sqrt{g^2-a^2}$ (4) $a$

**12.** Two solids $A$ and $B$ float in water. It is observed that $A$ floats with half its volume immersed and $B$ floats with 2/3 of its volume immersed. Compare the densities of $A$ and $B$:
(1) 4 : 3 (2) 2 : 3
(3) 3 : 4 (4) 1 : 3

**13.** The fraction of a floating object of volume $V_0$ and density $d_0$ above the surface of a liquid of density d will be:

(1) $\frac{d_0}{d}$ (2) $\frac{dd_0}{d+d_0}$

(3) $\frac{d-d_0}{d}$ (4) $\frac{dd_0}{d-d_0}$

**14.** The density of ice is $x$ gm/cc and that of water is $y$ gm/cc. What is the change in volume in $cc$, when $m$ gm of ice melts?

(1) $m(y-x)$ (2) $(y-x)/m$

(3) $mxy/(x-y)$ (4) $m(1/y-1/x)$

**15.** A body of density ρ is dropped from rest from a height '$h$' (from the surface of water) into a lake of density of water σ (σ > ρ). Neglecting all dissipative effects, the acceleration of body while it is in the lake is:

(1) $g\left(\frac{\sigma}{\rho}-1\right)$ upwards

(2) $g\left(\frac{\sigma}{\rho}-1\right)$ downwards

(3) $g\left(\frac{\sigma}{\rho}\right)$ upwards

(4) $g\left(\frac{\sigma}{\rho}\right)$ downwards

**16.** A block of silver of mass 4 kg hanging from a string is immersed in a liquid of relative density 0.72. If relative density of silver is 10, then tension in the string will be: [take $g = 10$ m/s$^2$]

(1) 37.12 N (2) 42 N

(3) 73 N (4) 21 N

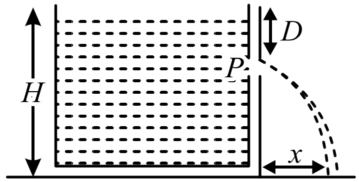
**17.** A boy carries a fish in one hand and a bucket (not full) of water in the other hand. If he places the fish in the bucket, the weight now carried by him (assume that water does not spill):

(1) Is less than before
(2) Is more than before
(3) Is the same as before
(4) Depends upon his speed

**18.** Two water pipes of diameters 2 cm and 4 cm are connected with the main supply line. The velocity of flow of water in the pipe of 2 cm diameter is

(1) 4 times that in the other pipe
(2) $\frac{1}{4}$ times that in the other pipe
(3) 2 times that in the other pipe
(4) $\frac{1}{2}$ times that in the other pipe

**19.** A tank is filled with water up to height $H$. Water is allowed to come out of a hole $P$ in one of the walls at a depth $D$ below the surface of water. Express the horizontal distance $x$ in terms of $H$ and $D$:



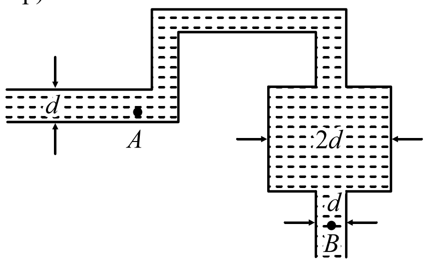

(1) $x=\sqrt{D(H-D)}$

(2) $x=\sqrt{\frac{D(H-D)}{2}}$

(3) $x=2\sqrt{D(H-D)}$

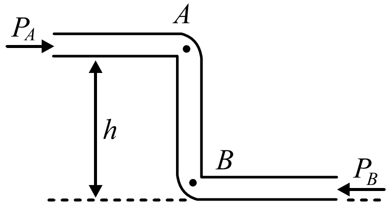
(4) $x=4\sqrt{D(H-D)}$

**20.** An ideal fluid is flowing through the given tubes which is placed on a horizontal surface. If the liquid has velocities $V_A$ and $V_B$, and pressures $P_A$ and $P_B$ at points $A$ and $B$ respectively, then the correct relation is ($A$ and $B$ are at same height from ground level, the figure shown is as if the system is seen from the top):




(1) $V_A > V_B, P_A < P_B$
(2) $V_A < V_B, P_A > P_B$
(3) $V_A = V_B, P_A = P_B$
(4) $V_A > V_B, P_A = P_B$

**21.** Figure shows an ideal fluid flowing through a uniform cross-sectional tube in the vertical tube with liquid velocities $v_A$ & $v_B$ and pressure $P_A$ & $P_B$. Knowing that tube offers no resistance to fluid flow then which of the following is true.




(1) $P_B > P_A$ (2) $P_B < P_A$
(3) $P_A = P_B$ (4) None of these

**22.** A block of volume $V$ and of density $\sigma_b$ is placed in liquid of density $\sigma_l$ ($\sigma_l > \sigma_b$), then block is moved upward upto a height $h$ and it is still in liquid. The increase in gravitational potential energy of the system is:

(1) $\sigma_b Vgh$ (2) $(\sigma_b + \sigma_l)Vgh$
(3) $(\sigma_b - \sigma_l)\,Vgh$ (4) None of these

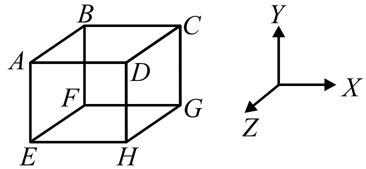
**23.** A block of iron is kept at the bottom of a bucket full of water at 2°C. The water exerts buoyant force on the block. If the temperature of water is increased by 1°C the temperature of iron block also increases by 1°C. The buoyant force on the block by water:

(1) Will increase
(2) Will decrease
(3) Will not change
(4) May decrease or increase depending on the values of their coefficient of expansion

**24.** The cubical container *ABCDEFGH* which is completely filled with an ideal (non-viscous and incompressible) fluid, moves in a gravity free space with an acceleration of:

$$\vec{a} = a_0\,(\hat{i} - \hat{j} + \hat{k})$$

Where $a_0$ is a positive constant. Then the only point in the container where pressure is maximum, is:




(1) $B$ (2) $C$
(3) $E$ (4) $F$

**25.** In previous question pressure will be minimum at point:

(1) $A$ (2) $B$
(3) $H$ (4) $F$

**26.** Consider a solid sphere of radius R and mass density $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right), 0 < r \le R$. The maximum density of a liquid in which it will float is

(1) $\frac{\rho_0}{5}$ (2) $\frac{2\rho_0}{5}$
(3) $\frac{2\rho_0}{3}$ (4) $\frac{\rho_0}{3}$

**27.** A block of steel of size 5 cm × 5 cm × 5 cm is weighed in water. If the relative density of steel is 7. Its apparent weight is:

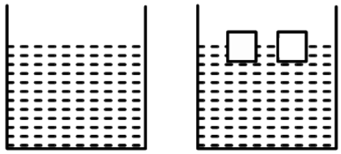
(1) $6 \times 5 \times 5 \times 5\ gf$
(2) $4 \times 4 \times 4 \times 7\ gf$
(3) $5 \times 5 \times 5 \times 7\ gf$
(4) $4 \times 4 \times 4 \times 6\ gf$

**28.** **STATEMENT-1:** Any pressure increase at one point of a static fluid passed to each point undiminished.

**STATEMENT-2:** Fluid is assumed to be incompressible.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**29.** **STATEMENT-1:** One of the two identical container is empty and the other contains two ice cubes. Now both the containers are filled with water to same level as shown. Then both the containers shall weigh the same.



**STATEMENT-2:** The weight of volume of water displaced by ice cube floating in water is equal to the weight of ice cube. Hence both the container in above situation shall weigh the same.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

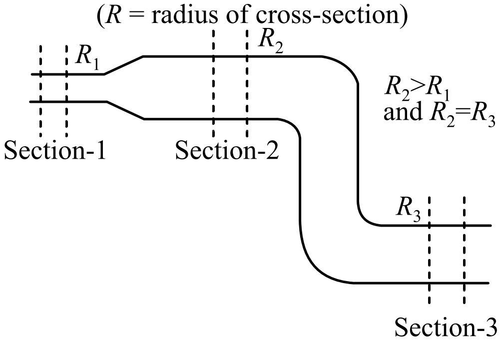
**30.** **STATEMENT-1:** Consider an object that floats in water but sinks in oil. When the object floats in water, half of it is submerged. If we slowly pour oil on top of water till it completely covers the object, the object moves up.

**STATEMENT-2:** As the oil is poured in the situation of statement-1, pressure inside the water will increase everywhere resulting in an increase in upward force on the object.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**31.** An arrangement of the pipes of circular cross-section is shown in the figure. The flow of water (incompressible and non-viscous) through the pipes is steady in nature. Three sections of the pipe are marked in which section 1 and section 2 are at same horizontal level, while being at a greater height than section 3. Correctly match order of the different physical parameter with the options given. In column-I certain statements are given and numbers given in column-II represent the section shown in figure. Match the statements in column-I with corresponding ranking in column-II

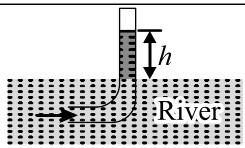
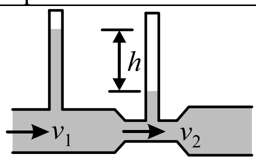
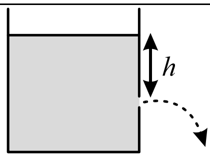
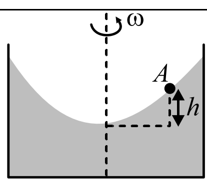
($R$ = radius of cross-section)




| | Column-I | | Column- II |
|---|---|---|---|
| I | Order of volume flow rate in section | P | 1 > 2 > 3 |
| II | Order of kinetic energy of a mass element while flowing through sections. | Q | 3 > 2 > 1 |
| III | Order of pressure in the sections. | R | 1 > 2 = 3 |
| IV | Order of flow speed in sections | S | 1 = 2 = 3 |

(1) I-R ; II-Q ; III-S ; IV-P
(2) I-P ; II-Q ; III-R ; IV-S
(3) I-S ; II-R ; III-Q ; IV-R
(4) I-R ; II-S ; III-P ; IV-Q

**32.** In **Column** I, position of water level are shown in certain cases and certain things are given and certain quantities are asked. Correctly match the asked quantity with the quantities given in **column II**.

| | **Column-I** | | **Column- II** |
|---|---|---|---|
| I |   Pitot tube is used to find the speed $v$ of the flow of the river water. The expression for $v^2$ is: | P | $2gh$ |
| II |   Area of cross section of the narrower part of the venturi tube is 1/2 of that of the wider part. If the velocity in the wider part is $v_1$ and that in the narrower part is $v_2$ then $v_1^2$ is: | Q | $\frac{2gh}{3}$ |
| III |   If the velocity of the efflux from a wide stationary tank and small orifice is $v$ then $v^2$ is: | R | $4gh$ |
| IV |   A cylindrical beaker containing some liquid is rotated with constant angular speed about its axis. If the speed of the point $A$ is $v$ then $v^2$ is: | S | $6gh$ |

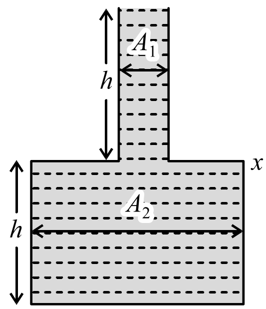
(1) I-Q ; II-S ; III-R ; IV-P
(2) I-P ; II-Q ; III-P ; IV-P
(3) I-R ; II-Q ; III-S ; IV-P
(4) I-S ; II-P ; III-R ; IV-Q

**33.** Pressure gradient in a static fluid is represented by ($z$–direction is vertically upwards, and x-axis is along horizontal, $d$ is density of fluid):

(1) $\frac{\partial p}{\partial z} = -dg$ (2) $\frac{\partial p}{\partial x} = dg$

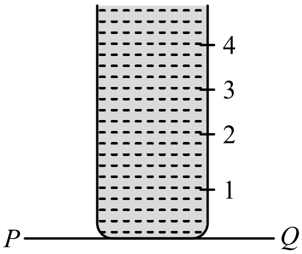
(3) $\frac{\partial p}{\partial x} = 0$ (4) $\frac{\partial p}{\partial z} = 0$

**34.** The vessel shown in Figure has two sections of area of cross-section $A_1$ and $A_2$. A liquid of density ρ fills both the sections, up to height $h$ in each. Neglecting atmospheric pressure,



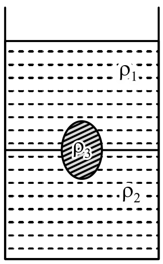

(1) The pressure at the base of the vessel is $2h\rho g$
(2) The weight of the liquid in vessel in equal to $2h\rho g A_2$
(3) The walls of the vessel at the level $X$ exert a force h $\rho g A_2$ downwards on the liquid.
(4) None of these

**35.** A cylindrical vessel of 90 cm height is kept filled upto the brim as shown in the figure. It has four holes 1, 2, 3, 4 which are respectively at heights of 20cm, 30cm, 40cm and 50cm from the horizontal floor $PQ$. The water falling at the minimum horizontal distance from the vessel comes from:




(1) Hole number 4
(2) Hole number 3
(3) Hole number 2
(4) Hole number 1.

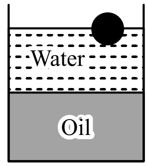
**36.** A jar is filled with two non-mixing liquids 1 and 2 having densities $\rho_1$ and $\rho_2$, respectively. A solid ball, made of a material of density $\rho_3$, is dropped in the jar. It comes to equilibrium in the position shown in the figure.

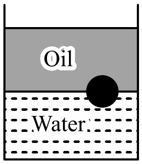


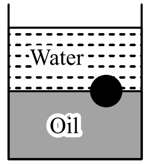

Which of the following is true for $\rho_1$, $\rho_2$ and $\rho_3$?

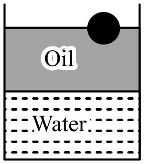
(1) $\rho_1 > \rho_3 > \rho_2$
(2) $\rho_1 < \rho_2 < \rho_3$
(3) $\rho_1 < \rho_3 < \rho_2$
(4) $\rho_3 < \rho_1 < \rho_2$

**37.** A ball is made of a material of density $\rho$ where $\rho_{oil} < \rho < \rho_{water}$ with $\rho_{oil}$ and $\rho_{water}$ representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position?

(1)



(2)


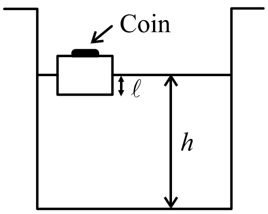

(3)



(4)



**38.** An application of Bernoulli's equation for fluid flow is found in:

(1) Dynamic lift of an aeroplane
(2) Viscosity meter
(3) Capillary rise
(4) Hydraulic press

**39.** A wooden block with a coin placed on its top, floats in water as shown in figure. The distance $\ell$ and $h$ are shown here. After some time the coin falls into the water. Then:




(1) $\ell$ decreases and $h$ increase
(2) $\ell$ increases and $h$ decreases
(3) Both $\ell$ and $h$ increases
(4) Both $\ell$ and $h$ decrease

**40.** **STATEMENT -1:** The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down. and

**STATEMENT -2:** In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

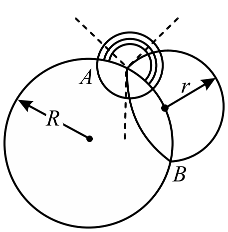
**41.** Neglecting gravity, the potential energy of a molecule of liquid on the surface of liquid when compared with *PE* of a molecule inside liquid is:
(1) Greater
(2) Less
(3) Equal
(4) Depending on the liquid sometimes more, sometimes less

**42.** Insects are able to run on the surface of water because:
(1) Insects have less weight
(2) Insects swim on water
(3) Of the Archimede's upthrust
(4) Surface tension makes the surface behave as elastic membrane.

**43.** At critical temperature, the surface tension of a liquid:
(1) Is zero
(2) Is infinity
(3) Is same as that at any other temperature
(4) Cannot be determined

**44.** The work done in increasing the size of a rectangular soap film with dimensions 8cm × 3.75 cm to 10 cm × 6 cm is $2 \times 10^{-4}$ J. The surface tension of the film in N/m is:
(1) $1.65 \times 10^{-2}$ (2) $3.3 \times 10^{-2}$
(3) $6.6 \times 10^{-2}$ (4) $8.25 \times 10^{-2}$

**45.** A soap - bubble with a radius '*r*' is placed on another bubble with a radius *R* (figure). Angles between the films at the points of contact will be:




(1) $120^0$ (2) $30^0$
(3) $45^0$ (4) $90^0$

**46.** A liquid rises in a capillary tube when the angle of contact is:
(1) Acute
(2) Obtuse
(3) $\pi/2$ radian
(4) $\pi$ radian

**47.** There is a horizontal film of soap solution. On it a thread is placed in the form of a loop. The film is pierced inside the loop and the thread becomes a circular loop of radius *R*. If the surface tension of the soap solution be *T*, then the tension in the thread will be:
(1) $\pi R^2/T$ (2) $\pi R^2 T$
(3) $2\pi RT$ (4) $2RT$

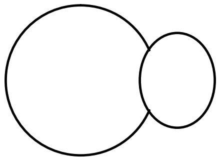
**48.** A soap bubble of radius $r_1$ is placed on another soap bubble of radius $r_2$ ($r_1 < r_2$). The radius *R* of the soapy film separating the two bubbles is:
(1) $r_1 + r_2$ (2) $\sqrt{r_1^2 + r_2^2}$
(3) $(r_1^3 + r_2^3)$ (4) $\frac{r_2 r_1}{r_2 - r_1}$

**49.** A water drop is divided into 8 equal droplets. The pressure difference between the inner and outer side of the big drop will be:
(1) Same as for smaller droplet
(2) 1/2 of that for smaller droplet
(3) 1/4 of that for smaller droplet
(4) Twice that for smaller droplet

**50.** A soap bubble in vacuum has a radius of 3 cm and another soap bubble in vacuum has a radius of 4 cm. If the two bubbles coalesce under isothermal conditions then the radius of the new bubble is:
(1) 2.3 cm (2) 4.5 cm
(3) 5 cm (4) 7 cm

**51.** The radius *R* of the soap bubble is doubled under isothermal condition. If *T* be the surface tension of soap bubble, the required surface energy in doing so is given by:
(1) $32\pi R^2 T$ (2) $24\pi R^2 T$
(3) $8\pi R^2 T$ (4) $4\pi R^2 T$

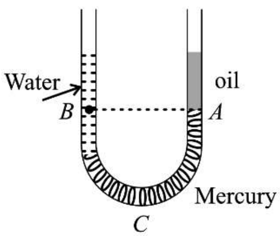
**52.** **STATEMENT–1:** When two soap bubble's of different radii are brought into contact, the common interface of contact bulges into the bubble of larger radii as shown.



**STATEMENT–2:** Pressure inside a soap bubble of lesser radius is more than pressure inside a soap bubble of larger radius.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**53.** **STATEMENT-1:** The static condition of tube and liquids in it are as shown. The pressure at *B* is more than that at *A*.




**STATEMENT-2:** Pressure at the same level in static fluid is same

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**54.** If two soap bubbles of different radii are connected by a tube:

(1) Air flows from the bigger bubble to the smaller bubble till the sizes become equal
(2) Air flows from bigger bubble to the smaller bubble till the sizes are interchanged
(3) Air flows from the smaller bubble to the bigger
(4) There is no flow of air

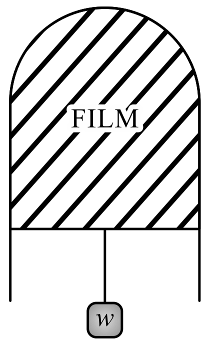
**55.** Work done in increasing the size of a soap bubble from a radius of 3 cm to 5 cm is nearly. (Surface tension of soap solution = 0.03 $Nm^{-1}$)

(1) $4\pi$ mJ  (2) $0.2\pi$ mJ
(3) $2\pi$ mJ  (4) $0.4\pi$ mJ

**56.** Two mercury drops (each of radius '$r$') merge to from bigger drop. The surface energy of the bigger drop, if $T$ is the surface tension, is:

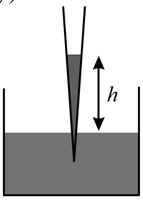
(1) $4\pi r^2T$  (2) $2\pi r^2T$
(3) $T\,2^{8/3}\,\pi r^2$  (4) $r^2T$

**57.** A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5 × $10^{-2}$ N (see figure). The length of the slider is 30 cm and its weight is negligible. The surface tension of the liquid film is:




(1) 0.0125 $Nm^{-1}$
(2) 0.1 $Nm^{-1}$
(3) 0.05 $Nm^{-1}$
(4) 0.025 $Nm^{-1}$

**58.** A glass capillary tube is of the shape of a truncated cone with an apex angle $\alpha$ so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross section is b. If the surface tension of water is S, its density is $\rho$, and its contact angle with glass is $\theta$, the value of h will be (g is the acceleration due to gravity)




(1) $\frac{2S}{b\rho g}\cos(\theta-\alpha)$

(2) $\frac{2S}{b\rho g}\cos(\theta+\alpha)$

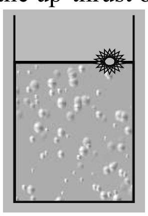
(3) $\frac{2S}{b\rho g}\cos(\theta-\alpha/2)$

(4) $\frac{2S}{b\rho g}\cos(\theta+\alpha/2)$

### *Integer Type Questions (59 to 73)*

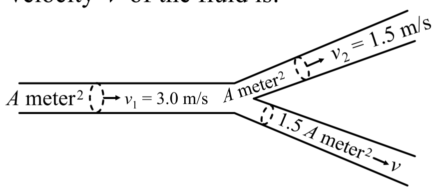
**59.** An open tank 10 m long and 2 m deep is filled up to 1.5 m height of oil of specific gravity 0.82. The tank is uniformly accelerated along its length from rest to a speed of 20 m/sec horizontally. The shortest time (in sec) in which the speed may be attained without spilling any oil is:
[$g$ = 10 m/sec$^2$]

**60.** A body floats in liquid contained in a beaker. If the whole system (shown in fig.) falls under gravity then the up-thrust on the body is:



**61.** A cubical block of copper of side 10 cm is floating in a vessel containing mercury. Water is poured into the vessel so that the copper block just gets submerged. The height (in cm) of water column is
($\rho_{Hg}$ = 13.6 g/cc, $\rho_{Cu}$ = 7.3 g/cc,
$\rho_{water}$ =1 gm/cc)

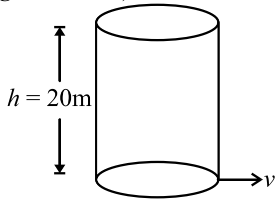
**62.** An incompressible liquid flows through a horizontal tube as shown in the figure. Then the velocity '$v$' of the fluid is:




**63.** The reading of a spring balance when a block is suspended from it in air is 60 newton. This reading is changed to 40 newton when the block is submerged in water. The specific gravity of the block must be therefore:

**64.** Two bodies are in equilibrium when suspended in water from the arms of a balance. The mass of one body is 36 g and its density is 9 g/cc. If the mass of the other is 48 g, its density in g/cc is:

**65.** A cylinder of height 20 m is completely filled with water. The velocity of efflux of water (in ms$^{-1}$) through a small hole on the side wall of the cylinder near its bottom, is:
(Take $g$ = 10 m/s$^2$)

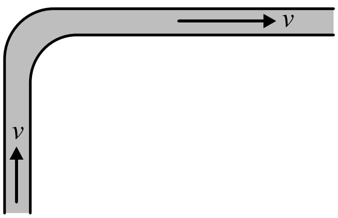



**66.** A uniform cylinder of length $L$ and mass $M$ having cross-sectional area $A$ is suspended, with its length vertical, from a fixed point by a massless spring such that it is half submerged in a liquid of density $\sigma$ at equilibrium position. The extension $x_0$ of the spring when it is in equilibrium is $\frac{Mg}{k}\left(1-\frac{LA\sigma}{xM}\right)$. Then find the value of $x$.

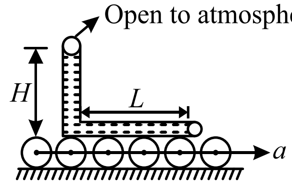
**67.** A 20 cm long capillary tube is dipped in water. The water rises upto 8 cm. If the entire arrangement is put in a freely falling elevator, the length of water column (in cm) in the capillary tube will be:

**68.** A hollow sphere of volume $V$ is floating on water surface with half immersed in it. The minimum volume of water poured inside the sphere so that the sphere now sinks into the water is $\frac{V}{n}$ then $n$ is:

**69.** A fire hydrant delivers water of density ρ at a volume rate $L$. The water travels vertically upward through the hydrant and then does $90^0$ turn to emerge horizontally at speed $v$. The pipe and nozzle have uniform cross-section throughout. The force exerted by the water on the corner of the hydrant is $\sqrt{n}\,\rho vL$ then $n$ is




**70.** A narrow tube completely filled with a liquid is lying on a series of cylinders as shown in figure. Assuming no sliding between any surfaces, the value of acceleration of the cylinders for which liquid will not come out of the tube from anywhere is given by $\frac{gH}{nL}$ then $n$ is:




**71.** The bob of a simple pendulum executes simple harmonic motion in water with a period $t$, while the period of oscillation of the bob is $t_0$ in air. Neglecting frictional force of water and given that the density of the bob is (4/3) × 1000 kg/m$^3$. The value of $\frac{t}{t_0}$ is.

**72.** A solid sphere of radius $R$ and density ρ is attached to one end of a mass-less spring of force constant $k$. The other end of the spring is connected to another solid sphere of radius $R$ and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The net elongation of the spring is $\frac{n\pi R^3\rho g}{3k}$ then $n$ is.

**73.** A capillary tube of radius $R$ is immersed in water and water rises in it to a height $H$. Mass of water in capillary tube is $M$. If the radius of the tube is doubled, mass of water that will rise in capillary tube will be $nM$. Then $n$ is

CHAPTER

11

# THERMODYNAMICS & KINETIC THEORY OF GASES

## *Single Option Correct Type Questions (01 to 61)*

**1.** At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm? Both the diameters have been measured at room temperature (27°C). (Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5}\ K^{-1}$)

(1) 125.7ºC (2) 91.7ºC
(3) 425.7ºC (4) 152.7ºC

**2.** A lead bullet penetrates into a solid object and melts. Assuming that 40% of its kinetic energy is used to heat it, the initial speed of bullet is: (Given, initial temperature of the bullet = 127°C, Melting point of the bullet = 327°C, Latent heat of fusion of lead = 2.5 × 104 $Jkg^{-1}$, Specific heat capacity of lead= 125 J/kg K)

(1) 125 $ms^{-1}$ (2) 500 $ms^{-1}$
(3) 250 $ms^{-1}$ (4) 600 $ms^{-1}$

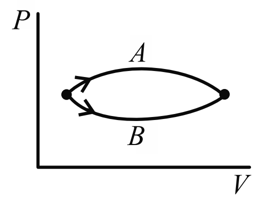
**3.** A calorimeter of water equivalent 20g contains 180g of water at 25°C. '*m*' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to (Latent heat of water = 540 cal $g^{-1}$, Specific heat of water = 1 cal $g^{-1}\ °C^{-1}$]

(1) 2 (2) 3.2
(3) 2.6 (4) 4

**4.** Two identical metal of thermal conductivities $K_1$ and $K_2$ respectively are connected in series. The effective thermal conductivity of the combination is:

(1) $\dfrac{K_1+K_2}{K_1K_2}$ (2) $\dfrac{K_1+K_2}{2K_1K_2}$
(3) $\dfrac{2K_1K_2}{K_1+K_2}$ (4) $\dfrac{K_1K_2}{K_1+K_2}$

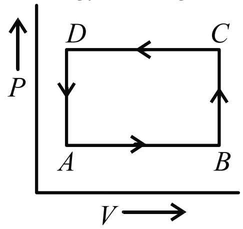
**5.** Refer to fig. Let $\Delta U_1$ and $\Delta U_2$ be the changes in internal energy of an ideal gas in the processes *A* and *B* then



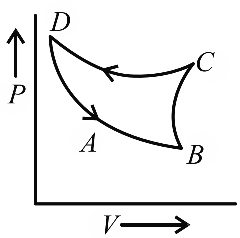

(1) $\Delta U_1 > \Delta U_2$ (2) $\Delta U_1 = \Delta U_2$
(3) $\Delta U_1 < \Delta U_2$ (4) $\Delta U_1 \neq \Delta U_2$

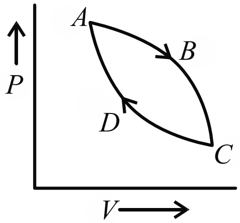
**6.** In the following figures (1) to (4), variation of volume by change of pressure is shown. A gas is taken along the path *ABCDA*. The change in internal energy of the gas will be:

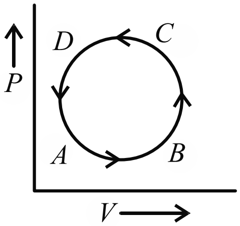
(a)




(b)

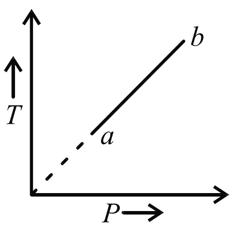


(c) 


(d) 

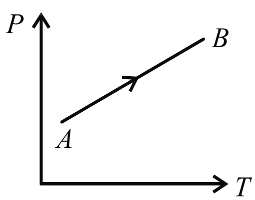

(1) positive in all cases from (a) to (d)
(2) positive in cases (a), (b) and (c) but zero in case (d)
(3) negative in cases (a), (b) and (c) but zero in case (d)
(4) zero in all the four cases

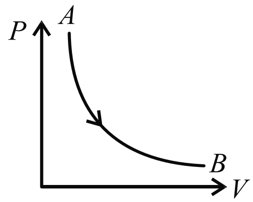
**7.** An ideal gas changes from state $a$ to state $b$ as shown in Fig. What is the work done by the gas in the process?

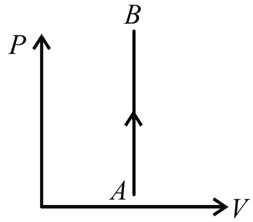


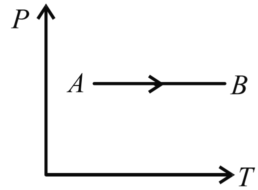

(1) Zero
(2) Positive
(3) Negative
(4) Infinite

**8.** The process $\Delta U = 0$, for an ideal gas can be best represented in the form of a graph :

(1) 


(2) 

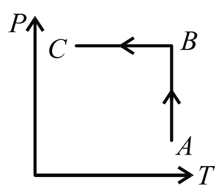

(3) 


(4) 


**9.** In the isothermal expansion of an ideal gas. Select wrong statement:

(1) there is no change in the temperature of the gas
(2) there is no change in the internal energy of the gas
(3) the work done by the gas is equal to the heat supplied to the gas
(4) the work done by the gas is equal to the change in its internal energy

**10.** Ideal gas is taken through process shown in figure:




(1) In process $AB$, work done by system is positive
(2) In process $AB$, heat is rejected out of the system.
(3) In process $AB$, internal energy increases
(4) In process $AB$ internal energy decreases and in process $BC$ internal energy increases.

**11.** A system can be taken from the initial state $p_1$, $V_1$ to the final state $p_2$, $V_2$ by two different methods. Let $\Delta Q$ and $\Delta W$ represent the heat given to the system and the work done by the system. Which of the following must be the same in both the methods?

(1) $\Delta Q$ (2) $\Delta W$
(3) $\Delta Q + \Delta W$ (4) $\Delta Q - \Delta W$

**12.** In isothermal process if heat is released from an ideal gas then,

(1) the internal energy of the gas will increase
(2) the gas will do positive work
(3) the gas will do negative work
(4) the given process is not possible

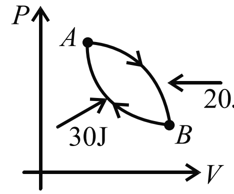
**13.** When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas is.

(1) $\frac{2}{5}$ (2) $\frac{3}{5}$
(3) $\frac{3}{7}$ (4) $\frac{5}{7}$

**14.** A gas is contained in a metallic cylinder fitted with a piston. The piston is suddenly moved in to compress the gas and is maintained at this position. As time passes, after this the pressure of the gas in the cylinder

(1) increases
(2) decreases
(3) remains constant
(4) increases or decreases depending on the nature of the gas.

**15.** In a cyclic process shown in the figure an ideal gas is adiabatically taken from $B$ and $A$, the work done on the gas during the process $B \to A$ is 30 $J$, when the gas is taken from $A \to B$ the heat absorbed by the gas is 20 $J$. The change in internal energy of the gas in the process $A \to B$ is:




(1) 20 $J$ (2) – 30 $J$
(3) 50 $J$ (4) – 10 $J$

**16.** An ideal gas is allowed to expand freely against a vacuum in a rigid insulated container. The gas undergoes:

(1) an increase in its internal energy
(2) a decrease in its internal energy
(3) neither an increase nor decrease in temperature or internal energy
(4) an increase in temperature

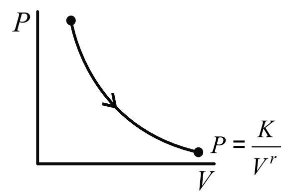
**17.** For free expansion of a gas in an adiabatic container which of the following is true?

(1) $Q = W = \Delta U = 0$
(2) $Q = 0$, $W > 0$ and $\Delta U = Q$
(3) $W = 0$, $Q > 0$ and $\Delta U = Q$
(4) $W = 0$, $Q < 0$ and $\Delta U = 0$

**18.** Starting with the same initial conditions, an ideal gas expands from volume $V_1$ to $V_2$ in three different ways. The work done by the gas is $W_1$ if the process is isothermal, $W_2$ if isobaric and $W_3$ if adiabatic, then

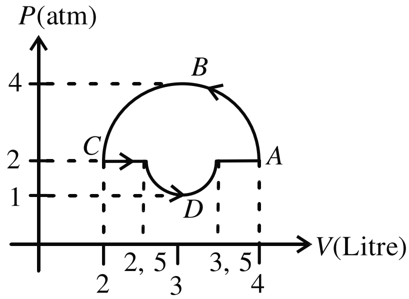
(1) $W_2 > W_1 > W_3$ (2) $W_2 > W_3 > W_1$
(3) $W_1 > W_2 > W_3$ (4) $W_1 > W_3 > W_2$

**19.** The molar heat capacity for the process shown in fig. is




(1) $C = C_p$
(2) $C = C_v$
(3) $C > C_v$
(4) $C = 0$

**20.** Find work done by the gas in the process shown in figure:




(1) $\frac{5}{2}\pi$ atm $L\frac{3}{2}$

(2) $\frac{5}{2}$ atm $L$

(3) $-\pi$ atm $L$

(4) $-\frac{5}{4}\pi$ atm $L$

**21.** **STATEMENT-1:** The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume. Because

**STATEMENT-2:** The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

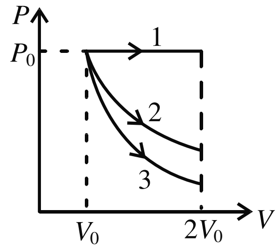
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True.

**22.** A gas is expanded from volume $V_0$ to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let $\Delta U_1$, $\Delta U_2$ and $\Delta U_3$ be the change in internal energy of the gas in these three processes. Then: (Take quantity along with sign)



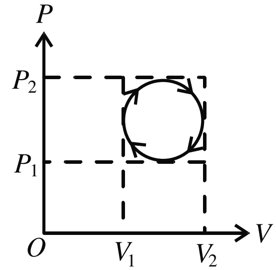

(1) $\Delta U_1 > \Delta U_2 > \Delta U_3$

(2) $\Delta U_1 < \Delta U_2 < \Delta U_3$

(3) $\Delta U_2 < \Delta U_1 < \Delta U_3$

(4) $\Delta U_2 < \Delta U_3 < \Delta U_1$

**23.** In the cyclic process shown on the $P - V$ diagram the magnitude of the work done is



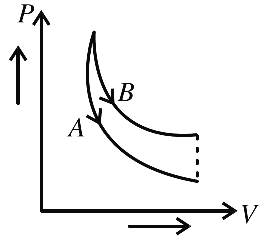

(1) $\pi\left(\frac{P_2 - P_1}{2}\right)^2$

(2) $\pi\left(\frac{V_2 - V_1}{2}\right)^2$

(3) $\frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

(4) $\pi(P_2V_2 - P_1V_1)$

**24.** $A$ and $B$ are two adiabatic curves for two different gases. Then $A$ and $B$ corresponds to:




(1) $Ar$ and $He$ respectively

(2) $He$ and $H_2$ respectively

(3) $O_2$ and $H_2$ respectively

(4) $H_2$ and $He$ respectively

**25.** A gas undergoes a process in which its pressure $P$ and volume $V$ are related as $VP^n$ = constant. The bulk modulus of the gas in the process is:
(1) $nP$ (2) $P^{1/n}$
(3) $P/n$ (4) $P^n$

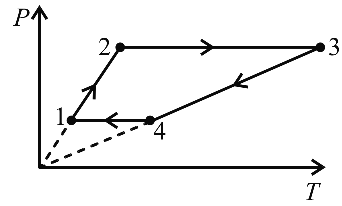
**26.** For adiabatic process of an ideal gas the value of $\frac{dP}{P}$ is equal to -
(1) $-\gamma\frac{dV}{V}$ (2) $-\gamma\frac{V}{dV}$
(3) $\frac{dV}{V}$ (4) $-\gamma^2\frac{dV}{V}$

**27.** A system is given 400 calories of heat and 1000 joule of work is done by the system, then the change in internal energy of the system will be - [1 cal = 4.2 J]
(1) 680 *joule* (2) 680 *erg*
(3) 860 *joule* (4) – 860 *joule*

**28.** Two samples of a gas *A* and *B* initially at same temperature and pressure, are compressed to half their initial volume, *A* isothermally and *B* adiabatically. The final pressure in -
(1) *A* and *B* will be same
(2) *A* will be more than in *B*
(3) *A* will be less than in *B*
(4) *A* will be double that in *B*

**29.** The isothermal bulk modulus of elasticity of a gas is $1.5 \times 10^5$ $N/m^2$. Its adiabatic bulk modulus of elasticity will be if $\gamma = 1.4$ -
(1) $1.5 \times 10^5$ $N/m^2$ (2) $3 \times 10^5$ $N/m^2$
(3) $2.1 \times 10^5$ $N/m^2$ (4) $\infty$

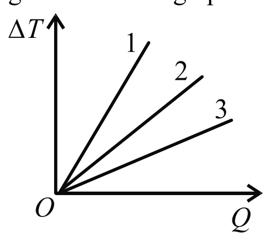
**30.** Three moles of an ideal monoatomic gas perform a cycle shown in figure. The gas temperatures in different states are $T_1 = 400\ K$, $T_2 = 800\ K$, $T_3 = 2400\ K$, and $T_4 = 1200\ K$. The work done by the gas during the cycle is: $\left[R = \frac{25}{3} J/mol-k\right]$




(1) 5 *kJ* (2) 10 *kJ*
(3) 15 *kJ* (4) 20 *kJ*

**31.** **Statement-1:** An ideal gas is enclosed within a container fitted with a piston. When volume of this enclosed gas is increased at constant temperature, the pressure exerted by the gas on the piston decreases.
**Statement-2:** In the above situation the rate of molecules striking the piston decreases. If the rate at which molecules of a gas having same average speed striking a given area of the wall decreases, the pressure exerted by gas on the wall decreases.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**32.** The straight lines in the figure depict the variations in temperature $\Delta T$ as a function of the amount of heat supplied $Q$ in different process involving the change of state of a monoatomic and a diatomic ideal gas. The initial states ($P$, $V$, $T$) of the two gases are the same. Match the processes as described, with the straight lines in the graph as numbered.



| | Column- I | | Column- II |
|---|---|---|---|
| I | Isobaric process of monoatomic gas. | P | 1 |
| II | Isobaric process of diatomic gas | Q | 2 |
| III | Isochoric process of monoatomic gas | R | 3 |
| IV | Isochoric process of diatomic gas | S | $x$-axis (Q-axis) |

(1) I-P; II-S; III-Q; IV-R
(2) I-R; II-Q; III-S; IV-P
(3) I-P; II-Q; III-R; IV-S
(4) I-Q; II-R; III-P; IV-Q

**33.** Match the following (Where the letters $dQ$, $dU$ and $dW$ have usual meaning)

| | Column-I | | Column- II |
|---|---|---|---|
| I | Adiabatic expansion | P | $dQ = 0$ |
| II | Adiabatic free expansion | Q | $dU = 0$ |
| III | Isochoric cooling | R | $dW = 0$ |
| IV | Isobaric expansion | S | $dQ = dU + dW$ |

(1) I-P, S; II-P, R, S; III-R, S; IV-S
(2) I-P, S; II-P, Q, R, S; III-R, S; IV-S
(3) I-P, S; II-P, Q, R, S; III-R, P; IV-S
(4) I-P, S; II-P, Q, R, S; III-R, Q; IV-S

**34.** 1 mole of a gas with $\gamma = 7/5$ is mixed with 1 mole of a gas with $\gamma = 5/3$, then the value of $\gamma$ for the resulting mixture is:
(1) 7/5 (2) 2/5
(3) 24/16 (4) 12/7

**35.** "Heat cannot itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of:
(1) second law of thermodynamics
(2) conservation of momentum
(3) conservation of mass
(4) first law of thermodynamics

**36.** During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio $C_p/C_v$ for the gas is:
(1) 4/3 (2) 2
(3) 5/3 (4) 3/2

**37.** Which of the following parameters does not characterise the thermodynamic state of matter?
(1) Temperature (2) Pressure
(3) Work (4) Volume

**38.** One mole of ideal monoatomic gas is mixed with one mole of diatomic gas. What is $\gamma$ for the mixture? $\gamma$ denotes the ratio of specific heat at constant pressure, to that at constant volume.
(1) 3/2 (2) 23/15
(3) 35/23 (4) 4/3

**39.** Which of the following statements is correct for any thermodynamic system?
(1) The internal energy changes in all processes
(2) Internal energy and entropy are state functions
(3) The change in entropy can never be zero
(4) The work done in an adiabatic process is always zero

**40.** Two thermally insulated vessels 1 and 2 are filled with air at temperature ($T_1$, $T_2$), volume ($V_1$, $V_2$) and pressure ($P_1$, $P_2$) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be:
(1) $T_1 + T_2$
(2) $(T_1 + T_2)/2$
(3) $\dfrac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$
(4) $\dfrac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

**41.** Which of the following is incorrect regarding the first law of thermodynamics?
(1) It is applicable to any cycle process
(2) It is a restatement of the principle of conservation of energy
(3) It introduces the concept of the internal energy
(4) It introduces the concept of the entropy

**42.** A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{C_v}$ of the mixture is:
(1) 1.59 (2) 1.62
(3) 1.4 (4) 1.54

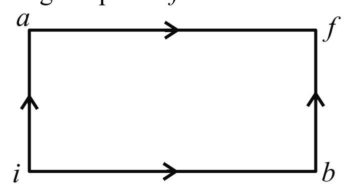
**43.** An ideal gas is expanding such that $PT^2$ = constant. The coefficient of volume expansion of the gas is (coefficient of volume expansion)
(1) $\frac{1}{T}$ (2) $\frac{2}{T}$
(3) $\frac{3}{T}$ (4) $\frac{4}{T}$

**44.** Two rigid boxes containing different ideal gases are placed on a table. Box *A* contains one mole of nitrogen at temperature $T_o$, while box *B* contains one mole of helium at temperature $(7/3)T_o$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature. (Ignore the heat capacity of boxes). Then, the final temperature of the gases, $T_f$ in terms of $T_0$ is:
(1) $T_f = \frac{3}{7}T_0$ (2) $T_f = \frac{7}{3}T_0$
(3) $T_f = \frac{3}{2}T_0$ (4) $T_f = \frac{5}{2}T_0$

**45.** The work of 146 *kJ* is performed in order to compress one kilo mole of a gas adiabatically and in this process the temperature of the gas increases by 7 ºC. The gas is
($R = 8.3\ J\ mol^{-1}\ K^{-1}$)
(1) diatomic
(2) triatomic
(3) mixture of monoatomic and diatomic
(4) monoatomic

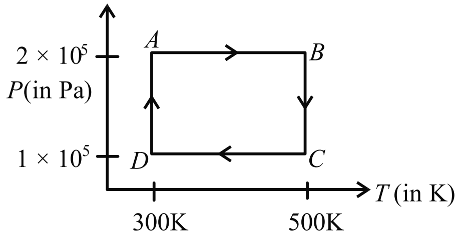
**46.** If $C_p$ and $C_V$ denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then
(1) $C_p - C_v = R/28$
(2) $C_p - C_v = R/14$
(3) $C_p - C_v = R$
(4) $C_p - C_v = 28R$

**47.** When a system is taken from state *i* to state *f* along the path *iaf*, it is found that *Q* = 50 *cal* and *W* = 20 *cal*. Along the path *ibf Q* = 36 *cal*. *W* along the path *ibf* is




(1) 6 cal
(2) 16 cal
(3) 66 cal
(4) 14 cal

**48.** Two moles of helium gas are taken over the cycle *ABCDA*, as shown in the P-T diagram.




Assume the gas to be ideal the magnitude of work done on the gas in taking it from *A* to *B* is
(1) 200 *R*
(2) 300 *R*
(3) 400 *R*
(4) 500 *R*

**49.** One kg of a diatomic gas is at a pressure of $8 \times 10^4$ N/m$^2$. The density of the gas is 4 kg/m$^3$. What is the energy of the gas due to its thermal motion?

(1) $5 \times 10^4$ J (2) $6 \times 10^4$ J
(3) $7 \times 10^4$ J (4) $3 \times 10^4$J

**50.** 100g of water is heated from 30ºC to 50ºC ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 *J/Kg/K*):

(1) 4.2 kJ (2) 8.4 kJ
(3) 84 kJ (4) 2.1 kJ

**51.** A thermally insulated vessel contains an ideal gas of molecular mass $M$ and ratio of specific heats $\gamma$. It is moving with speed $v$ and is suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by :

(1) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2$ (2) $\frac{(\gamma-1)}{2\gamma R}Mv^2$

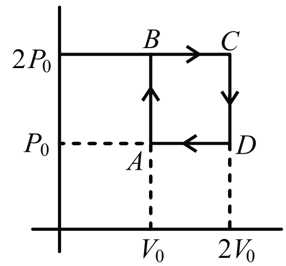
(3) $\frac{\gamma Mv^2}{2R}$ (4) $\frac{(\gamma-1)}{2R}Mv^2$

**52.** A container with insulating walls is divided into equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure $P$ and temperature $T$, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be :

(1) $\frac{P}{2}, \frac{T}{2}$ (2) $P, T$

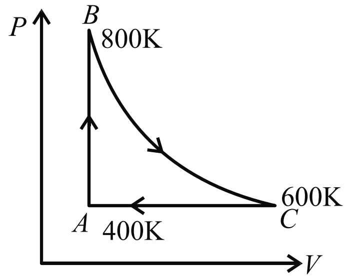
(3) $P, \frac{T}{2}$ (4) $\frac{P}{2}, T$

**53.** Helium gas goes through a cycle $ABCDA$ (consisting of two isochoric and isobaric lines) as shown in figure. Efficiency of this cycle is nearly: (Assume the gas to be close to ideal gas)




(1) 15.4% (2) 9.1%
(3) 10.5% (4) 12.5%

**54.** One mole of diatomic ideal gas undergoes a cyclic process $ABCA$ as shown in figure. The process $BC$ is adiabatic. The temperatures at $A$, $B$ and $C$ are 400 $K$, 800 $K$ and 600 $K$ respectively. Choose the correct statement :




(1) The change in internal energy in whole cyclic process is 250 $R$.
(2) The change in internal energy in the process $CA$ is 700 $R$
(3) The change in internal energy in the process $AB$ is – 350 $R$
(4) The change in internal energy in the process $BC$ is – 500 $R$

**55.** An open glass tube is immersed in mercury in such a way that a length of 8 *cm* extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 *cm*. What will be length of the air column above mercury in the tube now?

(Atmospheric pressure = 76 *cm* of *Hg*)

(1) 16 cm (2) 22 cm
(3) 38 cm (4) 6 cm

**56.** Consider a spherical shell of radius $R$ at temperature $T$. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between $T$ and $R$ is

(1) $T \propto e^{-R}$ (2) $T \propto e^{-3R}$

(3) $T \propto \frac{1}{R}$ (4) $T \propto \frac{1}{R^3}$

**57.** Consider an ideal gas confined in an isolated closed chamber. As the gas under goes an adiabatic expansion, the average time of collision between molecules increases as $V^q$, where $V$ is the volume of the gas. The value of $q$ is $\left(\gamma = \frac{C_P}{C_V}\right)$ :

(1) $\frac{3\gamma+5}{6}$ (2) $\frac{3\gamma-5}{6}$

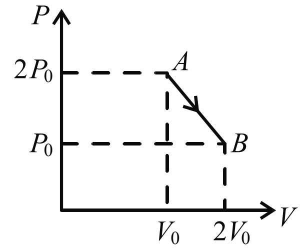
(3) $\frac{\gamma+1}{2}$ (4) $\frac{\gamma-1}{2}$

**58.** An ideal gas undergoes a quasistatic, reversible process in which its molar heat capacity $C$ remains constant. If during this process the relation of pressure $P$ and volume $V$ is given by $PV^n$ = constant, then $n$ is given by (Here $Cp$ and $C_V$ are molar specific heat at constant pressure and constant volume, respectively) :

(1) $n = \frac{C-C_p}{C-C_v}$ (2) $n = \frac{C_p-C}{C-C_v}$

(3) $n = \frac{C-C_v}{C-C_p}$ (4) $n = \frac{C_p}{C_v}$

**59.** '$n$' moles of an ideal gas undergoes a process $AB$ as shown in the figure. The maximum temperature of the gas during the process will be :




(1) $\frac{3P_0V_0}{2nR}$ (2) $\frac{9P_0V_0}{2nR}$

(3) $\frac{9P_0V_0}{nR}$ (4) $\frac{9P_0V_0}{4nR}$

**60.** $C_p$ and $C_v$ are specific heats per unit mass at constant pressure and constant volume respectively. It is observed that

$C_p - C_v = a$ for hydrogen gas

$C_p - C_v = b$ for nitrogen gas

The correct relation between a and b is :

(1) $a = 28\ b$ (2) $a = \frac{1}{14}b$

(3) $a = b$ (4) $a = 14\ b$

**61.** When the temperature of metal wire is increased from 0°C to 10°C, its length increase by 0.02%. The percentage change in its mass density will be close to:

(1) 0.008 (2) 0.8

(3) 0.06 (4) 2.3

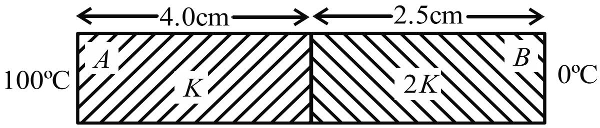
## *Integer Type Questions (62 to 76)*

**62.** A block of ice of mass 120 g at temperature 0ºC is put in 300 g of water at 25ºC. The $x$g of ice melts as the temperature of the water reaches 0ºC. The value of $x$ is _______.

[Use specific heat capacity of water = 4200 $Jkg^{-1} K^{-1}$, Latent heat of ice = $3.5 \times 10^5\ Jkg^{-1}$]

**63.** A steel rod with $y = 2.0 \times 10^{11}\ Nm^{-2}$ and $\alpha = 10^{-5}\ °C^{-1}$ of length 4 m and area of cross-section 10 $cm^2$ is heated from 0°C to 400°C without being allowed to extend. The tension produced in the rod is $x \times 10^5$ N where the value of $x$ is __________.

**64.** As per the given figure, two plates $A$ and $B$ of thermal conductivity $K$ and $2K$ are joined together to form a compound plate. The thickness of plates are 4.0 cm and 2.5 cm respectively and the area of cross-section is 120 $cm^2$ for each plate. The equivalent thermal conductivity of the compound plate is $\left(1+\frac{5}{\alpha}\right)K$, then the value of α will be_________.



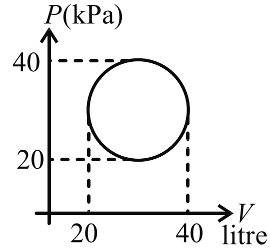

**65.** Number of molecules in a volume of 4 $cm^3$ of a perfect monoatomic gas at some temperature $T$ and at a pressure of 2 $cm$ of mercury is close to $n \times 10^{18}$? (Given, mean kinetic energy of a molecule (at $T$) is $4 \times 10^{-14}$ $erg$, $g = 980$ $cm/s^2$, density of mercury = 13.6 $g/cm^3$). Find $n$.

**66.** At temperature 300 $K$, the rms speed of oxygen molecules is $\sqrt{\frac{\alpha+5}{\alpha}}$ times to that of its average speed in the gas. Then, the value of α will be (use $\pi = \frac{22}{7}$)

**67.** 1 mole of rigid diatomic gas performs a work of $\frac{Q}{5}$ when heat Q is supplied to it. The molar heat capacity of the gas during this transformation is $\frac{xR}{8}$. The value of $x$ is ______. [$R$ = universal gas constant]

**68.** A closed vessel contains 0.1 mole of a monatomic ideal gas at 200 $K$. If 0.05 mole of the same gas at 400 $K$ is added to it, the final equilibrium temperature (in $K$) of the gas in the vessel will be $\frac{800}{n}$. Find $n$.

**69.** In the reported figure, heat energy absorbed by a system in going through a cyclic process is $x$ πJ. Find $x$.




**70.** Nitrogen gas is at 300°C temperature. The temperature (in $K$) at which the rms speed of a $H_2$ molecule would be equal to the rms speed of a nitrogen molecule, is $\frac{573}{x}K$. Find $x$. (Molar mass of $N_2$ gas 28 $g$).

**71.** The root mean square speed of molecules of a given mass of a gas at 27° C and 1 atmosphere pressure is 200 $ms^{-1}$. The root mean square speed of molecules of the gas at 127° C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}} ms^{-1}$. The value of $x$ will be ________.

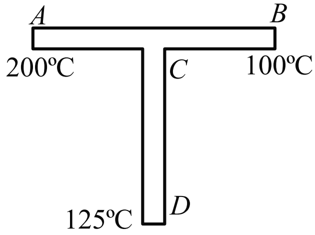
**72.** A container is divided into two chambers by a partition. The volume of first chamber is 4.5 litre and second chamber is 5.5 litre. The first chamber contain 3.0 moles of gas at pressure 2.0 atm and second chamber contain 4.0 moles of gas at pressure 3.0 atm. After the partition is removed and the mixture attains equilibrium, then, the common equilibrium pressure (in atm) existing in the mixture is $x \times 10^{-2}$. Value of $x$ is

**73.** Initially a gas of diatomic molecules is contained in a cylinder of volume $V_1$ at a pressure $P_1$ and temperature 250 $K$. Assuming that 25% of the molecules get dissociated causing a change in number of moles. The pressure of the resulting gas at temperature 2000 $K$, when contained in a volume $2V_1$ is given by $P_2$. The ratio $\frac{P_2}{P_1}$ is:

**74.** A system consists of two types of gas molecules *A* and *B* having same number density $2 \times 10^{25}/m^3$. The diameter of *A* and *B* are 10Å and 5Å respectively. They suffer collision at room temperature. The ratio of average distance covered by the molecule *A* to that of *B* between two successive collision is ________ $\times 10^{-2}$.

**75.** 0.056 *kg* of Nitrogen is enclosed in a vessel at a temperature of 127° C. The amount of heat required to double the speed of its molecules is *x kcal*. (Take $R = 2$ cal mole$^{-1}$ K$^{-1}$). Find *x*.

**76.** A rod *CD* of thermal resistance 10.0 kW$^{-1}$ is joined at the middle of an identical rod *AB* as shown in figure, The end *A*, *B* and *D* are maintained at 200°C, 100°C and 125°C respectively. The heat current in *CD* is *P* watt. The value of *P* is



CHAPTER

12

# OSCILLATIONS & WAVES

## Single Option Correct Type Questions (01 to 60)

**1.** Under similar conditions of temperature and pressure, In which of the following gases the velocity of sound will be maximum.

(1) $H_2$ (2) $N_2$

(3) He (4) $CO_2$

**2.** The terms pitch, quality and loudness of sound are associated with the following, respectively-

(1) intensity, frequency and waveform

(2) Frequency, intensity and waveform

(3) Frequency, waveform and intensity

(4) Waveform, frequency and intensity

**3.** When a sound wave travelling in air is reflected from a wall, the phase difference between the reflected and incident pressure wave is:

(1) 0

(2) $\pi$

(3) $\pi/2$

(4) $\pi/4$

**4.** In stationary sound waves, antinodes are the points where there is -

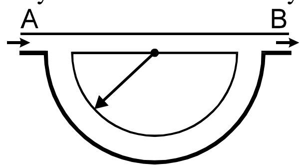
(1) Minimum displacement and minimum pressure change

(2) Minimum displacement and maximum pressure change

(3) Maximum displacement and maximum pressure change

(4) Maximum displacement and minimum pressure change

**5.** Sound signal is sent through a composite tube as shown in the figure. The radius of the semicircular portion of the tube is $r$, speed of sound in air is $v$. The source of sound is capable of giving varied frequencies in the range of $\nu_1$ and $\nu_2$ (where $\nu_2 > \nu_1$). If $n$ is an integer then frequency for maximum intensity is given by :




(1) $\frac{nv}{r}$ (2) $\frac{nv}{r(\pi-2)}$

(3) $\frac{nv}{\pi r}$ (4) $\frac{nv}{(r-2)\pi}$

**6.** **STATEMENT 1 :** The base of Laplace correction was that exchange of heat between the region of compression and rarefaction in air is negligible.

**STATEMENT 2 :** Air is bad conductor of heat and velocity of sound in air is quite large.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**7.** **STATEMENT 1 :** In sound waves variation of pressure and density of gas above and below average have maximum value at displacement node.

**STATEMENT 2 :** When particle on opposite side of displacement node approach each other gas between them is compressed and pressure rises so that at displacement node gas undergoes maximum amount of compression.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**8.** Regarding speed of sound in gas, match the statements in column-I with the results in column-II

| Column I | | Column II | |
|---|---|---|---|
| I | Temperature of gas is made 4 times and pressure 2 times | P | speed becomes $2\sqrt{2}$ times the initial value |
| II | Only pressure is made 4 times without change in temperature | Q | speed becomes 2 times the initial value |
| III | Only temperature is changed to 4 times | R | speed remains unchanged |
| IV | Gas is changed so that only Molecular mass of the gas is made 4 times | S | speed becomes half the initial value |

(1) I-Q; II-R; III-Q; IV–S
(2) I-R; II-Q; III-P; IV–S
(3) I-P; II-Q; III-R; IV–S
(4) I-S; II-R; III-P; IV–Q

**9.** The speed of sound in oxygen ($O_2$) at a certain temperature is 460 $ms^{-1}$. The speed of sound in helium (He) at the same temperature will be (assume both gases to be ideal) :

(1) 500 $ms^{-1}$ (2) 650 $ms^{-1}$
(3) 330 $ms^{-1}$ (4) 1419 $ms^{-1}$

**10.** A closed organ pipe of length $L$ and an open organ pipe contain gases of densities $\rho_1$ and $\rho_2$ respectively. The compressibility of gases are equal in both the pipe. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is:

(1) $\frac{L}{3}$ (2) $\frac{4L}{3}$
(3) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (4) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

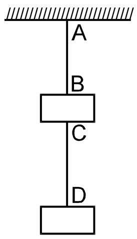
**11.** A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is 320 $ms^{-1}$, the mass of the string is :

(1) 5 grams (2) 10 grams
(3) 20 grams (4) 40 grams

**12.** A student is performing the experiment of Resonance Column. The diameter of the column tube is 4cm . The distance frequency of the tuning for $k$ is 512 Hz. The air temperature is 38°C in which the speed of sound is 336 m/s. The zero of the meter scale coincides with the top end of the Resonance column tube. When first resonance occurs, the reading of the water level in the column is

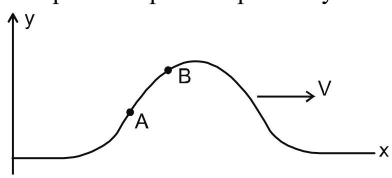
(1) 14.0
(2) 15.2
(3) 16.4
(4) 17.6

**13.** Two blocks each having a mass of 3.2 kg are connected by a wire *CD* and the system is suspended from the ceiling by another wire *AB* (figure). The linear mass density of the wire *AB* is 10 g/m and that of *CD* is 8 g/m. The speed of a transverse wave pulse produced in *AB* and in *CD* are :



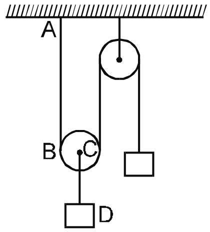

(1) 80 m/s and 63 m/s
(2) 63 m/s and 79 m/s
(3) 63 m/s in both
(4) 79 m/s in both

**14.** A wave pulse is generated in a string that lies along x-axis. At the points A and B, as shown in figure, if $R_A$ and $R_B$ are ratios of wave speed to the particle speed respectively then :




(1) $R_A > R_B$
(2) $R_B > R_A$
(3) $R_A = R_B$
(4) Information is not sufficient to decide.

**15.** Both the strings, show in figure, are made of same material and have same cross-section. The pulleys are light. The wave speed of a transverse wave in the string *AB* is $v_1$ and in *CD* it is $v_2$. Then $v_1/v_2$ is (Assume that tension doesn't vary due to masses of the strings and system is in equilibrium)




(1) 1
(2) 2
(3) $\sqrt{2}$
(4) $\frac{1}{\sqrt{2}}$

**16.** When two waves of the same amplitude and frequency but having a phase difference of $\phi$, travelling with the same speed in the same direction (positive *x*), interfere, then

(1) their resultant amplitude will be twice that of a single wave but the frequency will be same
(2) their resultant amplitude and frequency will both be twice that of a single wave
(3) their resultant amplitude will depend on the phase angle while the frequency will be the same
(4) the frequency and amplitude of the resultant wave will depend upon the phase angle.

**17.** A heavy but uniform rope of length *L* is suspended from a ceiling. A particle is dropped from the ceiling at the instant when the bottom end is given the jerk. Where will the particle meet the pulse :

(1) At a distance $\frac{2L}{3}$ from the bottom
(2) At a distance $\frac{L}{3}$ from the bottom
(3) At a distance $\frac{3L}{4}$ from the bottom
(4) None of these

**18.** **Assertion :** The wave function of a pulse given by $y = \dfrac{3}{(2x+3t+4)}$ propagates in (– ve $x$-direction)

**Reason :** The given wave function is of the form $y = f\,(kx + \omega t)$ which represent a wave travelling in negative $x$- direction. (symbols have usual meaning)

(1) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

(2) Both Assertion and Reason are true, but Reason is not correct explanation of Assertion.

(3) Assertion is true but Reason is false.

(4) Assertion is false but Reason is true.

**19.** **Assertion :** A wave can represented by function $y = f(kx \pm \omega t)$.

**Reason :** Because it satisfy the differential equation

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\left(\frac{\partial^2 y}{\partial t^2}\right) \text{ where } v = \frac{\omega}{k}$$

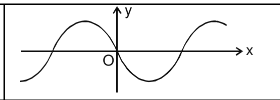
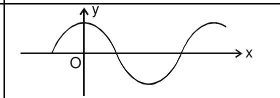
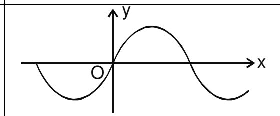
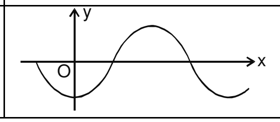
(1) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

(2) Both Assertion and Reason are true, but Reason is not correct explanation of Assertion.

(3) Assertion is true but Reason is false.

(4) Assertion is false but Reason is true.

**20.** For four sine waves, moving on a string along positive $x$ direction, displacement-distance curves ($y$-$x$ curves) are shown at time $t = 0$. In the right column, expressions for $y$ as function of distance $x$ and time $t$ for sinusoidal waves are given. All terms in the equations have general meaning. Correctly match $y$-$x$ curves with corresponding equations.

| | Column I | | Column II |
|---|---|---|---|
| I |  | P | $y = A\cos(\omega t - kx)$ |
| II |  | Q | $y = -A\cos(kx - \omega t)$ |
| III |  | R | $y = A\sin(\omega t - kx)$ |
| IV |  | S | $y = A\sin(kx - \omega t)$ |

(1) I-S; II-P; III-R; IV-Q

(2) I-R; II-P; III-S; IV-Q

(3) I-R; II-Q; III-S; IV-P

(4) I-R; II-S; III-Q; IV-P

**21.** Length of a string tied to two rigid supports is 40 cm. Maximum length (wavelength in cm) of a stationary wave produced on it, is -

(1) 20 (2) 80

(3) 40 (4) 120

**22.** The equation of a wave on a string of linear mass density 0.04 kg m$^{-1}$ is given by

$$y = 0.02\ (\text{m})\ \sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right].$$

The tension in the string is :

(1) 4.0 N (2) 12.5 N

(3) 0.5 N (4) 6.25 N

**23.** A travelling wave represented by $y = A\sin(\omega t - kx)$ is superimposed on another wave represented by $y = A\sin(\omega t + kx)$. The resultant is:

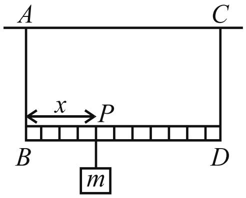
(1) A wave travelling along + $x$ direction

(2) A wave travelling along – $x$ direction

(3) A standing wave having nodes at $x = \dfrac{n\lambda}{2}$, $n = 0, 1, 2$ ....

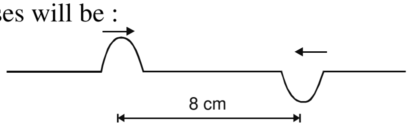
(4) A standing wave having nodes at $x = \left(n + \dfrac{1}{2}\right)\dfrac{\lambda}{2}$; $n = 0, 1, 2$ .....

**24.** A massless rod *BD* is suspended by two identical massless strings *AB* and *CD* of equal length ℓ. A block of mass '*m*' is suspended point *P* such that *BP* is equal to '*x*', if the fundamental frequency of the left wire is twice the fundamental frequency of right wire, then the value of *x* is :



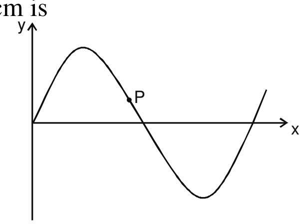

(1) ℓ/5 (2) ℓ/4
(3) 4ℓ/5 (4) 3ℓ/4

**25.** Two symmetrical and identical pulses in a stretched string, whose centres are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 seconds, the total energy of the pulses will be :




(1) zero
(2) purely kinetic
(3) purely potential
(4) partly kinetic and partly potential

**26.** A transverse sinusoidal wave moves along a string in the positive x-direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap-shot of the wave is shown in figure. The velocity of point P when its displacement is 5 cm is




(1) $\frac{\sqrt{3}\pi}{50}\hat{j}$ m/s (2) $-\frac{\sqrt{3}\pi}{50}\hat{j}$ m/s
(3) $\frac{\sqrt{3}\pi}{50}\hat{i}$ m/s (4) $-\frac{\sqrt{3}\pi}{50}\hat{i}$ m/s

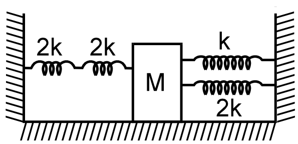
**27.** Two SHM's are represented by $y = a \sin(\omega t - kx)$ and $y = b \cos(\omega t - kx)$. The phase difference between the two is :

(1) $\frac{\pi}{2}$ (2) $\frac{\pi}{4}$
(3) $\frac{\pi}{6}$ (4) $\frac{3\pi}{4}$

**28.** A force of 6.4 N stretches a vertical spring by 0.1 m. The mass that must be suspended from the spring so that it oscillates with a period of (π/4) sec is :

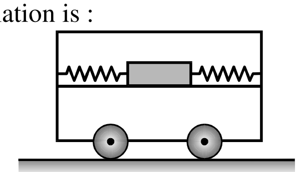
(1) (π/4) kg (2) 1 kg
(3) (1/π) kg (4) 10 kg

**29.** Four massless springs whose force constants are 2*k*, 2*k*, *k* and 2*k* respectively are attached to a mass *M* kept on a frictionless plane (as shown in figure). If the mass M is displaced in the horizontal direction, then the frequency of the system.




(1) $\frac{1}{2\pi}\sqrt{\frac{k}{4M}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{4k}{M}}$
(3) $\frac{1}{2\pi}\sqrt{\frac{k}{7M}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{7k}{M}}$

**30.** Two springs, each of spring constant *k*, are attached to a block of mass m as shown in the figure. The block can slide smoothly along a horizontal platform clamped to the opposite walls of the trolley of mass *M*. If the block is displaced by *x* cm and released, the period of oscillation is :



(1) $T = 2\pi\sqrt{\dfrac{M+m}{2k}}$

(2) $T = 2\pi\sqrt{\dfrac{mM}{k(m+M)}}$

(3) $T = 2\pi\sqrt{\dfrac{mM}{2k(M+m)}}$

(4) $T = 2\pi\dfrac{(M+m)^2}{k}$

**31.** A student says that he had applied a force $F = -k\sqrt{x}$ on a particle and the particle moved in simple harmonic motion. He refuses to tell whether $k$ is a constant or not. Assume that he has worked only with positive $x$ and no other force acted on the particle.

(1) As $x$ increases $k$ increases

(2) As $x$ increases $k$ decreases

(3) As $x$ increases $k$ remains constant.

(4) The motion cannot be simple harmonic.

**32.** A particle moves on the x-axis according to the equation $x = x_0 \sin^2 \omega t$. The motion is simple harmonic

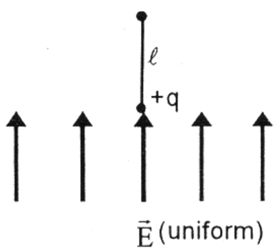
(1) with amplitude $x_0$

(2) with amplitude $2x_0$

(3) with time period $\dfrac{2\pi}{\omega}$

(4) with time period $\dfrac{\pi}{\omega}$

**33.** A simple pendulum with its bob (mass $m$) charged with $+q$ oscillates in a uniform electric field $E$, as shown in the figure the period of oscillation shall be-




(1) $2\pi\left(\dfrac{\ell}{g}\right)^{1/2}$

(2) $2\pi\left(\dfrac{\ell}{g+qE/m}\right)^{1/2}$

(3) $2\pi\left(\dfrac{\ell}{g-qE/m}\right)^{1/2}$

(4) $2\pi\left(\dfrac{\ell\ q}{gE/m}\right)^{1/2}$

**34.** Two bodies $A$ and $B$ of equal mass are suspended from two separate massless springs of spring constant $k_1$ and $k_2$ respectively. If the bodies oscillate vertically such that their maximum velocities are equal, the ratio of the amplitude of $A$ to that of $B$ is

(1) $k_1/k_2$ (2) $\sqrt{k_1/k_2}$

(3) $k_2/k_1$ (4) $\sqrt{k_2/k_1}$

**35.** The displacement of a particle executing periodic motion is given by $y = 4\cos^2(0.5t)\sin(1000\,t)$. The given expression is composed by minimum :

(1) no SHM

(2) four SHMs

(3) three SHMs

(4) one SHM

**36.** **STATEMENT-1 :** Kinetic energy of SHM at mean position is equal to potential energy at ends for a particle moving in SHM.

**STATEMENT-2 :** Total energy in SHM is conserved.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

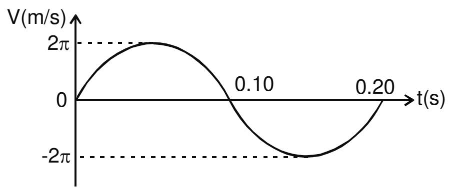
(4) Statement-1 is False, Statement-2 is True

**37.** **STATEMENT-1 :** A particle is moving along x-axis. The resultant force $F$ acting on it is given by $F = -ax - b$. Where a and b are both positive constants. The motion of this particle is not SHM.

**STATEMENT-2 :** In SHM resultant force must be proportional to the displacement from mean position.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

**38.** A simple harmonic oscillator consists of a block attached to a spring with $k = 200$ N/m. The block slides on a frictionless horizontal surface, with equilibrium point $x = 0$. A graph of the block's velocity $v$ as a function of time $t$ is shown. Correctly match the required information in the column-I with the values given in the column-II. (use $\pi^2 = 10$)




| Column-I | | Column-II | |
|---|---|---|---|
| I | The mass of block in kg | P | – 0.20 |
| II | The x-coordinate of block at $t = 0$ in metres | Q | – 200 |
| III | The acceleration of block at $t = 0.10$ s in m/s$^2$ | R | 0.20 |
| IV | The block's maximum kinetic energy in Joule | S | 4.0 |

(1) I-P; II-R; III-S; IV-Q
(2) I-S; II-Q; III-P; IV-R
(3) I-R; II-P; III-Q; IV-S
(4) I-Q; II-R; III-P; IV-S

**39.** In a simple harmonic oscillator, at the mean position:

(1) kinetic energy is minimum, potential energy is maximum
(2) both kinetic and potential energies are maximum
(3) kinetic energy is maximum, potential energy is minimum
(4) both kinetic and potential energies are minimum

**40.** The length of a simple pendulum executing simple harmonic motion is increased by 21%. The percentage increase in the time period of the pendulum of increased length is :

(1) 11% (2) 21%
(3) 42% (4) 10%

**41.** A particle at the end of a spring executes simple harmonic motion with a period $t_1$, while the corresponding period for another spring is $t_2$. If the period of oscillation with the two springs in series is $T$, then :

(1) $T = t_1 + t_2$
(2) $T^2 = t_1^2 + t_2^2$
(3) $T^{-1} = t_1^{-1} + t_2^{-1}$
(4) $T^{-2} = t_1^{-2} + t_2^{-2}$

**42.** If a simple harmonic motion is represented by $\frac{d^2x}{dt^2} + \alpha x = 0$, its time period is :

(1) $\frac{2\pi}{\alpha}$ (2) $\frac{2\pi}{\sqrt{\alpha}}$
(3) $2\pi\alpha$ (4) $2\pi\sqrt{\alpha}$

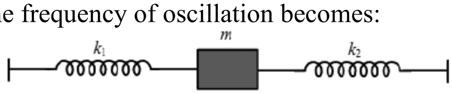
**43.** The bob of a simple pendulum is a spherical hollow ball filled with water. A plugged hole near the bottom of the oscillating bob gets suddenly unplugged. During observation, till water is coming out, the time period of oscillation would :

(1) first increase and then decrease to the original value
(2) first decrease and then increase to the original value
(3) remain unchanged
(4) increase towards a saturation value

**44.** A coin is placed on a horizontal platform which undergoes vertical simple harmonic motion of angular frequency ω. The amplitude of oscillation is gradually increased. The coin will leave contact with the platform for the first time:

(1) In between the highest position and mean position of the platform
(2) at the mean position of the platform
(3) for an amplitude of $\frac{g}{\omega^2}$
(4) for an amplitude of $\frac{g^2}{\omega^2}$

**45.** Two springs, of force constants $k_1$ and $k_2$, are connected to a mass m as shown. The frequency of oscillation of mass is $f$. If both $k_1$ and $k_2$ are made four times their original values, the frequency of oscillation becomes:




(1) $f/2$ (2) $f/4$
(3) 4f (4) $2f$

**46.** A particle of mass m executes simple harmonic motion with amplitude $a$ and frequency $f$. The time average of kinetic energy during its motion from the position of equilibrium to the end is :

(1) $\pi^2 ma^2f^2$ (2) $\frac{1}{4}ma^2f^2$
(3) $4\pi^2 ma^2f^2$ (4) $2\pi^2 ma^2f^2$

**47.** A mass $M$, attached to a horizontal spring, executes SHM with a amplitude $A_1$. On a smooth horizontal surface when the mass $M$ passes through its mean position then a smaller mass $m$ is placed over it and both of them move together with amplitude $A_2$. The ratio of $\left(\frac{A_1}{A_2}\right)$ is :

(1) $\frac{M}{M+m}$ (2) $\frac{M+m}{M}$
(3) $\left(\frac{M}{M+m}\right)^{1/2}$ (4) $\left(\frac{M+m}{M}\right)^{1/2}$

**48.** A wooden cube (density of wood '$d$') of side '$\ell$' floats in a liquid of density 'ρ' with its upper and lower surfaces horizontal. If the cube is pushed slightly down and released, it performs simple harmonic motion of period '$T$'. Then, '$T$' is equal to :

(1) $2\pi\sqrt{\frac{\ell d}{\rho g}}$ (2) $2\pi\sqrt{\frac{\ell\rho}{dg}}$
(3) $2\pi\sqrt{\frac{\ell d}{(\rho-d)g}}$ (4) $2\pi\sqrt{\frac{\ell\rho}{(\rho-d)g}}$

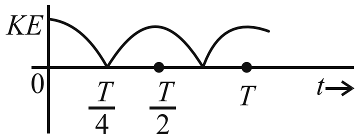
**49.** A particle moves with simple harmonic motion in a straight line. In first τ s, after starting from rest it travels a distance $a$, and in next τ s it travels $2a$, in same direction, then :

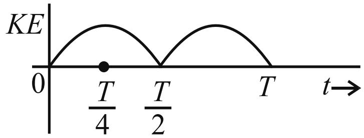
(1) time period of oscillations is 2τ
(2) time period of oscillations is 8τ
(3) time period of oscillations is 3τ
(4) time period of oscillations is 6τ

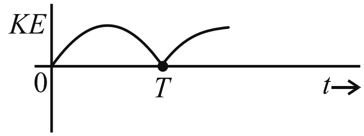
**50.** A particle performs simple harmonic motion with amplitude $A$. Its speed is tripled at the instant that it is at distance $\frac{2A}{3}$ from equilibrium position . The new amplitude of the motion is.

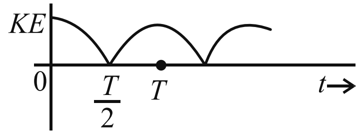
(1) $3A$ (2) $A\sqrt{3}$
(3) $\frac{7A}{3}$ (4) $\frac{A}{3}\sqrt{41}$

**51.** A particle is executing simple harmonic motion with a time period T. At time = 0, it is at its position of equilibrium. The kinetic energy-time graph of the particle will look like :

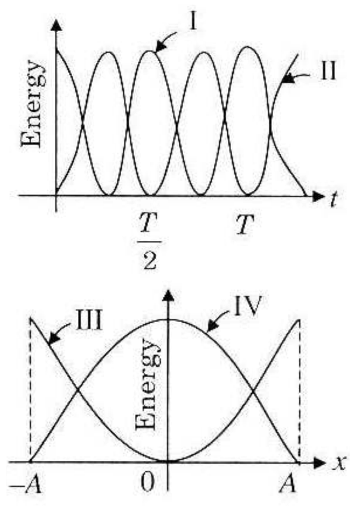
(1)



(2)



(3)


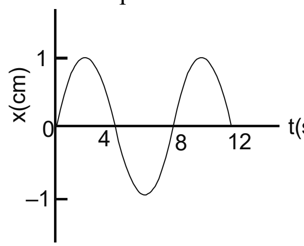

(4)



**52.** For a particle executing SHM the displacement $x$ is given by $x = A\cos\omega t$. Identify the graphs which represents the variation of potential energy (P.E.) as a function of time $t$ and displacement $x$ :



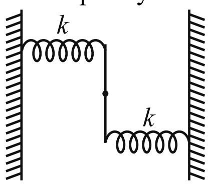

(1) I and III (2) II and IV
(3) II and III (4) I and IV

**53.** The $x$-$t$ graph of a particle undergoing simple harmonic motion is shown below. The acceleration of the particle at $t = 4/3$ s is



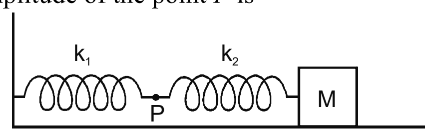

(1) $\frac{\sqrt{3}}{32}\pi^2$ cm/s$^2$ (2) $\frac{-\pi^2}{32}$ cm/s$^2$
(3) $\frac{\pi^2}{32}$ cm/s$^2$ (4) $-\frac{\sqrt{3}}{32}\pi^2$ cm/s$^2$

**54.** A uniform rod of length $L$ and mass $M$ is pivoted at the centre. Its two ends are attached to two springs of equal spring constants $k$. The springs are fixed to rigid supports as shown in the figure, and the rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle $\theta$ in one direction and released. The frequency of oscillation is :



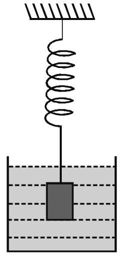

(1) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$
(3) $\frac{1}{2\pi}\sqrt{\frac{6k}{M}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{24k}{M}}$

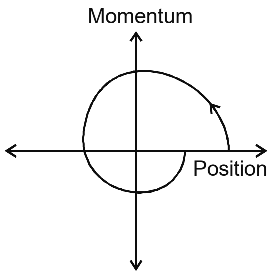
**55.** The mass $M$ shown in the figure oscillates in simple harmonic motion with amplitude $A$. The amplitude of the point $P$ is

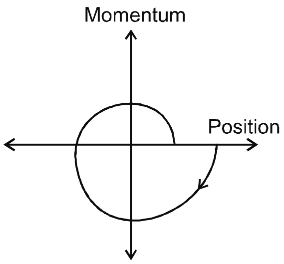


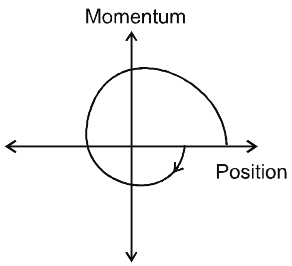

(1) $\frac{k_1 A}{k_2}$ (2) $\frac{k_2 A}{k_1}$
(3) $\frac{k_1 A}{k_1 + k_2}$ (4) $\frac{k_2 A}{k_1 + k_2}$

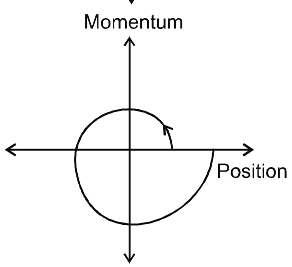
**56.** Consider the spring-mass system, with the mass submerged in water, as shown in the figure. The phase space diagram for one cycle of this system is :



(1)



(2)



(3)



(4)


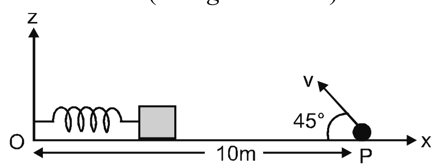

**57.** A point mass is subjected to two simultaneous sinusoidal displacements in x-direction, $x_1(t) = A\sin\omega t$ and $x_2(t) = A\sin\left(\omega t + \frac{2\pi}{3}\right)$.

Adding a third sinusoidal displacement $x_3(t) = B\sin(\omega t + \phi)$ brings the mass to a complete rest. The values of $B$ and $\phi$ are

(1) $\sqrt{2}A, \frac{3\pi}{4}$ (2) $A, \frac{4\pi}{3}$

(3) $\sqrt{3}A, \frac{5\pi}{6}$ (4) A, $\frac{\pi}{3}$

**58.** A small block is connected to one end of a massless spring of un-stretched length 4.9 m. The other end of the spring (see the figure) is fixed. The system lies on a horizontal frictionless surface. The block is stretched by 0.2 $m$ and released from rest at $t$ = 0. It then executes simple harmonic motion with angular frequency $\omega = \frac{\pi}{3} rad/s$. Simultaneously at $t$ = 0, a small pebble is projected with speed $v$ from point $P$ at an angle of 45° as shown in the figure. Point $P$ is at a horizontal distance of 10 m from $O$. If the pebble hits the block at $t$ = 1s, the value of $v$ is (take $g = 10\ m/s^2$):




(1) $\sqrt{50}$ m/s (2) $\sqrt{51}$ m/s

(3) $\sqrt{52}$ m/s (4) $\sqrt{53}$ m/s

**59.** A steel wire with mass per unit length $7.0 \times 10^{-3}$ kg is under tension of 70 N. The speed of transverse waves in the wire will be:

(1) 200 π m/s

(2) 100 m/s

(3) 10 m/s

(4) 50 m/s

**60.** A string is clamped at both the ends and it is vibrating in its $4^{th}$ harmonic. The equation of the stationary wave is $Y = 0.3 \sin(0.157x) \cos(200\pi t)$. The length of the string is: (All quantities are in SI units.)

(1) 20 m (2) 80 m
(3) 60 m (4) 40 m

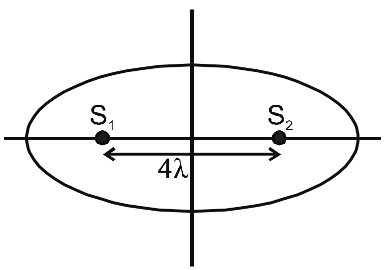
## *Integer Type Questions (61 to 75)*

**61.** The frequency of a man's voice is 300 Hz and its wavelength is 1 meter. If the wavelength of a child's voice is 1.5 m, then the frequency of the child's voice is (in Hz)

**62.** Two identical wires are stretched by the same tension of 101 N & each emits a note of frequency 202 Hz. If the tension in one wire is increased by 1 N, then the beat frequency is (in Hz)

**63.** The sound intensity is 0.008 W/m$^2$ at a distance of 10 m from an isotropic point source of sound. The power of the source to the nearest integer is (in watt)

**64.** $S_1$, $S_2$ are two coherent sources (having initial face difference zero) of sound located along $x$-axis separated by $4\lambda$ where $\lambda$ is wavelength of sound emitted by them. Number of maxima located on the elliptical boundary around it will be :




**65.** A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of :

**66.** A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300 m/s. The frequency of sound recorded by an observer who is standing in air is (in Hz)

**67.** A vibrating string of certain length $\ell$ under a tension $T$ resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats per second when excited along with a tuning fork of frequency $n$. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity of sound in air to be 340 m/s, the frequency $n$ of the tuning fork in Hz is

**68.** The displacement $y$ of a particle in a medium can be expressed as :

$y = 10^{-6} \sin(100t + 20x + \frac{\pi}{4})$m, where $t$ is in second and $x$ in metre. The speed of the wave is (in m/s):

**69.** A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is : (take g = 10 ms$^{-2}$) $n\sqrt{2}$ m/sec then $n$ is

**70.** A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by a mass $M$, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of $M$ is (in kg)

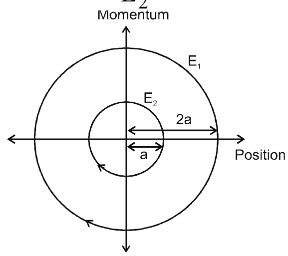
**71.** A 20cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibrations using an external vibrator of frequency 100 Hz. Find the separation (**in cm**) between the successive nodes on the string.

**72.** The bob of a simple pendulum executes simple harmonic motion in water with a period $t$, while the period of oscillation of the bob is $t_0$ in air. Neglecting frictional force of water and given that the density of the bob is $(4/3) \times 1000$ kg/m$^3$. Then ratio of $\frac{t}{t_0}$ is

**73.** Two particles are executing simple harmonic motion of the same amplitude $A$ and frequency $\omega$ along the $x$-axis. Their mean position is separated by distance $X_0$ ($X_0 > A$). If the maximum separation between them is $(X_0 + A)$, the phase difference between their motion is $\frac{\pi}{n}$ then $n$ is

**74.** A simple pendulum has time period $T_1$. The point of suspension is now moved upward according to the relation $y = kt^2$ ($k = 1$ m/s$^2$) where y is the vertical displacement, the time period now becomes $T_2$. The ratio of $\left(\frac{T_1}{T_2}\right)^2$ is $\frac{n}{5}$ then $n$ is ($g = 10$ m/s$^2$)

**75.** The phase space diagram for simple harmonic motion is a circle centered at the origin. In the figure, the two circles represent the same oscillator but for different initial conditions, and $E_1$ and $E_2$ are the total mechanical energies respectively. Then $\frac{E_1}{E_2}$ is



CHAPTER

13

# CHARGES AND ELECTROSTATIC FIELD

## Single Option Correct Type Questions (01 to 60)

**1.** **Statement I:** To find field due to charge distribution by Gauss's law, Gaussian surface is drawn symmetrical to the charge distribution.
**Statement II:** If Gaussian surface is symmetrical to the charge distribution, then flux integral is easier to evaluate.
(1) Both Statement I and Statement II are correct and statement II is the correct explanation of statement I
(2) Both Statement I and Statement II are correct and Statement II is not the correct explanation of statement I
(3) Statement I is correct but Statement II is incorrect
(4) Statement II is correct but Statement I is incorrect

**2.** Two equal and like charges when placed 5 cm apart experience a repulsive force of 0.144 newton. The magnitude of the charge in microcoulomb will be :
(1) 0.2 (2) 2
(3) 20 (4) 12

**3.** Two charges of +1 μC & + 5 μC are placed 4 cm apart, the ratio of the force exerted by both charges on each other will be -
(1) 1 : 1 (2) 1 : 5
(3) 5 : 1 (4) 25 : 1

**4.** Coulomb's law for the force between electric charges most closely resembles with :
(1) Law of conservation of energy
(2) Newton's law of gravitation
(3) Newton's 2$^{nd}$ law of motion
(4) The law of conservation of charge

**5.** A fixed charge $Q_1$ exerts force on a second fixed charge $Q_2$. If a 3$^{rd}$ charge $Q_3$ is brought near, the force of $Q_1$ exerted on $Q_2$.
(1) Will increase
(2) Will decrease
(3) Will remain unchanged
(4) Will increase if $Q_3$ is of the same sign as $Q_1$ and will decrease if $Q_3$ is of opposite sign

**6.** Three charge +4q, $Q$ and $q$ are placed in a straight line of length $\ell$ at points distance 0, $\ell/2$ and $\ell$ respectively. What should be the value of Q in order to make the net force on $q$ to be zero?
(1) $-q$ (2) $-2q$
(3) $-q/2$ (4) $4q$

**7.** Two point charges placed at a distance r in air exert a force $F$ on each other. The value of distance $R$ between them at which they experience force 4F when placed in a medium of dielectric constant $K = 16$ is :
(1) $r$ (2) $r/4$
(3) $r/8$ (4) $2r$

**8.** If $Q = 2$ coloumb and force on it is $F = 100$ newton, then the value of field intensity will be:
(1) 100 N/C (2) 50 N/C
(3) 200 N/C (4) 10 N/C

**9.** Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respective electric fields at a distance $r$ from a point charge $Q$, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. if $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance $r_0$, then

(1) $Q = 4\sigma\pi r_0^2$

(2) $r_0 = \dfrac{\lambda}{2\pi\sigma}$

(3) $E_1(r_0/2) = 2E_2(r_0/2)$

(4) $E_2(r_0/2) = 4E_3(r_0/2)$

**10.** The intensity of an electric field at some point distant r from the axis of infinite long pipe having charges per unit length as $q$ will be :

(1) proportional to $r^2$

(2) proportional to $r^3$

(3) inversely proportional to $r$.

(4) inversely proportional to $r^2$.

**11.** The electric field intensity due to a uniformly charged sphere is zero :

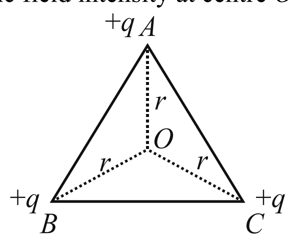
(1) outside sphere everywhere

(2) at only infinity

(3) at the centre and at infinite distance

(4) on the surface

**12.** $ABC$ is an equilateral triangle. Charges $+q$ are placed at each corner as shown in fig. The electric field intensity at centre $O$ will be




(1) $\dfrac{1}{4\pi\epsilon_0}\dfrac{q}{r}$

(2) $\dfrac{1}{4\pi\epsilon_0}\dfrac{q}{r^2}$

(3) $\dfrac{1}{4\pi\in_0}\dfrac{3q}{r^2}$

(4) Zero

**13.** Total charge on a sphere of radius 10 cm is 1 μC. If charge is distributed uniformly the maximum electric field due to the sphere in N/C will be -

(1) $9 \times 10^{-5}$ (2) $9 \times 10^{3}$

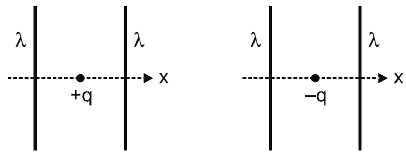
(3) $9 \times 10^{5}$ (4) $9 \times 10^{15}$

**14.** A charged water drop of radius 0.1 μm is under equilibrium in some electric field. The charge on the drop is equivalent to electronic charge. The intensity of electric field is ($g = 10\ m/s^2$)-

(1) $1.61\ NC^{-1}$ (2) $26.2\ NC^{-1}$

(3) $262\ NC^{-1}$ (4) $1610\ NC^{-1}$

**15.** The figures below depict two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charges q and –q are kept in equilibrium between them. The point charges are confined to move in the $x$-direction only. If they are given a small displacement about their equilibrium positions, then the correct statement(s) is (are) :



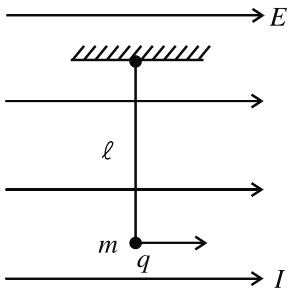

(1) Both charges execute simple harmonic motion.

(2) Both charges will continue moving in the direction of their displacement.

(3) Charge +q executes simple harmonic motion while charge –q continues moving in the direction of its displacement.

(4) Charge –q executes simple harmonic motion while charge +q continues moving in the direction of its displacement.

**16.** A simple pendulum has a length $\ell$, mass of bob m. The bob is given a charge $q$ coulomb. The pendulum is suspended in a uniform horizontal electric field of strength $E$ as shown in figure, then calculate the time period of oscillation when the bob is slightly displace from its mean position is :



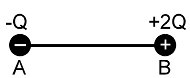

(1) $2\pi\sqrt{\frac{\ell}{g}}$

(2) $2\pi\sqrt{\left\{\frac{\ell}{g+\frac{qE}{m}}\right\}}$

(3) $2\pi\sqrt{\left\{\frac{\ell}{g-\frac{qE}{m}}\right\}}$

(4) $2\pi\sqrt{\frac{\ell}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

**17.** Charge 2Q and –Q are placed as shown in figure. The point at which electric field intensity is zero will be:



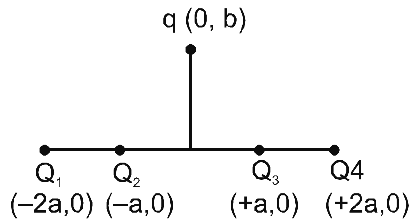

(1) Somewhere between –Q and 2Q
(2) Somewhere on the left of –Q
(3) Somewhere on the right of 2Q
(4) Somewhere on the right bisector of line joining –Q and 2Q

**18.** The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will be :

(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$

(3) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$ (4) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{2\sqrt{3}R^2}$

**19.** Four charge $Q_1$,$Q_2$,$Q_3$, and $Q_4$,of same magnitude are fixed along the x axis at x = –2a –a, +a and +2a, respectively. A positive charge q is placed on the positive y axis at a distance b > 0. Four options of the signs of these charges are given in List-I . The direction of the forces on the charge q is given in List- II Match List-1 with List-II and select the correct answer using the code given below the lists.




| **List-I** | | **List-II** | |
|---|---|---|---|
| I | $Q_1$, $Q_2$, $Q_3$, $Q_4$, all positive | P | +x |
| II | $Q_1$, $Q_2$ positive $Q_3$, $Q_4$ negative | Q | –x |
| III | $Q_1$, $Q_4$ positive $Q_2$, $Q_3$ negative | R | +y |
| IV | $Q_1$, $Q_3$ positive $Q_2$, $Q_4$ negative | S | –y |

(1) I-R, II-P, III-S, IV-Q
(2) I-Q, II-Q, III-R, IV-P
(3) I-R, II-P, III-Q, IV-S
(4) I-Q, II-Q, III-P, IV-R

**20.** A dipole of dipole moment p, is placed in an electric field $\vec{E}$ and is in stable equilibrium. The torque required to rotate the dipole from this position by angle θ at equilibrium will be -

(1) pE cos θ (2) pE sin θ

(3) pE tan θ (4) –pE cosθ

**21.** The ratio of electric fields due to an electric dipole on the axis and on the equatorial line at equal distance will be -

(1) 4 : 1 (2) 1 : 2

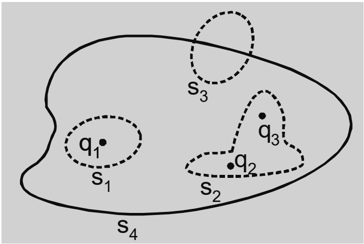
(3) 2 : 1 (4) 1 : 1

**22.** A dipole of electric dipole moment P is placed in a uniform electric field of strength E. If θ is the angle between positive directions of P and E, then the potential energy of the electric dipole is largest when θ is :

(1) zero (2) π/2

(3) π (4) π/4

**23.** Three charges $q_1 = 1 \times 10^{-6}$, $q_2 = 2 \times 10^{-6}$, $q_3 = -3 \times 10^{-6}$ C have been placed, as shown in figure, in four surfaces $S_1$, $S_2$, $S_3$ and $S_4$ electrical flux emitted from the surface $S_2$ in N–m$^2$/C will be -




(1) $36\pi \times 10^3$ (2) $-36\pi \times 10^3$

(3) $36\pi \times 10^9$ (4) $-36\pi \times 10^9$

**24.** Eight charges, 1μC,. -7μC, -4μC, 10μC, 2μC, -5μC, -3μC and 6μC are situated at the eight corners of a cube of side 20 cm. A spherical surface of radius 80 cm encloses this cube. The centre of the sphere coincides with the centre of the cube. Then the total outgoing flux from the spherical surface (in unit of volt meter) is-

(1) $36\pi$ x $10^3$

(2) $684\pi$ x $10^3$

(3) zero

(4) none of the above

**25.** A closed cylinder of radius R and length L is placed in a uniform electric field E, parallel to the axis of the cylinder. Then net the electric flux through the cylinder must be -

(1) $2\pi R^2 E$

(2) $(2\pi R^2 + 2\pi RL)E$

(3) $2\pi RLE$

(4) zero

**26.** The inward and outward electric flux from a closed surface are respectively $8 \times 10^3$ and $4 \times 10^3$ units. Then the net charge inside the closed surface is

(1) $\frac{-4\times10^3}{\varepsilon_0}C$ (2) $4\times10^3\varepsilon_0\ C$

(3) $\frac{4\times10^3}{\varepsilon_0}C$ (4) $-4\times10^3\varepsilon_0\ C$

**27.** The electric charge in uniform motion produces-

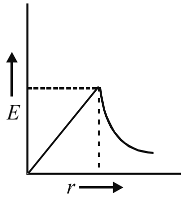
(1) an electric field only

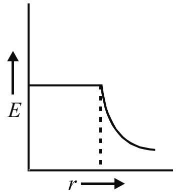
(2) a magnetic field only

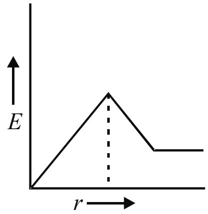
(3) both electric and magnetic fields

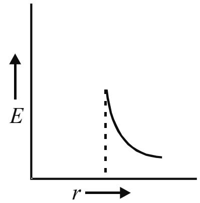
(4) neither electric nor magnetic fields

**28.** Which of the following represents the correct graph for electric field intensity and the distance r from the centre of a hollow uniformly charged sphere of radius R :

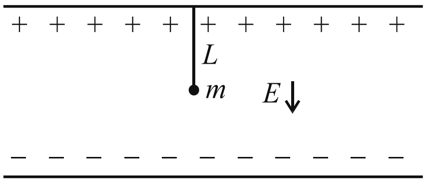
(1)



(2)



(3)



(4)


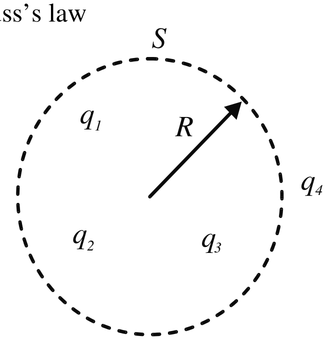
**29.** A small sphere carrying a charge '$q$' is hanging in between two parallel plates by a string of length $L$. Time period of pendulum is $T_0$. When parallel plates are charged, the time period changes to $T$. The ratio $T/T_0$ is equal to ($E$ is uniformly distributed electric field between the plates)




(1) $\left(\dfrac{g+\dfrac{qE}{m}}{g}\right)^{1/2}$ (2) $\left(\dfrac{g}{g+\dfrac{qE}{m}}\right)^{3/2}$

(3) $\left(\dfrac{g}{g+\dfrac{qE}{m}}\right)^{1/2}$ (4) $\left(\dfrac{g}{g+\dfrac{qE}{m}}\right)^{5/2}$

**30.** $q_1$. $q_2$, $q_3$ and $q_4$ are point charges located at points as shown in the figure and $S$ is a spherical Gaussian surface of radius $R$. Which of the following is true according to the Gauss's law




(1) $\oint_s \left(\vec{E}_1+\vec{E}_2+\vec{E}_3+\vec{E}_4\right).d\vec{A} = \dfrac{q_1+q_2+q_3}{2\varepsilon_0}$

(2) $\oint_s \left(\vec{E}_1+\vec{E}_2+\vec{E}_3+\vec{E}_4\right).d\vec{A} = \dfrac{q_1+q_2+q_3}{\varepsilon_0}$

(3) $\oint_s \left(\vec{E}_1+\vec{E}_2+\vec{E}_3+\vec{E}_4\right).d\vec{A} = \dfrac{(q_1+q_2+q_3+q_4)}{\varepsilon_0}$

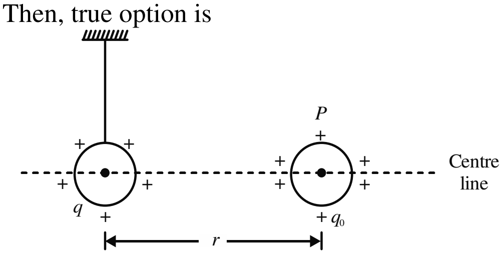
(4) None of the above

**31.** A small ball of mass $m$ and charge $q$ is rotated in a vertical plane by using a string of length $l$. An electric field $E$ also exits in the region which points upwards. If ball is imparted a horizontal velocity $v$ at top of the vertical circle, such that tension in the string in the lower most position of ball is 15 times of the weight of the ball, then $v$ is

(1) $\sqrt{\dfrac{l}{m}(10mg+qE)}$ (2) $\sqrt{\dfrac{l}{m}(5mg+qE)}$

(3) $\sqrt{\dfrac{l}{m}(10mg+5qE)}$ (4) $\sqrt{\dfrac{l}{m}(mg+qE)}$

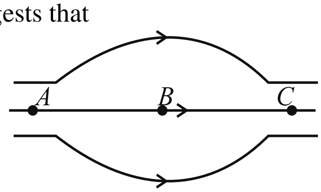
**32.** A uniform positively charged non conducting ball with charge $q$ hangs from a rigid support as shown. Another charged ball with charge $q_0$ is placed at $P$ for a distance $r$ from $q$.
Value of force $F$ on charge $q_0$ due to $q$ is found, then ratio $\dfrac{F}{q_0}$ is calculated.
Then, true option is




Then, true option

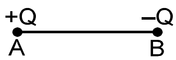
(1) Electric field at $P$ is equal to $F/q_0$
(2) Electric field at $P$ is more than $F/q_0$
(3) Electric field at $P$ is less than $F/q_0$
(4) Electric field at $P$ cannot be estimated using such technique

**33.** Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that




(1) $E_A > E_B > E_C$ (2) $E_A = E_B = E_C$
(3) $E_A = E_C > E_B$ (4) $E_A = E_C < E_B$

**34.** Two point charges of the same magnitude and opposite sign are fixed at points A and B. A third small point charge is to be balanced at point P by the electrostatic force due to these two charges. The point P :




(1) lies on the perpendicular bisector of line AB

(2) is at the mid point of line AB

(3) lies to the left of A

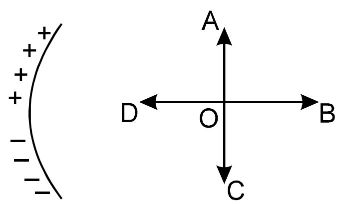
(4) none of these.

**35.** Three point charges $Q_1$, $Q_2$, $Q_3$ in the order are placed equally spaced along a straight line. $Q_2$ and $Q_3$ are equal in magnitude but opposite in sign. If the net force on $Q_3$ is zero. The value of $Q_1$ is

(1) $Q_1 = 4(Q_3)$ (2) $Q = 2(Q_3)$

(3) $Q_1 = \sqrt{2}(Q_3)$ (4) $Q_1 = (Q_3)$

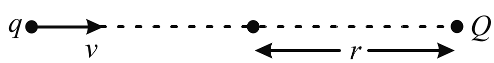
**36.** The linear charge density on upper half of a segment of ring is equal and opposite to that at lower half. The direction of electric field at centre O of ring is :




(1) along OA (2) along OB

(3) along OC (4) along OD

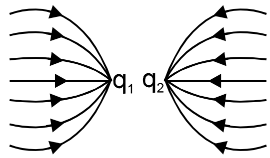
**37.** A charged particle '$q$' is shot from a large distance with speed $v$ towards a fixed charged particle $Q$. It approaches $Q$ upto a closest distance $r$ and then returns. If q were given a speed '$2v$', the closest distance of approach would be :




(1) $r$ (2) $2r$

(3) $\frac{r}{2}$ (4) $\frac{r}{4}$

**38.** The given figure gives electric lines of force due to two charges $q_1$ and $q_2$. What are the signs of the two charges?




(1) Both are negative

(2) Both are positive

(3) $q_1$ is positive but $q_2$ is negative

(4) $q_1$ is negative but $q_2$ is positive

**39.** A square of side 'a' is lying in xy plane such that two of its sides are lying on the axis. If an electric field $\vec{E} = E_0 x\hat{k}$ is applied on the square. The flux passing through the square is

(1) $E_0a^3$ (2) $\frac{E_0a^3}{2}$

(3) $\frac{E_0a^3}{3}$ (4) $\frac{E_0a^2}{2}$

**40.** Which of the following statement(s) is/are correct?

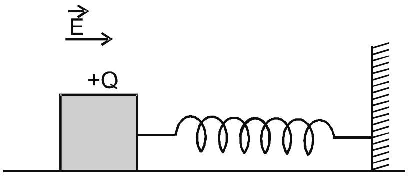
(1) If the electric field due to a point charge varies as $r^{-2.5}$ instead of $r^{-2}$, then the Gauss law will still be valid.

(2) The Gauss law can be used to calculate the field distribution around an electric dipole.

(3) If the electric field between two point charges is zero somewhere, then the sign of the two charges is the same.

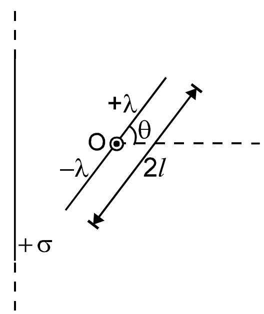
(4) The work done by the external force in moving a unit positive charge from point A at potential $V_A$ to point B at potential $V_B$ is always $(V_B — V_A)$.

**41.** A wooden block performs SHM on a frictionless surface with frequency, $\nu_0$. The block carries a charge +Q on its surface. If now a uniform electric field $\vec{E}$ is switched-on as shown, then the SHM of the block will be



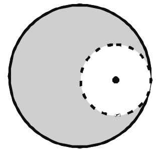

(1) of the same frequency and with shifted mean position.
(2) of the same frequency and with the same mean position.
(3) of changed frequency and with shifted mean position.
(4) of changed frequency and with the same mean position.

**42.** A large sheet carries uniform surface charge density $\sigma$. A rod of length $2\ell$ has a linear charge density $\lambda$ on one half and $-\lambda$ on the second half. The rod is hinged at mid-point O and makes angle $\theta$ with the normal to the sheet. The electric force experienced by the rod is



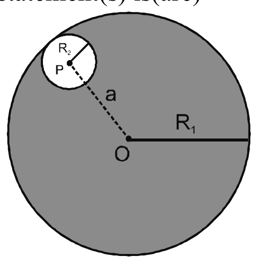

(1) 0
(2) $\dfrac{\sigma\lambda\ell^2}{2\epsilon_0}\sin\theta$
(3) $\dfrac{\sigma\lambda\ell^2}{\epsilon_0}\sin\theta$
(4) None of these

**43.** A solid non-conducting sphere of radius R, having a spherical cavity of radius $\dfrac{R}{2}$ as shown, carries a uniformly distributed charge q. The electric field at the centre of the cavity is E. If there were no cavity and charge remains same (q), the field at the same point will be



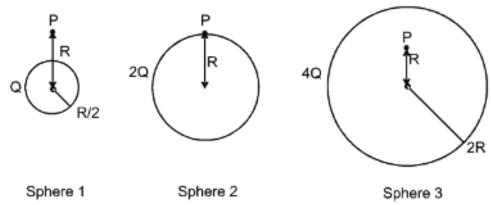
(1) E
(2) $\dfrac{3}{4}$ E
(3) $\dfrac{7}{8}$ E
(4) None of these

**44.** Consider a uniform spherical charge distribution of radius $R_1$ centred at the origin O. In this distribution, a spherical cavity of radius $R_2$, centred at P with distance $OP = a = R_1 - R_2$ (see figure) is made. If the electric field inside the cavity at position $\vec{r}$ is $\vec{E}(\vec{r})$, then the correct statement(s) is(are)



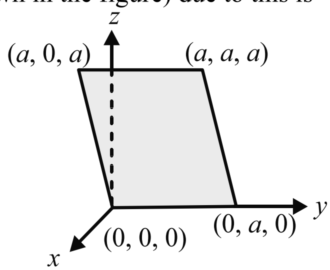

(1) $\vec{E}$ is uniform, its magnitude is independent of $R_2$ but its direction depends on $\vec{r}$
(2) $\vec{E}$ is uniform, its magnitude independent of $R_2$ and its direction depends on $\vec{r}$
(3) $\vec{E}$ is uniform, its magnitude is independent of a but its direction depends on $\vec{a}$
(4) $\vec{E}$ is uniform, and both its magnitude and direction $\vec{a}$ depends on

**45.** Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii R/2, R and 2R respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are $E_1$ $E_2$ and $E_3$ respectively, then




(1) $E_1 > E_2 > E_3$ (2) $E_3 > E_1 > E_2$
(3) $E_2 > E_1 > E_3$ (4) $E_3 > E_2 > E_1$

**46.** Consider an electric field $E = E_0\hat{i}$ where $E_0$ is constant. The flux through the shaded area (as shown in the figure) due to this is



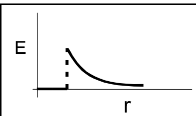
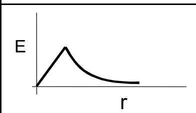
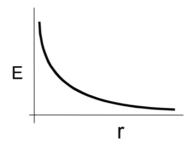
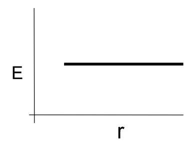

(1) $2E_0a^2$ (2) $\sqrt{2}E_0a^2$
(3) $E_0\alpha^2$ (4) $\frac{E_0a^2}{\sqrt{2}}$

**47.** Choose the correct statements:
(1) The density of electric lines of force at a point is independent of the magnitude of electric intensity vector $E$ at the point
(2) The density of electric lines of force at a point is proportional to the magnitude of electric intensity vector $E$ at that point
(3) Actually, the electric field lines form as closed loop.
(4) Practically, the electric field lines exist

**48.** A uniform infinite line charge produce a field of $7.182 \times 10^8 NC^{-1}$ at a distance of 2 cm. The linear charge density is [K (Proportionality constant) = $9 \times 10^9$ $Nm^2/C^2$]
(1) $7.27 \times 10^{-4}$ $Cm^{-1}$
(2) $7.98 \times 10^{-4}$ $Cm^{-1}$
(3) $7.11 \times 10^{-4}$ $Cm^{-1}$
(4) $7.04 \times 10^{-4}$ $Cm^{-1}$

**49.** The maximum electric field intensity on the axis of a uniformly charged ring of charge $q$ and radius $R$ will be:
(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$
(2) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$
(3) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$
(4) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{2\sqrt{3}R^2}$

**50.**

| List-I | | List-II | |
|---|---|---|---|
| I |  | P | infinitely large sheet |
| II |  | Q | line charge |
| III |  | R | uniformly charged spherical shell |
| IV |  | S | uniformly charged solid sphere |

(1) I–(R), II–(S), III–(Q), IV–(P)
(2) I–(R), II–(S), III–(P), IV–(Q)
(3) I–(Q), II–(P), III–(Q), IV–(S)
(4) I–(S), II–(Q), III–(R), IV–(P)

**51.** Under the influence of the Coulomb field of a fixed charge +Q, a charge –q is moving around it in an elliptical orbit. Find out the correct statement(s).

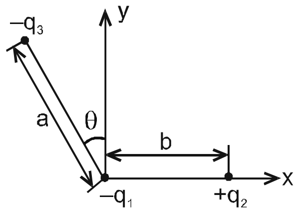
(1) The angular momentum of the charge –q about is constant

(2) The linear momentum of the charge –q is constant

(3) The angular velocity of the charge – q Q is constant

(4) The linear speed of the charge –q is constant

**52.** Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in the figure. The x-component of the force on $-q_1$ is proportional to :




(1) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\cos\theta$ (2) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\sin\theta$

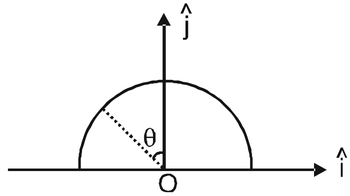
(3) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\cos\theta$ (4) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\sin\theta$

**53.** Let $\rho(r) = \frac{Q}{\pi R^4}r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point 'P' inside the sphere at distance $r_1$ from the centre of sphere, the magnitude of electric field is:

(1) $\frac{Q}{4\pi\varepsilon_0 r_1^2}$ (2) $\frac{Qr_1^2}{4\pi\varepsilon_0 R^4}$

(3) $\frac{Qr_1^2}{3\pi\varepsilon_0 R^4}$ (4) 0

**54.** A thin semi-circular ring of radius r has a positive charge q distributed uniformly over it. The net field $\vec{E}$ at the centre O is :




(1) $\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$

(2) $-\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$

(3) $-\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

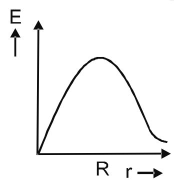
(4) $\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

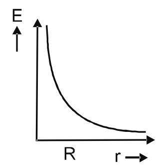
**55.** Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of 30º with each other. When suspended in a liquid of density 0.8 g cm$^{-3}$, the angle remains the same. If density of the material of the sphere is 1.6 g cm$^{-3}$, the dielectric constant of the liquid is

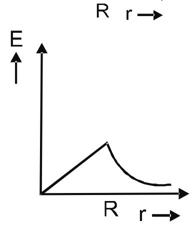
(1) 4 (2) 3

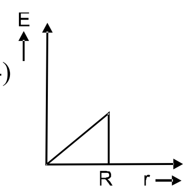
(3) 2 (4) 1

**56.** In a uniformly charged sphere of total charge Q and radius R, the electric field E is plotted as function of distance from the centre. The graph which would correspond to the above will be :

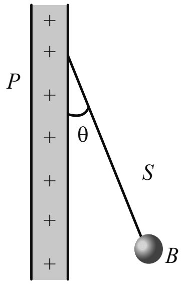
(1)



(2)



(3)



(4)


**57.** A charged ball $B$ hangs from a silk thread $S$, which makes an angle $\theta$ with a large uniformly charged sheet $P$, as shown in the figure. The surface charge density $\sigma$ of the sheet is proportional to




(1) $\sin\theta$ (2) $\tan\theta$

(3) $\cos\theta$ (4) $\cot\theta$

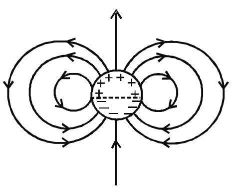
**58.** Two charges, each equal to q, are kept at $x = -a$ and $x = a$ on the x-axis. A particle of mass m and charge $q_0 = -\frac{q}{2}$ is placed at the origin. If charge $q_0$ is given a small displacement ($y << a$) along the y-axis, the net force acting on the particle is proportional to :

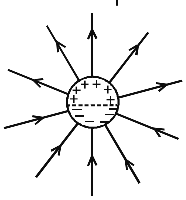
(1) $y$ (2) $-y$

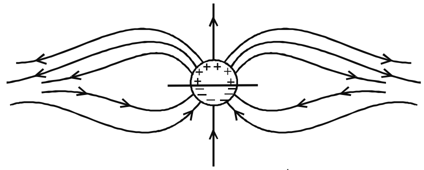
(3) $\frac{1}{y}$ (4) $-\frac{1}{y}$

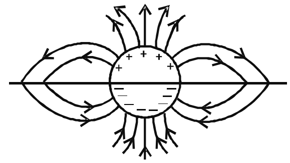
**59.** A long cylindrical shell carries positive surface charge $\sigma$ in the upper half and negative surface charge $-\sigma$ in the lower half. The electric field lines around the cylinder will look like figure given in :

(figures are schematic and not drawn to scale)

(1) 

(2) 

(3) 

(4) 

**60.** An oil drop of radius $r$ and density $\rho$ is held stationary in a uniform vertically upwards electric field '$E$'. If $\rho_0$ ($<\rho$) is the density of air and $e$ is quanta of charge, then the drop has–

(1) $\frac{4\pi r^3(\rho-\rho_0)g}{3eE}$ excess electrons

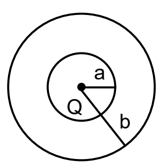
(2) $\frac{4\pi r^2(\rho-\rho_0)g}{eE}$ excess electrons

(3) Deficiency of $\frac{4\pi r^3(\rho-\rho_0)g}{3eE}$ electrons

(4) Deficiency of $\frac{4\pi r^2(\rho-\rho_0)g}{eE}$ electrons

***Integer Type Questions (61 to 75)***

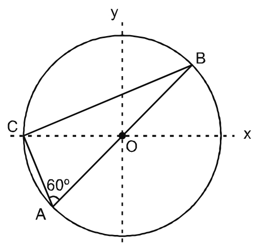
**61.** The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), has volume charge density $\rho = \frac{A}{r}$, where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is $\frac{Q}{n\pi a^2}$. Find $n$.



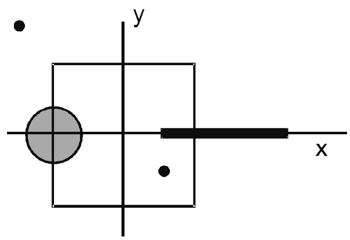
**62.** An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E_1\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences a torque $\vec{T}_2 = -\vec{T}_1$. The angle θ (in degree) is :

**63.** A solid sphere of radius $R$ has a charge distribution $\rho = kr^a$ with a total charge of $Q$ coulombs. $K$ and $a$ are constants and $r$ is distance from centre. If electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times of that at $r = R$, then the value of $a$ is

**64.** Consider a system of three charges $\frac{q}{3}$, $\frac{q}{3}$ and $-\frac{2q}{3}$ placed at points A, B and C, respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle CAB = 60°. The magnitude of the force between the charges at C and B is $\frac{q^2}{n\pi\varepsilon_0 R^2}$. Find $n$.

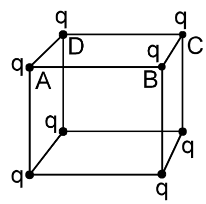



**65.** A disk of radius a/4 having a uniformly distributed charge 6C is placed in the x-y plane with its centre at (–a/2, 0, 0). A rod of length a carrying a uniformly distributed charge 8C is placed on the x-axis from $x$ = a/4 to x = 5a/4. Two point charges –7C and 3C are placed at (a/4, –a/4, 0) and (–3a/4, 3a/4, 0), respectively. Consider a cubical surface formed by six surfaces x = ± a/2, y = ± a/2, z = ±a/2. The electric flux through this cubical surface is $\left(\frac{-x}{\varepsilon_0}\right)$ coulomb. Find $x$.




**66.** A Charged wire is bent in the form of a semi-circular arc of radius a. If charge per unit length is λ coulomb/metre, the electric field at the centre O is $\frac{\lambda}{n\pi\varepsilon_0 a}$. Find $n$.

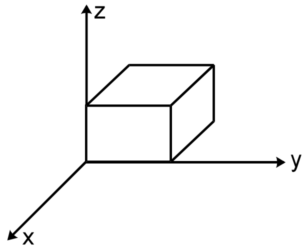
**67.** Eight point charges (can be assumed as small spheres uniformly charged and their centres at the corner of the cube) having values $q$ each are fixed at vertices of a cube. The electric flux through square surface ABCD of the cube is $\frac{q}{n\epsilon_0}$. Find $n$.




**68.** Two spherical shells of radii 2 cm and 4 cm are charged equally, then the ratio of charge density on the surfaces of the spheres will be $x$ : 1. Find $x$.

**69.** Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities $\rho_1$ and $\rho_2$ respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere towards larger sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ is $x$ : 1. Find $x$.

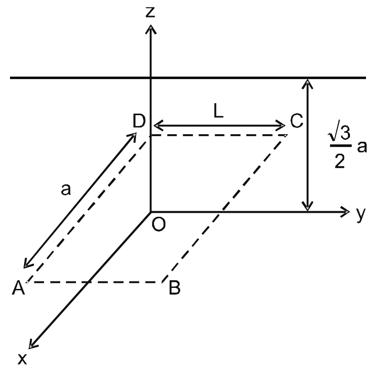
**70.** Figure below shows a closed Gaussian surface in the shape of a cube of edge length 3.0 m. There exists an electric field given by $\vec{E}$ = [(2.0x + 4.0) $\hat{i}$ + 8.0 $\hat{j}$ + 3.0 $\hat{k}$] N/C, where x is in metres, in the region in which it lies. The net charge in coulombs enclosed by the cube is equal to $x \in_0$. Find $x$.



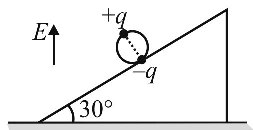

**71.** Two infinite linear charges are placed parallel at 0.1 m apart. If each has charge density of 5µ C/m, then the force per unit length of one of linear charges in N/m is $\frac{x}{2}$. Find $x$.

**72.** The force on a charge situated on the axis of a dipole is F. If the charge is shifted to double the distance, the acting force will be $\frac{F}{x}$. Find $x$.

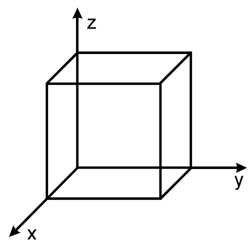
**73.** An infinitely long uniform line charge distribution of charge per unit length λ lies parallel to the y-axis in the y-z plane at $z = \frac{\sqrt{3}}{2}a$ (see figure). If the magnitude of the flux of the electric field through the rectangular surface ABCD lying in the x-y plane with its centre at the origin is $\frac{\lambda L}{n\varepsilon_0}$ ($\varepsilon_0$ = permittivity of free space), then the value of n is :




**74.** A wheel having mass m has charges $+q$ and $-q$ fixed at diametrically opposite ends. For the wheel to be in equilibrium on a rough inclined plane in the presence of uniform vertical electric field $E$, the magnitude of $E$ is $\frac{mg}{xq}$. Find the value of $x$.




**75.** Electric field in a region is given by $\vec{E} = -4x\hat{i} + 6y\hat{j}$. Then find the charge enclosed in the cube of side 1m oriented as shown in the diagram.



CHAPTER

14

# ELECTROSTATIC POTENTIAL AND CAPACITANCE

## *Single Option Correct Type Questions (01 to 59)*

**1.** A force of 3000 N is acting on a charge of 3 coulomb moving in a uniform electric field. The potential difference between two point at a distance of 1 cm in this field is :

(1) 10V (2) 90V

(3) 1000V (4) 9000V

**2.** If we move in a direction opposite to the electric lines of force :

(1) electrical potential decreases.

(2) electrical potential increases.

(3) electrical potential remains uncharged

(4) nothing can be said.

**3.** The distance between two plates is 2 cm, when an electric potential difference of 10 volt is applied between the plates, then the value of electric field will be -

(1) 20 N/C

(2) 500 N/C

(3) 5 N/C

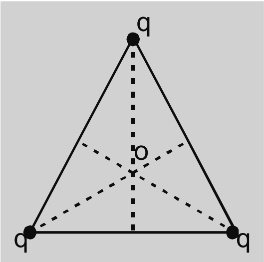
(4) 250 N/C

**4.** Potential difference between centre and the surface of sphere of radius $R$ and having uniform volume charge density ρ within it will be:

(1) $\frac{\rho R^2}{6 \in_0}$ (2) $\frac{\rho R^2}{4 \in_0}$

(3) 0 (4) $\frac{\rho R^2}{2 \in_0}$

**5.** Three equal charges are placed at the three corners of an equilateral triangle as shown in the figure. The statement which is true for electric potential $V$ and the field intensity $E$ at the centre of the triangle -




(1) $V = 0, E = 0$ (2) $V = 0, E \neq 0$

(3) $V \neq 0, E = 0$ (4) $V \neq 0, E \neq 0$

**6.** An infinite number of charges of equal magnitude q, but alternate charge of opposite sign are placed along the $x$-axis at $x = 1$, $x = 2$, $x = 4$, $x = 8$,... and so on. The electric potential at the point $x = 0$ due to all these charges will be -

(1) $kq/2$ (2) $kq/3$

(3) $2kq/3$ (4) $3kq/2$

**7.** In H atom, an electron is rotating around the proton in an orbit of radius $r$. Work done by *a* force exerted by proton on electron along the orbit will be

(1) $ke/r$ (2) $ke^2/r^2$

(3) $ke^2/r$ (4) zero

**8.** When the separation between two charges is increased, the electric potential energy of the charges

(1) increases

(2) decreases

(3) remains the same

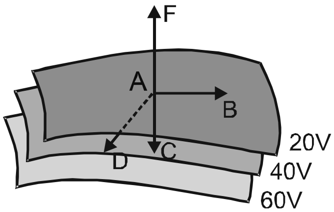
(4) may increase or decrease

**9.** You are given an arrangement of three point charges $q$, $2q$ and $xq$ separated by equal finite distances so that electric potential energy of the system is zero. Then the value of $x$ is :

(1) $-\frac{2}{3}$ (2) $-\frac{1}{3}$

(3) $\frac{2}{3}$ (4) $\frac{3}{2}$

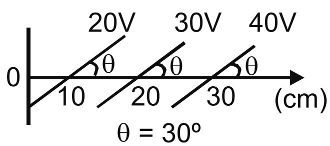
**10.** A family of equipotential surfaces are parallel as shown in the figure. The direction of the electric field at point A is along -




(1) AB (2) AC

(3) AD (4) AF

**11.** Some equipotential surfaces are shown in the figure. The magnitude and direction of the electric field is-




(1) 100 V/m making angle $120^0$ with the x-axis

(2) 100 V/m making angle $60^0$ with the x-axis

(3) 200 V/m making angle $120^0$ with the x-axis

(4) none of the above

**12.** A dipole of electric dipole moment P is placed in a uniform electric field of strength $E$. If θ is the angle between positive directions of $P$ and $E$, then the potential energy of the electric dipole is largest when θ is :

(1) zero (2) π/2

(3) π (4) π/4

**13.** A conducting shell of radius 10 cm is charged with 3.2 x $10^{-19}$ C. The electric potential at a distance 4cm from its centre in volt be -

(1) 9 x $10^{-9}$ (2) 288

(3) 2.88 x $10^{-8}$ (4) zero

**14.** The potential on the conducting spheres of radii $r_1$ and $r_2$ is same, the ratio of their charge densities will be-

(1) $r_1/r_2$ (2) $r_2/r_1$

(3) $r_1^2/r_2^2$ (4) $r_2^2/r_1^2$

**15.** Two conducting spheres of radii $R$ and $2R$ are given source equally positive charged and then connected by a long conducting wire, then the positive charge will

(1) flow from smaller sphere to the bigger sphere.

(2) flow from bigger sphere to the smaller sphere

(3) not flow.

(4) oscillate between the spheres.

**16.** On moving a charge of 20 coulombs by 2 cm, 2 $J$ of work is done, then the potential difference between the points is:

(1) 0.1 V (2) 8 V

(3) 2 V (4) 0.5 V

**17.** The potential at a point $x$ (measured in μm) due to some charges situated on the $x$-axis is given by

$V(x) = 20/(x^2 - 4)$ volts. The electric field $E$ at $x = 4$ μ$m$ is given by :

(1) 5/3 volt/μm and in the –ve $x$ direction

(2) 5/3 volt/μm and in the +ve $x$ direction

(3) 10/9 volt/μm and in the –ve $x$ direction

(4) 10/9 volt/μm and in the +ve $x$ direction

**18.** Two points $P$ and $Q$ are maintained at the potentials of 10 V and –4 V respectively. The work done in moving 100 electrons from $P$ to $Q$ is :

(1) $9.60 \times 10^{-17}$ J (2) $-2.24 \times 10^{-16}$ J

(3) $2.24 \times 10^{-16}$ J (4) $-9.60 \times 10^{-17}$ J

**19.** **Statement 1 :** For a charged particle moving from point $P$ to point $Q$, the net work done by an electrostatic field on the particle is independent of the path connecting point $P$ to point $Q$.

**Statement 2 :** The net work done by a conservative force on an object moving along a closed loop is zero.

(1) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.
(2) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1.
(3) Statement-1 is false, Statement-2 is true.
(4) Statement-1 is true, Statement-2 is false.

**20.** The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where $r$ is the distance from the centre; $a,b$ are constants. Then the charge density inside the ball is :

(1) $-24\pi a\varepsilon_0 r$ (2) $-6\pi a\varepsilon_0 r$
(3) $-24\pi a\varepsilon_0$ (4) $-6 a\varepsilon_0$

**21.** An insulating solid sphere of radius $R$ has a uniformly positive charge density $\rho$. As a result of this uniform charge distribution there is a finite value of electric potential at the centre of the sphere, at the surface of the sphere and also at a point outside the sphere. The electric potential at infinite is zero.

**Statement-1 :** When a charge '$q$' is take from the centre to the surface of the sphere its potential energy changes by $\frac{q\rho}{3\varepsilon_0}$.

**Statement-2 :** The electric field at a distance $r$ ($r < R$) from the centre of the sphere is $\frac{\rho r}{3\varepsilon_0}$.

(1) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of statement-1.
(2) Statement-1 is true Statement-2 is false.
(3) Statement-1 is false Statement-2 is true.
(4) Statement-1 is true, Statement-2 is true, Statement-2 is the correct explanation of Statement-1.

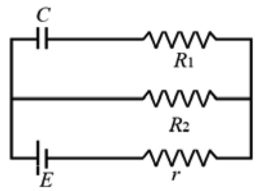
**22.** Assume that an electric field $\vec{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$, where $V_O$ is the potential at the origin and $V_A$ the potential at $x = 2$ m is :

(1) 120 V (2) –120 V
(3) – 80 V (4) 80 V

**23.** Eight drops of mercury of same radius and having same charge coalesce to form a big drop. Capacitance of big drop relative to that of small drop will be

(1) 16 times (2) 8 times
(3) 4 times (4) 2 times

**24.** The magnitude of charge in steady state on either of the plates of capacitor $C$ in the adjoining circuit is-




(1) $CE$ (2) $\frac{CER_2}{(R_1 + r)}$
(3) $\frac{CER_2}{(R_2 + r)}$ (4) $\frac{CER_1}{(R_2 + r)}$

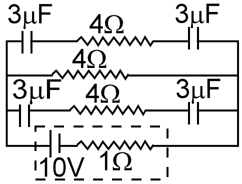
**25.** A capacitor of capacitance 500μF is charged at the rate of 100μC/s. The time in which the potential difference will become 20 V, is

(1) 100 s (2) 50 s
(3) 20 s (4) 10 s

**26.** The radius of the circular plates of a parallel plate capacitor is $R$. Air is dielectric medium between the plates. If the capacitance of the capacitor is equal to the capacitance of a sphere of radius $R$, then the distance between the plates is

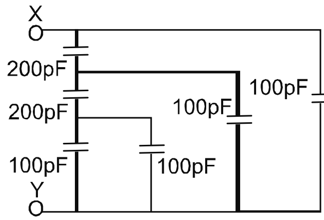
(1) $R/4$ (2) $R/2$
(3) $R$ (4) $2R$

**27.** In the following figure, the charge on each capacitor in the steady state will be–



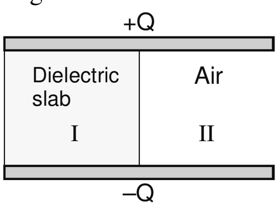

(1) 3μC (2) 6μC
(3) 9μC (4) 12μC

**28.** The equivalent capacitance between the terminals X and Y in the figure shown will be–




(1) 100 pF (2) 200 pF
(3) 300 pF (4) 400 pF

**29.** **STATEMENT-1 :** A charged plane parallel plate capacitor has half interplanar region (I) filled with dielectric slab. The other half region II has air. Then the magnitude of net electric field in region I is less than that in region II.

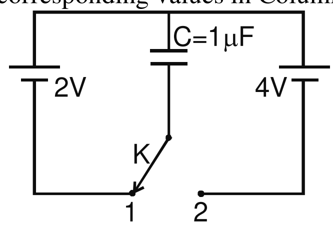



**STATEMENT-2 :** In a dielectric medium induced (or polarised) charges tend to reduce the electric field inside the dielectric.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**30.** **Statement-1 :** The charge capacitor be handled cautiously even when there is no current.
**Statement-2 :** A charged capacitor, can discharge through our body and harm us.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**31.** The circuit involves two ideal cells connected to a 1 μF capacitor via a key K. Initially the key K is in position 1 and the capacitor is charged fully by 2V cell. The key is then pushed to position 2. Column I gives physical quantities involving the circuit after the key is pushed from position 1. Column II gives corresponding results. Match the statements in Column I with the corresponding values in Column II.




| | Column I | | Column II |
|---|---|---|---|
| (A) | The net charge crossing the 4 volt cell in μC is | (p) | 2 |
| (B) | The magnitude of work done by 4 Volt cell in μJ is | (q) | 6 |
| (C) | The gain in potential energy of capacitor in μJ is | (r) | 8 |
| (D) | The net heat produced in circuit in μJ is | (s) | 16 |

(1) (A) p (B) r (C) q (D) p
(2) (A) r (B) r (C) s (D) p
(3) (A) q (B) r (C) p (D) s
(4) (A) p (B) q (C) r (D) s

**32.** If there are n capacitors each of capacitance $C$ is parallel connected to $V$ volt source, then the energy stored is equal to :

(1) $CV$ (2) $\frac{1}{2}nCV^2$

(3) $CV^2$ (4) $\frac{1}{2n}CV^2$

**33.** Capacitance (in F) of a spherical conductor having radius 1m, is :

(1) $1.1 \times 10^{-10}$

(2) $10^{-6}$

(3) $9 \times 10^{-9}$

(4) $10^{-3}$

**34.** A fully charged capacitor has a capacitance '$C$'. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity '$s$' and mass '$m$'. If the temperature of the block is raised by '$\Delta T$', the potential difference '$V$' across the capacitance was :

(1) $\sqrt{\frac{2mC\Delta T}{s}}$ (2) $\frac{mC\Delta T}{s}$

(3) $\frac{ms\Delta T}{C}$ (4) $\sqrt{\frac{2ms\Delta T}{C}}$

**35.** Let $C$ be the capacitance of a capacitor discharging through a resistor $R$. Suppose $t_1$ is the time taken for the energy stored in the capacitor to reduce to half its initial value and $t_2$ is the time taken for the charge to reduce to one-fourth its initial value. Then the ratio $t_1/t_2$ will be

(1) 1 (2) $\frac{1}{2}$

(3) $\frac{1}{4}$ (4) 2

**36.** Two capacitors $C_1$ and $C_2$ are charged to 120 V and 200 V respectively. It is found that by connecting them together the opposite charge plate the potential on each one can be made zero. Then:

(1) $5C_1 = 3C_2$ (2) $3C_1 = 5C_2$

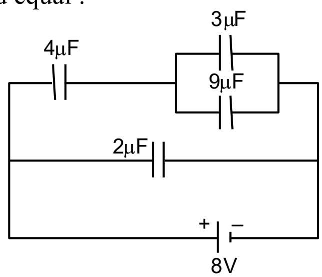
(3) $3C_1 + 5C_2 = 0$ (4) $9C_1 = 4C_2$

**37.** A parallel plate capacitor is made of two circular plates separated by a distance of 5 mm and with a dielectric of dielectric constant K = 2.2 between them. When the electric field in the dielectric is $3 \times 10^4$ V/m, the charge density of the positive plate will be close to :

(1) $5.8 \times 10^{-7} C/m^2$ (2) $3 \times 10^{-7} C/m^2$

(3) $3 \times 10^4 C/m^2$ (4) $6 \times 10^4 C/m^2$

**38.** A combination of capacitors is set up as shown in the figure. The magnitude of the electric field, due to a point charge $Q$ (having a charge equal to the sum of the charges on the 4μF and 9μF capacitors), at a point distance 30 m from it, would equal :




(1) 360 N/C (2) 420 N/C

(3) 480 N/C (4) 240 N/C

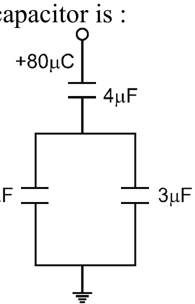
**39.** A capacitance of 2μF is required in an electrical circuit across a potential difference of 1.0 kV. A large number of 1μF capacitors are available which can withstand a potential difference of not more than 300 V.

The minimum number of capacitors required to achieve this is :

(1) 32 (2) 2

(3) 16 (4) 24

**40.** In the given circuit, a charge of +80 μC is given to the upper plate of the 4μF capacitor. Then in the steady state, the charge on the upper plate of the 3μF capacitor is :




(1) +32 μC (2) +40 μC

(3) +48 μC (4) +80 μC

**41.** The radii of two metallic spheres are 5 cm and 10 cm and both carry equal charge of 75μC. If the two spheres are shorted then charge that will be transferred is
(1) 25 μC from smaller to bigger
(2) 25 μC from bigger to smaller
(3) 50 μC from smaller to bigger
(4) 50 μC from bigger to smaller

**42.** A parallel plate capacitor is charged and then isolated. On increasing the plate separation–

| | Charge | Potential | Capacitance |
|---|---|---|---|
| (1) | remains constant | remains constant | Decreases |
| (2) | remains constant | Increases | Decreases |
| (3) | remains constant | Decreases | Increases |
| (4) | Increases | Increases | Decreases |

**43.** The capacitance of a spherical conductor is proportional to
(1) $C \propto R^2$ (2) $C \propto R^{-2}$
(3) $C \propto R$ (4) $C \propto R^{-1}$

**44.** If the energy of a capacitor of capacitance 2μF is 0.16 joule, then its potential difference will be
(1) 800 V (2) 400 V
(3) 16 × 104 V (4) $16 \times 10^{-4}$ V

**45.** The potential of earth is zero because it is
(1) uncharged
(2) an object of zero capacitance
(3) net charge is very small but radius is very large
(4) having infinite charge

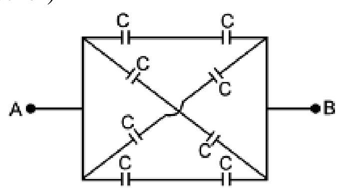
**46.** The work done against electric forces in increasing the potential difference of a capacitor from 20V to 40V is $W$. The work done in increasing its potential difference from 40V to 50V will be (**Note :** without changing the capacitance value)
(1) $4W$ (2) $\frac{3W}{4}$
(3) $2W$ (4) $\frac{W}{2}$

**47.** A capacitor of capacitance 10μF is charged to a potential of 100 V. Now connecting it in parallel with an uncharged capacitor, the resultant potential difference becomes 40 volt. The capacitance of this capacitor is
(1) 2.5 μF (2) 5 μF
(3) 10 μF (4) 15 μF

**48.** The capacitance of a parallel plate capacitor is 12μF. If the distance between its plates is reduced to half and the area of plates is doubled, then the capacitance of the capacitor will become
(1) 2 μF (2) 12 μF
(3) 16 μF (4) 48 μF

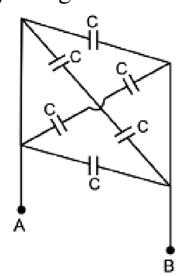
**49.** Two conducting spheres of capacitances 3 μF and 5 μF are charged to 300 V and 500 V respectively and are connected together. The common potential in steady state will be
(1) 400 V (2) 425 V
(3) 350 V (4) 375 V

**50.** In the adjoining circuit, the capacity between the points $A$ and $B$ will be (will same polarity together)



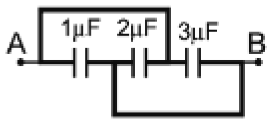

(1) C (2) 2 C
(3) 3 C (4) 4 C

**51.** The resultant capacity between the points $A$ and $B$ in the adjoining circuit will be -




(1) C (2) 2C
(3) 3C (4) 4C

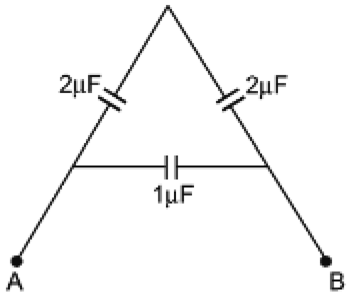
**52.** The equivalent capacitance between *A* and *B* of the combination, shown in the figure, will be




(1) 1.5 μF (2) 3.0 μF

(3) $\frac{6}{11}$ μF (4) 6 μF

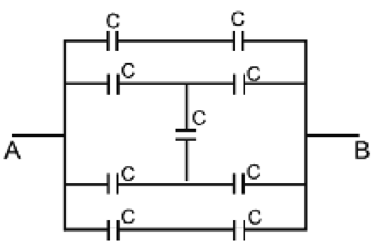
**53.** The effective capacitance between *A* and *B* is




(1) 1 μF (2) 2 μF

(3) 1.5 μF (4) 2.5 μF

**54.** In the figure given, the effective capacitance between *A* and *B* will be




(1) C (2) C/2

(3) 2C (4) 3C

**55.** The plates of a capacitor of capacitance 10 μF, charged to 60 μC, are joined together by a wire of resistance 10 Ω at $t = 0$, then the charge on the capacitor in the circuit at $t = 0$ is :

(1) 120 μC (2) 60 μC

(3) 30 μC (4) 44 μC

**56.** An uncharged capacitor of capacitance 4μF, a battery of emf 12 volt and a resistor of 2.5 MΩ are connected in series. The time after which $V_C = 3V_R$ is (take ln2 = 0.693)

(1) 6.93 seconds (2) 13.86 seconds

(3) 7 seconds (4) 14 seconds

**57.** The distance between the plates of a parallel plate capacitor is *d*. If a copper plate of same area but thickness $\frac{d}{2}$ is placed between the plates then the new capacitance will become:

(1) half (2) double

(3) one fourth (4) unchanged

**58.** A parallel plate capacitor is connected to a battery of e.m.f. 4 volt. If a plate of dielectric constant equal to 8 is inserted into it, then the potential difference across the capacitor will be-

(1) 1/2V (2) 2V

(3) 4V (4) 32V

**59.** In the above problem if the battery is disconnected before inserting the dielectric, then potential difference will be-

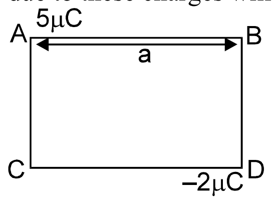
(1) 1/2V (2) 2V

(3) 4V (4) 32V

## *Integer Type Questions (60 to 71)*

**60.** A parallel plate capacitor of capacitance 200 μF is connected to a battery of 200 V. A dielectric slab of dielectric constant 2 is now inserted into the space between plates of capacitor while the battery remains connected. The change in the electrostatic energy in the capacitor will be_____J.

**61.** In the figure shown two point charges 5μ*C* and –2μ*C* are placed at two corners of a square. The potential difference between the other two corners due to these charges will be (in V)



**62.** Two points (0, $a$) and (0, $-a$) have charges $q$ and $-q$ respectively then the electrical potential at origin will be-

**63.** 64 charged drops coalesce to form a bigger charged drop. The potential of bigger drop will be $x$ times that of smaller drop. Find $x$

**64.** At a certain distance from a point charge the electric field is 500 V/m and the potential is 3000 V. What is the distance ? (in m)

**65.** A semicircular ring of radius 0.5 m is uniformly charged with a total charge of $1.5 \times 10^{-9}$ C. The electric potential at the centre of this ring is (in V)

**66.** An electric dipole of dipole moment is $6.0 \times 10^{-6}$ cm placed in a uniform electric field of $1.5 \times 10^{3}$ $NC^{-1}$ in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be ____ mJ

**67.** A capacitor has capacitance 5μF when its parallel plates are separated by air medium of thickness $d$. A slab of a material of dielectric constant 1.5 having area equal to that of plates but thickness $\frac{d}{2}$ is inserted between the plates. Capacitance of the capacitor in the presence of slab will be __________ μF.

**68.** Two parallel plate capacitors of capacity $C$ and 3C are connected in parallel combination and charged to a potential difference 18V. The battery is then disconnected and the space between the plates of the capacitor of capacity $C$ is completely filled with a material of dielectric constant 9. The final potential difference across the combination of capacitors will be ______V.

**69.** The total charge (in μC)on the system of capacitors $C_1$ = 1 μF, $C_2$ = 2μF, $C_3$ = 4μF and $C_4$ = 3μF connected in parallel is (Assume a battery of 20 V is connected to the combination)

**70.** A parallel plate capacitor has plate area 100 $m^2$ and plate separation of 10m.The space between the plates is filled up to a thickness 5m with material of dielectric constant of 10. The resultant capacitance of the system is '$x$' $pF$. The value of $\varepsilon_0 = 8.85 \times 10^{-12}$ $Fm^{-1}$ The value of '$x$' to the nearest integer is________.

**71.** A capacitor of capacitance 50 pF is charged by 100 V source. It is then connected to another uncharged identical capacitor. Electrostatic energy loss in the process is _________nJ.

CHAPTER

15

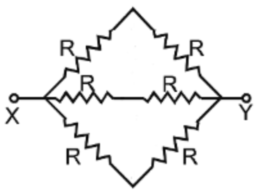
# CURRENT ELECTRICITY

## Single Option Correct Type Questions (01 to 60)

**1.** There are two wires of the same length and of the same material and radii $r$ and $2r$. The ratio of their specific resistance is (respectively)

(1) 1 : 2 (2) 1 : 1
(3) 1 : 4 (4) 4 : 1

**2.** The effective resistance between $X$ and $Y$ is




(1) $2R/3$ (2) $R/3$
(3) $2R$ (4) $3R$

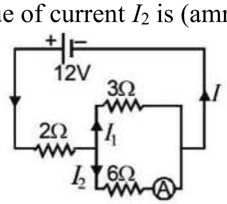
**3.** Two non ideal batteries are connected in parallel. Consider the following statements

(I) The equivalent emf is smaller than either of the two emfs.

(II) The equivalent internal resistance is smaller than either of the two internal resistance.

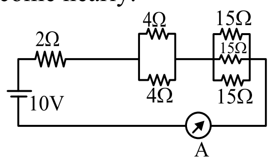
(1) Both I and II are correct
(2) I is correct but II is wrong
(3) II is correct but I is wrong
(4) Each of I and II is wrong.

**4.** The value of current $I_2$ is (ammeter is ideal)



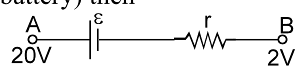

(1) 4 (2) 3
(3) 1 (4) 2

**5.** The current through the ammeter shown in figure is 1 A. If each of the 4Ω resistor is replaced by 2Ω resistor, the current in circuit will become nearly:



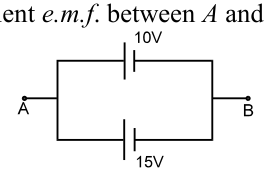

(1) $\frac{10}{9}A$ (2) $\frac{5}{4}A$
(3) $\frac{9}{8}A$ (4) $\frac{9}{8}A$

**6.** In the figure a part of circuit is shown (E = 4V ideal battery) then



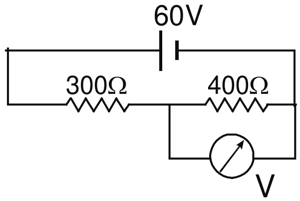

(1) current will flow from $A$ to $B$
(2) current may flow from $A$ to $B$
(3) the direction of current will depend on $r$.
(4) None of these

**7.** Two cells of *e.m.f.* 10 V & 15 V are connected in parallel to each other between points $A$ & $B$. The cell of *e.m.f.* 10 V is ideal but the cell of *e.m.f.* 15 V has internal resistance 1 Ω. The equivalent *e.m.f.* between $A$ and $B$ is:




(1) $\frac{25}{2}$ V (2) Not defined
(3) 15 V (4) 10 V

**8.** In the circuit shown, reading of the voltmeter connected across 400 Ω resistance is 30 V. If it is connected across 300 Ω resistance then reading will be

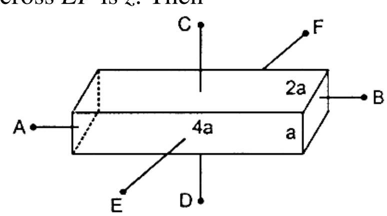



(1) 45 V (2) 32.5 V
(3) 22.5 V (4) 18 V

**9.** **Statement-1 :** The current density $\vec{J}$ at any point in ohmic resistor is in direction of electric field $\vec{E}$ at that point.
**Statement-2 :** A point charge when released from rest in a region having only electrostatic field always moves along electric lines of force.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

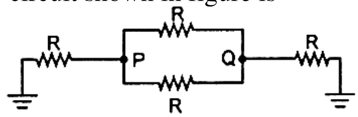
**10.** The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be
(1) 300 % (2) 200 %
(3) 100 % (4) 50 %

**11.** A conductor with rectangular cross section has dimension ($a \times 2a \times 4a$) as shown in fig. Resistance across $AB$ is $x$, across $CD$ is $y$ and across $EF$ is $z$. Then




(1) $x = y = z$ (2) $x > y > z$
(3) $y > z > x$ (4) $x > z > y$

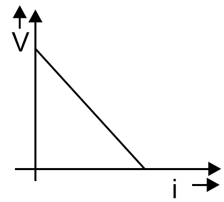
**12.** The net resistance between points $P$ and $Q$ in the circuit shown in figure is

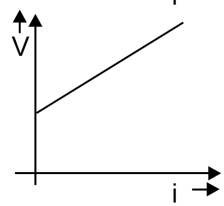


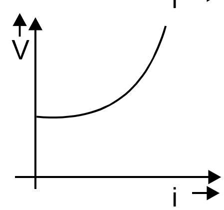

(1) $R/2$ (2) $2R/5$
(3) $3R/5$ (4) $R/3$

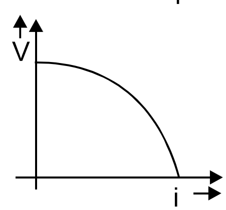
**13.** Two wires of same dimension but resistivities $\rho_1$ and $\rho_2$ are connected in series. The equivalent resistivity of the combination is
(1) $\rho_1 + \rho_2$ (2) $\frac{(\rho_1 + \rho_2)}{2}$
(3) $\sqrt{\rho_1 \rho_2}$ (4) $2(\rho_1 + \rho_2)$

**14.** If internal resistance of a cell is proportional to current drawn from the cell. Then the best representation of terminal potential difference of a cell with current drawn from cell will be:

(1)



(2)



(3)


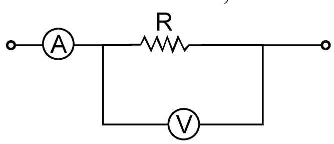

(4)


**15.** **Statement-1 :** In a Meter Bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.

**Statement-2 :** Resistance of a metal increases with increase in temperature.

(1) Statement-1 is True, Statement -2 is True; Statement-2 is a correct explanation for Statement -1
(2) Statement -1 is True, Statement -2 is True; Statement -2 is NOT a correct explanation for Statement -1
(3) Statement -1 is True, Statement -2 is False
(4) Statement -1 is False, Statement -2 is True.

**16.** In the circuit shown the readings of ammeter and voltmeter are 4A and 20V respectively. The meters are non-ideal, then $R$ is




(1) 5 Ω
(2) less than 5Ω
(3) greater than 5Ω
(4) between 4Ω and 5Ω.

**17.** Two electric bulbs marked 25W – 220V and 100W – 220 V are connected in series to a 440 V supply. Which of the bulbs will fuse?

(1) Both (2) 100 W
(3) 25 W (4) Neither

**18.** When 5V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is $2.5 \times 10^{-4}$ ms$^{-1}$. If the electron density in the wire is $8 \times 10^{28}$ m$^{-3}$, the resistivity of the material is close to

(1) $1.6 \times 10^{-8}$ Ωm (2) $1.6 \times 10^{-7}$ Ωm
(3) $1.6 \times 10^{-6}$ Ωm (4) $1.6 \times 10^{-5}$ Ωm

**19.** An ammeter reads upto 1 A. Its internal resistance is 0.81 Ω. To increase the range to 10 A the value of the required shunt resistance (connected parallel to ammeter) is

(1) 0.09 Ω (2) 0.03 Ω
(3) 0.3 Ω (4) 0.9 Ω

**20.** Two sources of equal emf are connected with similar polarity to an external resistance in series $R$. The internal resistances of the two sources are $R_1$ and $R_2(R_2 > R_1)$. If the potential difference across the source of internal resistance $R_2$, is zero, then:

(1) $R = \dfrac{R_2 \times (R_1 + R_2)}{(R_2 - R_1)}$
(2) $R = R_2 - R_1$
(3) $R = \dfrac{R_1 R_2}{(R_2 + R_1)}$
(4) $R = \dfrac{R_1 R_2}{(R_2 - R_1)}$

**21.** In a large building, there are 15 bulbs of 40W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of the electric mains is 220 V. Among the following the minimum capacity of the main fuse of the building will be

(1) 8 A
(2) 10 A
(3) 12 A
(4) 14 A

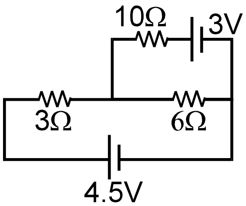
**22.** The drift velocity of electrons in a conducting wire is of the order of 1 mm/s, yet the bulb glows very quickly after the switch is put on because

(1) The random speed of electrons is very high, of the order of $10^6$ *m/s*
(2) The electrons transfer their energy very quickly through collisions
(3) Electric field is set up in the wire very quickly, producing a current through each cross section, almost instantaneously
(4) All of above

**23.** A galvanometer having a coil resistance of 100 Ω gives a full scale deflection, when a current of 1 mA is passed through it. The value of the resistance, which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is

(1) 2 Ω
(2) 0.1 Ω
(3) 3 Ω
(4) 0.01 Ω

**24.** Find the current through the 10 Ω resistor shown in figure

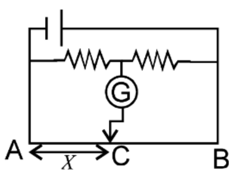



(1) Zero (2) 1 A
(3) 2 A (4) 5 A

**25.** The resistance of a wire is 5 Ω at 50º C and 6 Ω at 100ºC. The resistance of the wire at 0ºC will be

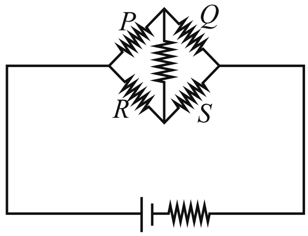
(1) 2 Ω
(2) 1 Ω
(3) 4 Ω
(4) 3 Ω

**26.** In the given circuit, no current is passing through the galvanometer. If the cross-sectional diameter of the wire *AB* is doubled, then for null point of galvanometer, the value of *AC* would be :




(1) $2X$ (2) $X$
(3) $\frac{X}{2}$ (4) None

**27.** The resistance of *P*, *Q*, *R*, *S* arms of a Wheatstone bridge are 5, 15, 20 and 60 Ω. A cell of 4volt emf and 4Ω internal resistance is connected with them, then the current flowing (in ampere) from battery is

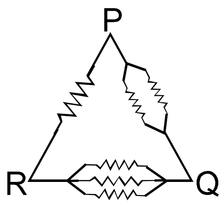



(1) 0.1 (2) 0.2
(3) 1 (4) 2

**28.** On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1 KΩ. How much was the resistance on the left slot before interchanging the resistances?

(1) 550 Ω (2) 910 Ω
(3) 990 Ω (4) 505 Ω

**29.** In the given circuit all resistors are of equal value then equivalent resistance will be maximum between the points.

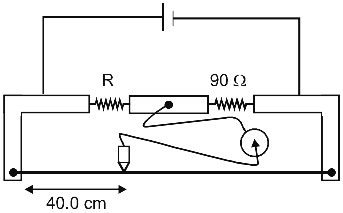



(1) *PR* (2) *PQ*
(3) *RQ* (4) same for all

**30.** In an electric circuit containing a battery, the positive charge inside the battery

(1) Always goes from the positive terminal to the negative terminal
(2) May go from the positive terminal to the negative terminal
(3) Always goes from the negative terminal to the positive terminal
(4) Does not move.

**31.** During an experiment with a metre bridge, the galvanometer shows a null point when the joceky is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the meter bridge is 1 mm. The unknown resistance is




(1) $60 \pm 0.15\Omega$  (2) $135 \pm 0.56\Omega$
(3) $60 \pm 0.25\Omega$  (4) $135 \pm 0.23\Omega$

**32.** Two conductors have the same resistance at 0ºC but their temperature coefficients of resistance are $\alpha_1$ and $\alpha_2$. The respective temperature coefficients of their series and parallel combinations are nearly

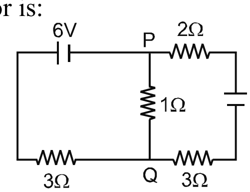
(1) $\frac{\alpha_1 + \alpha_2}{2}$, $\alpha_1 + \alpha_2$

(2) $\alpha_1 + \alpha_2$, $\frac{\alpha_1 + \alpha_2}{2}$

(3) $\alpha_1 + \alpha_2$, $\frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2}$

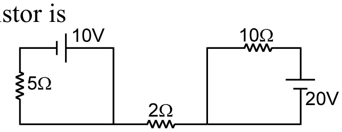
(4) $\frac{\alpha_1 + \alpha_2}{2}$, $\frac{\alpha_1 + \alpha_2}{2}$

**33.** In the circuit shown, the current in the 1Ω resistor is:




(1) 1.3 A, from $P$ to $Q$
(2) 0 A
(3) 0.13 A, from $Q$ to $P$
(4) 0.13 A, from $P$ to $Q$

**34.** In the figure shown the current through 2Ω resistor is




(1) 2 A  (2) 0 A
(3) 4 A  (4) 6 A

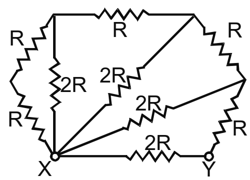
**35.** A material '$B$' has twice the specific resistance that of '$A$'. A circular cross-section wire made of '$B$' has twice the diameter of a wire made of '$A$'. Then for the two wires to have the same resistance, the ratio $l_A / l_B$ of their respective lengths must be

(1) 2  (2) 1
(3) 1/2  (4) 1/4

**36.** If a wire is stretched to make it 0.1% longer, its resistance will:

(1) increase by 0.05%
(2) increase by 0.2%
(3) decrease by 0.2%
(4) decrease by 0.05%

**37.** Equivalent resistance (in Ω) between X and Y is




(1) $R$  (2) 2 $R$
(3) 3 $R$  (4) $R$/2

**38.** Read the following statements carefully:

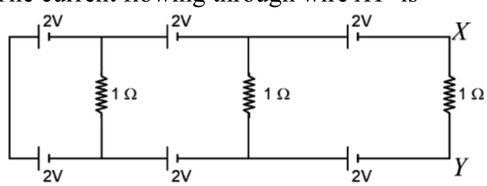
$Y$: The resistivity of semiconductor decreases with increase of temperature.

$Z$: In a conducting solid, the rate of collisions between free electrons and ions increases with increase of temperature.

Select the correct statement (s) from the following:

(1) $Y$ is true but $Z$ is false
(2) $Y$ is false but $Z$ is true
(3) Both $Y$ and $Z$ are true
(4) $Y$ is true and $Z$ is the correct reason for $Y$

**39.** The current flowing through wire $XY$ is

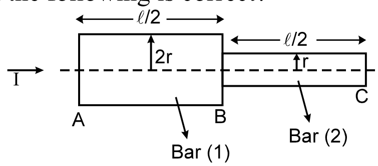



(1) 0 A  (2) 1 A
(3) 0.25 A  (4) 0.5 A

**40.** A galvanometer has resistance 100 Ω and it requires current 100 μA for full scale deflection. A resistor 0.1Ω is connected in parallel to make it an ammeter. The smallest current required in the circuit to produce the full scale deflection is

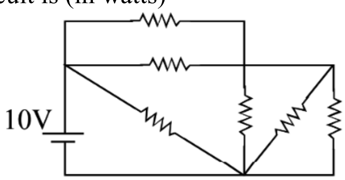
(1) 1000.1 mA (2) 1.1 mA
(3) 10.1 mA (4) 100.1 mA

**41.** Two bars of equal resistivity ρ and radii '$r$' and '$2r$' are kept in contact as shown. An electric current $I$ is passed through the bars. Which one of the following is correct?



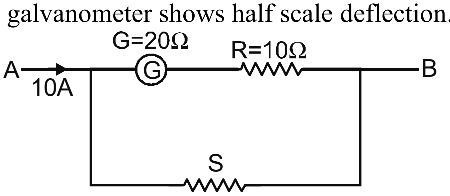

(1) Heat produced in bar (1) is 2 times the heat produced in bar (2)
(2) Electric field in both halves is equal
(3) Current density across $AB$ is double that across $BC$.
(4) Potential difference across $BC$ is 4 times that across $AB$.

**42.** In the figure shown each resistor is of 20 Ω and the cell has emf 10 volt with negligible internal resistance. Then rate of joule heating in the circuit is (in watts)



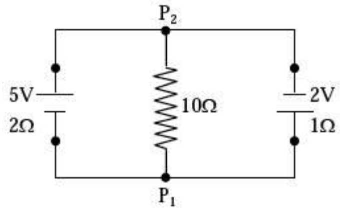

(1) 100/11 (2) 10000/11
(3) 11 (4) None of these

**43.** Full scale deflection current for galvanometer is 1 mA. What should be the value of shunt resistance (approximately) so that galvanometer shows half scale deflection.




(1) 1.5 mΩ (2) 3 mΩ
(3) 10 mΩ (4) 15 mΩ

**44.** A 5 V battery with internal resistance 2 Ω and a 2 V battery with internal resistance 1Ω are connected to a 10Ω resistor as shown in the figure.



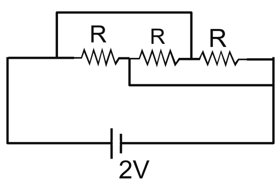

The current in the 10 Ω resistor is -

(1) 0.03 A from $P_1$ to $P_2$
(2) 0.03 A from $P_2$ to $P_1$
(3) 0.27 A from $P_1$ to $P_2$
(4) 0.27 A from $P_2$ to $P_1$

**45.** In the presence of an applied electric field ($\vec{E}$) in a metallic conductor.

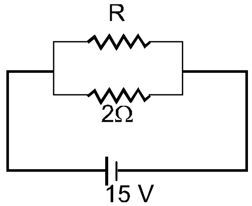
(1) The electrons move in the direction of $\vec{E}$
(2) The electrons move in a direction opposite to $\vec{E}$
(3) The electrons may move in any direction randomly, but slowly drift in the direction of $\vec{E}$.
(4) The electrons move randomly but slowly drift in a direction opposite to $\vec{E}$.

**46.** Three equal resistance each of $R$ Ω are connected as shown in figure. A battery of 2 volts of internal resistance 0.1 Ω is connected across the circuit. Calculate the value of $R$ for which the heat generated in the external circuit is maximum




(1) 0.1 Ω (2) 0.2 Ω
(3) 0.3 Ω (4) 0.4 Ω

**47.** If in the circuit, power dissipation is 150 W then $R$ is




(1) 2 Ω (2) 6 Ω
(3) 5 Ω (4) 4 Ω

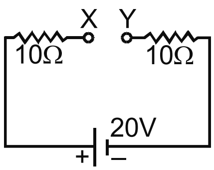
**48.** The resistance of the series combination of two resistances is $S$. When they are joined in parallel, the total resistance is $P$. If $S = nP$, then the minimum possible value of $n$ is :

(1) 4 (2) 3
(3) 2 (4) 1

**49.** The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 W and 200 V lamp when not in use:

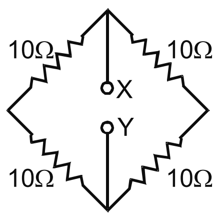
(1) 40 Ω (2) 20 Ω
(3) 400 Ω (4) 200 Ω

**50.** Potential difference between $X$ and $Y$ is




(1) 10 (2) 20
(3) 0 (4) 5

**51.** The equivalent resistance between X and Y is.

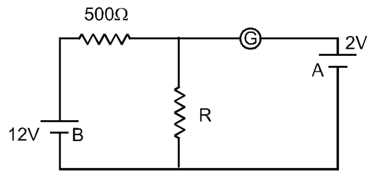



(1) 10 Ω
(2) 20 Ω
(3) 30 Ω
(4) ∞ Ω

**52.** An electric bulb is rated 220 volt - 100 watt. The power consumed by it when operated on 110 volt will be

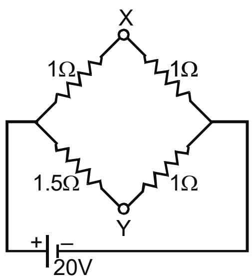
(1) 25 watt (2) 50 watt
(3) 75 watt (4) 40 watt

**53.** In the circuit, the galvanometer $G$ shows zero deflection. If the batteries $A$ and $B$ have negligible internal resistance, the value of the resistor $R$ will be:



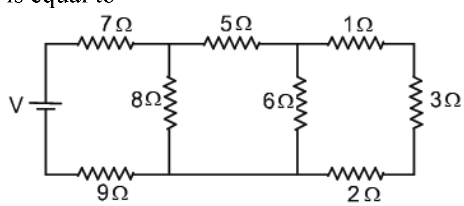

(1) 200 Ω (2) 100 Ω
(3) 500 Ω (4) 1000 Ω

**54.** Potential difference between $X$ and $Y$ in the given circuit is




(1) 0.1 (2) 2
(3) 0.3 (4) 0.4

**55.** In the ladder network shown, current through the resistor 3 Ω is 0.25 A. The input voltage '$V$' is equal to




(1) 10 volt
(2) 20 volt
(3) 5 volt
(4) $\frac{15}{2}$ volt

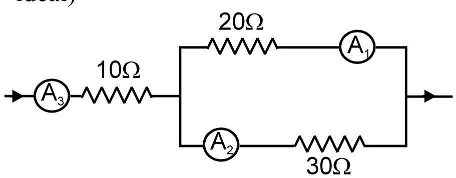
**56.** The resistance of bulb filament is 100 Ω at a temperature of 100°C. If its temperature coefficient of resistance be 0.005 per °C, its resistance will become 200 Ω at a temperature of (assume reference point for resistance at 0°C).

(1) 500°C (2) 200°C
(3) 300°C (4) 400°C

**57.** Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then maximum possible error in the value of resistance of the wire is :

(1) 6% (2) zero
(3) 1% (4) 3%

**58.** If the reading of ammeter $A_1$ in figure is 2.4 A. Neglecting the resistances of the ammeters, the reading of ammeter $A_2$ will be: (ammeters are ideal)




(1) 1.6 A (2) 1.2 A
(3) 1 A (4) 2 A

**59.** A current passes through a wire of non-uniform cross-section. Which of the following quantities are independent of the cross-section?

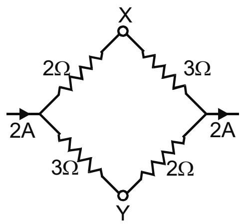
(1) the charge crossing in a given time interval
(2) drift speed
(3) current density
(4) Electric field

**60.** The current density in a wire is 10 A/cm$^2$ and the electric field in the wire is 5 V/cm. Find the ρ (resistivity of material)

(1) $\rho = 5 \times 10^{-3}\ \Omega$ m
(2) $\rho = 200\Omega$ m
(3) $\rho = 100\Omega$ m
(4) $\rho = 2 \times 10^{-3}\Omega$ m

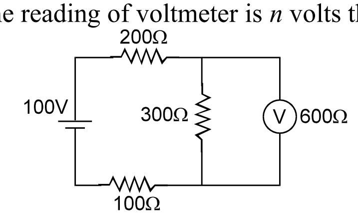
*Integer Type Questions (61 to 75)*

**61.** Potential difference between $x$ and $y$ is $n$ volts then $n$ is




**62.** A wire has a resistance of 12 Ω. If it is bent in the form of a circle. The effective resistance (in ohms) between the two points on any diameter is equal to

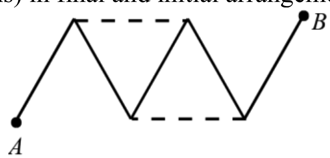
**63.** The reading of voltmeter is $n$ volts then $n$ is



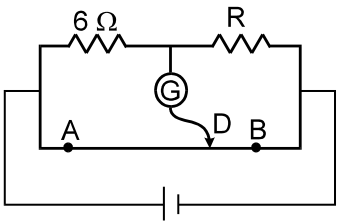

**64.** A wire when connected to 220 V mains supply has power dissipation $P_1$. Now the wire is cut into two equal pieces which are now connected in parallel to the same supply. Power dissipation in this case is $P_2$. Then $P_2$: $P_1$ is-

**65.** A resistance of 2 Ω is connected across one gap of a metre-bridge (the length of the wire is 100 cm) and an unknown resistance, greater than 2 Ω, is connected across the other gap. When these resistances are interchanged, the balance point shifts by 20 *cm*. Neglecting any end corrections, the unknown resistance (in ohms) is

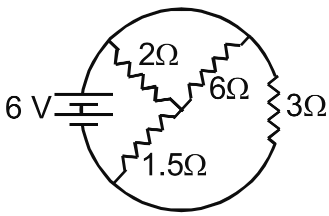
**66.** Five identical resistors each of resistance 1 Ω are initially arranged as shown in the figure by clear lines. If two resistances, similar to previous one are added as shown by the dashed lines then magnitude of change in equivalent resistance between end points $A$ and $B$ (in ohms) in final and initial arrangement is



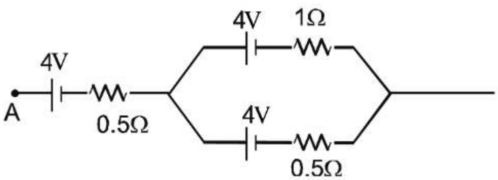
**67.** The meter-bridge wire *AB* shown in figure is 50 *cm* long. When *AD* = 30 cm, no deflection occurs in the galvanometer. Find *R* (in Ω).



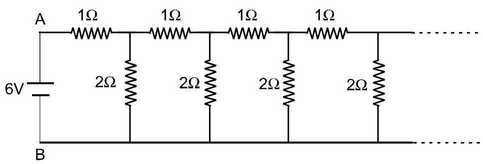

**68.** The total current (in A) supplied to the circuit by the battery is :



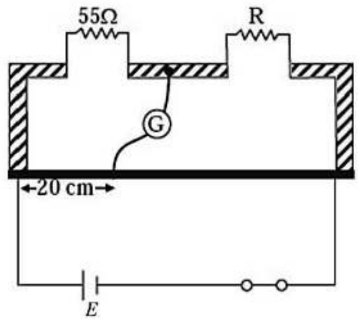

**69.** Find the equivalent *emf* (in volts) of the three batteries as shown in the figure.



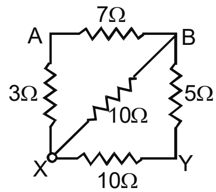

**70.** An infinite ladder network of resistance is constructed with 1Ω and 2Ω resistance, as shown in figure. What will be the effective resistance between *A* and *B*.




**71.** Shown in the figure below is a meter-bridge set up with null deflection in the galvanometer. The value of the unknown resistor *R* is (in Ω)

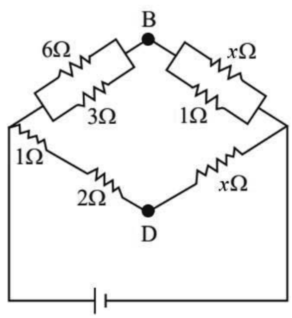



**72.** Equivalent resistance (in Ω) across *X* and *Y* is




**73.** Eight copper wire of length *l* and diameter *d* are joined in parallel to from a single composite conductor of resistance *R*. If a single copper wire of length 2 *l* have the same resistance (*R*) then its diameter will be *nd* then the value of *n* is

**74.** If the potential difference between *B* and *D* is zero, the value of *x* is $\frac{1}{n}$ Ω. The value of *n* is




**75.** 10 resistors each of resistance 10 Ω can be connected in such as to get maximum and minimum equivalent resistance. The ratio of maximum and minimum equivalent resistance will be _________.

CHAPTER 16

# MAGNETIC EFFECTS OF CURRENT & MAGNETISM

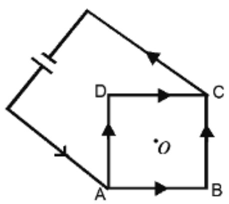
*Single Option Correct Type Questions (01 to 55)*

**1.** A ring of radius $r$ is uniformly charged with charge $q$. If the ring is rotated with angular frequency $\omega$, then the magnetic induction at its centre will be -

(1) $10^{-7} \times \frac{\omega}{qr}$  (2) $10^{-7} \times \frac{q}{\omega r}$

(3) $10^{-7} \times \frac{r}{q\omega}$  (4) $10^{-7} \times \frac{q\omega}{r}$

**2.** A thin wire is bent to form a square loop $ABCD$. A battery of e.m.f 2V is connected between the points $A$ and $C$. The magnetic induction due to the current in the loop at centre $O$ will-




(1) be zero

(2) point away from the plane of paper

(3) point along the plane of paper

(4) point into the plane of paper

**3.** A proton beam is going from north to south and an electron beam is going from south to north. Neglecting the earth's magnetic field, the electron beam will be deflected

(1) towards the proton beam

(2) away from the proton beam

(3) away from the electron beam

(4) None of these

**4.** When a charged particle moves at right angles to a magnetic field then which of the following quantities changes-

(1) energy  (2) velocity

(3) speed  (4) all of above

**5.** A charged particle with charge $q$ is moving in a uniform magnetic field. If this particle makes any angle $\theta$ with the magnetic field then its path will be – ($\theta \neq 0^{\circ}, 90^{\circ}, 180^{\circ}$)

(1) circular  (2) straight line

(3) helical  (4) parabolic

**6.** A conducting circular loop of radius $r$ carries a constant current $i$. It is placed in a uniform magnetic field $B$ such that $B$ is perpendicular to the plane of the loop. The magnetic force acting on the loop is

(1) $i\,r\,B$  (2) $2\,\pi\,r\,i\,B$

(3) Zero  (4) $\pi\,r\,i\,B$

**7.** If an electron and a proton having same momentum enter perpendicularly to a magnetic field, then:

(1) curvature of path of electron and proton will be same (ignoring the sense of revolution)

(2) they will move undeflected

(3) curved path of electron is more curved than that of proton

(4) path of proton is more curved

**8.** A moving charge produces

(1) electric field only

(2) magnetic field only

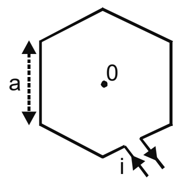
(3) both of them

(4) none of these

**9.** A bar magnet has a magnetic moment 2.5 $JT^{-1}$ and is placed in a magnetic field of 0.2 *T*. Work done in turning the magnet from parallel to antiparallel position relative to the field direction.

(1) 0.5 J (2) 1 J
(3) 2.0 J (4) Zero

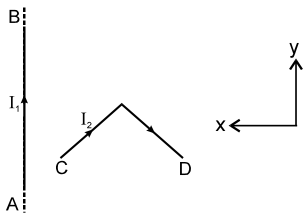
**10.** A current is flowing in a hexagonal coil of side a (Fig.). The magnetic induction at the centre of the coil will be (the separation between the wires carrying current in and out is negligible)




(1) $\frac{3\sqrt{3}\mu_0 i}{\pi a}$ (2) $\frac{\mu_0 i}{3\sqrt{3}\,\pi a}$

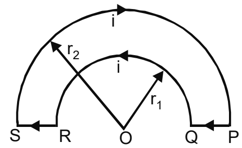
(3) $\frac{\mu_0 i}{\sqrt{3}\,\pi a}$ (4) $\frac{\sqrt{3}\,\mu_0 i}{\pi a}$

**11.** In the figure shown a current $I_1$ is established in the long straight wire *AB*. Another wire *CD* carrying current $I_2$ is placed in the plane of the paper. The line joining the ends of this wire is perpendicular to the wire *AB*. The resultant force on the wire *CD* is:




(1) zero
(2) towards negative x-axis
(3) towards positive y-axis
(4) none of these

**12.** A wire loop *PQRSP* is constructed by joining two semi circular coils of radii $r_1$ and $r_2$ respectively as shown in the fig. Current *i* is flowing in the loop. The magnetic induction at point *O* will be –




(1) $\frac{\mu_0 i}{4}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ (2) $\frac{\mu_0 i}{4}\left[\frac{1}{r_1}+\frac{1}{r_2}\right]$

(3) $\frac{\mu_0 i}{2}\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$ (4) $\frac{\mu_0 i}{2}\left[\frac{1}{r_1}+\frac{1}{r_2}\right]$

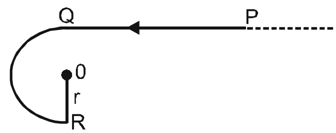
**13.** Which of the following particles will experience maximum magnetic force (magnitude) when projected with the same velocity perpendicular to a magnetic field?

(1) electron (2) proton
(3) $He^+$ (4) $Li^{++}$

**14.** Two parallel wires one of length 1m and other is infinite length, are lying at a distance of 2m. If the current flowing in each wire is 1 ampere then the force between them will be -

(1) $2 \times 10^{-7}$ N (2) $10^{-7}$ N
(3) 0.5 N (4) $10^7$ N

**15.** The magnetic induction at centre *O* due to the arrangement shown in fig.-




(1) $\frac{\mu_0 i}{4\pi r}(1+\pi)$ (2) $\frac{\mu_0 i}{4\pi r}$

(3) $\frac{\mu_0 i}{4\pi r}(1-\pi)$ (4) $\frac{\mu_0 i}{r}$

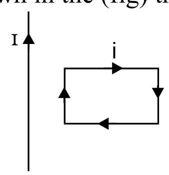
**16.** A current-carrying, straight wire is kept along the axis of a circular loop carrying a current. The straight wire

(1) will exert an inward force on the circular loop
(2) will exert an outward force on the circular loop
(3) will not exert any force on the circular loop
(4) will exert a force on the circular loop parallel to itself.

**17.** A charge particle moves in a region having a parallel uniform magnetic field and, uniform electric field. At some instant, the direction of velocity of the particle is perpendicular to both. The path of the particle will be
(1) a straight line
(2) a circle
(3) a helix with uniform pitch
(4) a helix with nonuniform pitch.

**18.** A wire is wound on a long rod of material of relative permeability $\mu_r$ = 4000 to make a solenoid. If the current through the wire is 5 A and number of turns per unit length is 1000 per metre, then the magnetic field inside the solenoid is: (Take π = 3.14)
(1) 25.12 mT (2) 12.56 m T
(3) 12.56 T (4) 25.12 T

**19.** A rectangular loop carrying a current $i$ is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and the plane of the loop is same of the left wire. If a steady current $I$ is established in the wire as shown in the (fig) the loop will-




(1) Rotate about an axis parallel to the wire
(2) Move away from the wire
(3) Move towards the wire
(4) Remain stationary.

**20.** An electric current $i$ is flowing in a circular coil of radius $a$. At what distance from the centre on the axis of the coil will the magnetic field be 1/8th of its value at the centre-
(1) 3a (2) $\sqrt{3}a$
(3) $\frac{a}{3}$ (4) $\frac{a}{\sqrt{3}}$

**21.** The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of the loop?
(1) 250 μT (2) 150 μT
(3) 125 μT (4) 75 μT

**22.** Two thin, long, parallel wires, separated by a distance '$d$' carry a current of '$i$' A in the same direction. They will:
(1) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$ per unit length
(2) repel, each other with a force of $\frac{\mu_0 i^2}{(2\pi d)}$
(3) attract each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$ per unit length
(4) repel each other with a force of $\frac{\mu_0 i^2}{(2\pi d^2)}$

**23.** A magnetic needle lying parallel to a magnetic field requires $W$ units of work to turn it through 60º. The torque needed to maintain the needle in this position will be:
(1) $\sqrt{3}W$ (2) W
(3) $(\sqrt{3}/2)W$ (4) 2W

**24.** A charged particle of mass $m$ and charge $q$ travels on a circular path of radius $r$ that is perpendicular to a magnetic field $B$. The time taken by the particle to complete one revolution is:
(1) $\frac{2\pi mq}{B}$ (2) $\frac{2\pi q^2 B}{B}$
(3) $\frac{2\pi qB}{m}$ (4) $\frac{2\pi m}{qB}$

**25.** Consider a long, straight wire of cross-section area A carrying a current $i$. Let there be $n$ free electrons per unit volume. An observer places himself on a trolley moving in the direction opposite to the current with a speed $v_d = (i/nAe)$ and separated from the wire by a distance $r$. The magnetic field seen by the observer is
(1) $\frac{\mu_0 i}{2\pi r}$ (2) Zero
(3) $\frac{\mu_0 i}{\pi r}$ (4) $\frac{2\mu_0 i}{\pi r}$

**26.** A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected along the direction of the fields with a certain velocity, then:

(1) its velocity will decrease and than increase
(2) its velocity will increase and then decrease
(3) it will turn towards right of direction of motion
(4) it will turn towards left of direction of motion.

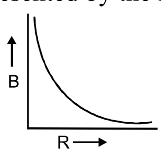
**27.** The magnetic induction due to circular current carrying conductor of radius $a$, at its centre is $B_c$. The magnetic induction on its axis at a distance $a$ from its centre is $B_p$. The value of $B_c$ : $B_p$ will be -

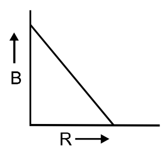
(1) $\sqrt{2}:2$ (2) $1:2\sqrt{2}$
(3) $2\sqrt{2}:1$ (4) $2:\sqrt{2}$

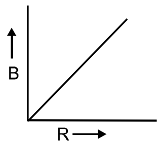
**28.** If a current is passed through a spring then the spring will:

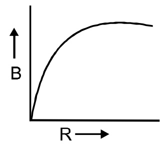
(1) expand (2) compress
(3) remain same (4) none of these

**29.** A charge $Q$ is uniformly distributed over the surface of non-condcting disc of radius $R$. The disc rotates about an axis perpendicular to its plane and passing through its centre with an angular velocity ω. As a result of this rotation a magnetic field of induction $B$ is obtained at the centre of the disc. if we keep both the amount of charge placed on the disc and its angular velocity to be constant and vary the radius of the disc then the variation of the magnetic induction at the centre of the disc will be represented by the figure:

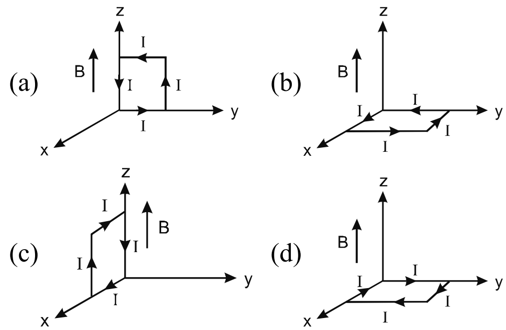
(1) 


(2) 


(3) 


(4) 

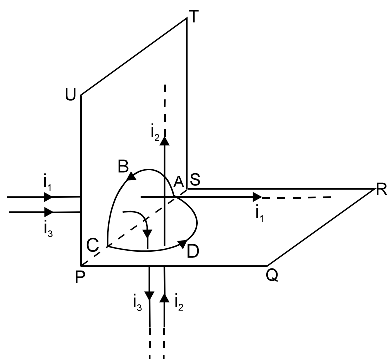

**30.** A rectangular loop of sides 10 cm and 5 cm carrying a current $I$ of 12 A is placed in different orientations as shown in the figures below:




If there is a uniform magnetic field of 0.3 $T$ in the positive $z$ direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium?

(1) (a) and (b), respectively
(2) (a) and (c), respectively
(3) (b) and (d), respectively
(4) (b) and (c), respectively

**31.** Figure shows an amperian path $ABCDA$. Part $ABC$ is in vertical plane $PSTU$ while part $CDA$ is in horizontal plane $PQRS$. Direction of circulation along the path is shown by an arrow near point $B$ and at $D$. $\oint \vec{B}.d\vec{\ell}$ for this path according to Ampere's law will be:




(1) $(i_1 - i_2 + i_3)\,\mu_0$ (2) $(-i_1 + i_2)\,\mu_0$
(3) $i_3\mu_0$ (4) $(i_1 + i_2)\,\mu_0$

**32.** A circular loop of area 1 $cm^2$, carrying a current of 10 A, is placed in a magnetic field of 0.1 T perpendicular to the plane of the loop. The torque on the loop due to the magnetic field is

(1) Zero  (2) $10^{-4}$ N–m

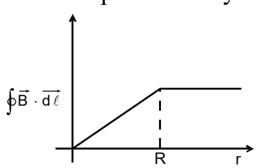
(3) $10^{-2}$ N–m  (4) 1 N–m

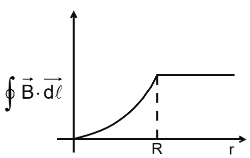
**33.** Two similar coils of radius $R$ and $N$ number of turns are lying concentrically with their planes at right angles to each other. The currents flowing in them are $I$ and $I\sqrt{3}$ respectively. The resultant magnetic induction at the centre will be (in Wb/$m^2$).

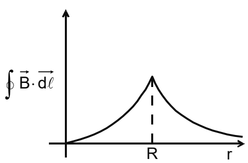
(1) $\frac{\mu_0 NI}{2R}$  (2) $\frac{\mu_0 NI}{R}$

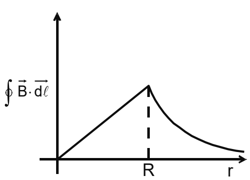
(3) $\sqrt{3}\,\mu_0 \frac{NI}{2R}$  (4) $\sqrt{5}\,\frac{\mu_0 NI}{2R}$

**34.** A cylindrical wire of radius $R$ is carrying current $i$ uniformly distributed over its cross-section. If a circular loop of radius '$r$' is taken as amperian loop, then the variation value of $\oint \vec{B}\cdot\vec{d\ell}$ over this loop with radius '$r$' of loop will be best represented by:

(1) 


(2) 


(3) 


(4) 


**35.** Two parallel wires carry currents of 20 A and 40 A in opposite directions. Another wire carrying a current antiparallel to 20 A is placed midway between the two wires. The magnetic force on it will be

(1) Towards 20 A

(2) Towards 40 A

(3) Zero

(4) Perpendicular to the plane of the currents

**36.** Proton, Deuteron and alpha particle of same kinetic energy are moving in circular trajectories in a constant magnetic field. The radii of proton, deuteron and alpha particle are respectively $r_p$, $r_d$ and $r_\alpha$. Which one of the following relation is correct?

(1) $r_\alpha = r_p = r_d$  (2) $r_\alpha = r_p < r_d$

(3) $r_\alpha > r_d > r_p$  (4) $r_\alpha = r_d > r_p$

**37.** An electric current $i$ is flowing in a circular coil of radius $a$. At what distant from the centre on the axis of the coil will the magnetic field be $\frac{1}{27}$ th of its value at the centre-

(1) $2a$  (2) $2\sqrt{2}\,a$

(3) $\frac{a}{\sqrt{2}}$  (4) $\frac{a}{2\sqrt{2}}$

**38.** In a region, steady and uniform electric and magnetic fields are present. A charged particle can move with constant velocity if

(1) Particle moves parallel to magnetic field and perpendicular to electric field

(2) Particle moves parallel to electric field and perpendicular to magnetic field

(3) Particle moves perpendicular to both magnetic field and electric field

(4) Particle moves parallel to both magnetic field and electric field

**39.** A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is $B$. It is then bent into a circular loop of $n$ turns. The magnetic field at the centre of the coil will be:

(1) $nB$  (2) $n^2B$

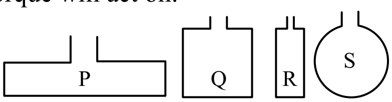
(3) $2nB$  (4) $2n^2B$

**40.** A long solenoid has 200 turns per cm and carries a current $i$. The magnetic field at its centre is $6.28\times10^{-2}$ Weber/m$^2$. Another long solenoid has 100 turns per cm and it carries a current $i/3$. The value of the magnetic field at its centre is: (approximately)
(1) $1.05 \times 10^{-4}$ Weber/m$^2$
(2) $1.05 \times 10^{-2}$ Weber/m$^2$
(3) $1.05 \times 10^{-5}$ Weber/m$^2$
(4) $1.05 \times 1010^{-3}$ Weber/m$^2$

**41.** A small linear segment of an electric circuit is lying on x-axis extending from $x = -\frac{a}{2}$ to $x = \frac{a}{2}$ and a current $i$ is flowing in it. The magnetic induction due to the segment at a point $x = a$ will be-
(1) $\propto a$ (2) Zero
(3) $\propto a^2$ (4) $\propto \frac{1}{a}$

**42.** A long straight wire of radius $a$ carries a steady current $i$. The current is uniformly distributed across its cross-section. The ratio of the magnetic field at $\frac{a}{2}$ and $2a$ from axis is:
(1) 1/4 (2) 4
(3) 1 (4) 1/2

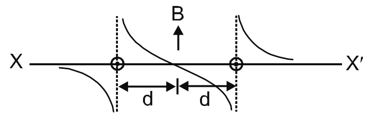
**43.** Four wires of equal length are bent in the form of four loops $P$, $Q$, $R$ and $S$. These are suspended in a uniform magnetic field and same current is passed in them. The maximum torque will act on.

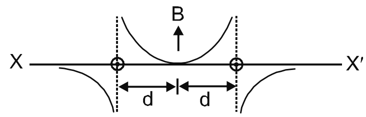


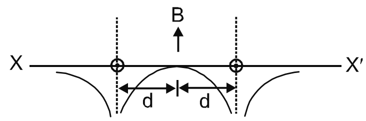

(1) P (2) Q
(3) R (4) S

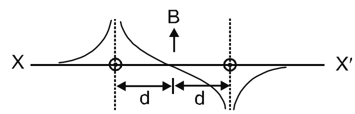
**44.** A current of $i$ ampere is flowing in an equilateral triangle of side $a$. The magnetic induction at the centroid will be -
(1) $\frac{\mu_0 i}{3\sqrt{3}\pi a}$ (2) $\frac{3\mu_0 i}{2\pi a}$
(3) $\frac{5\sqrt{2}\mu_0 i}{3\pi a}$ (4) $\frac{9\mu_0 i}{2\pi a}$

**45.** Two long parallel wires are at a distance $2d$ apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of magnetic field $B$ along the line $XX'$ is given by

(1) 

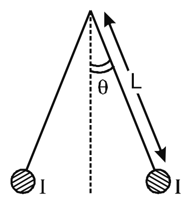

(2) 


(3) 


(4) 


**46.** Two long current carrying thin wires, both with current $I$ in opposite direction are held by insulating threads of length $L$ and are in equilibrium as shown in the figure, with threads making an angle 'θ' with the vertical at equilibrium position. If wires have mass $\lambda$ per unit length then the value of $I$ is:

($g$ = gravitational acceleration)




(1) $\sin\theta\sqrt{\frac{\pi\lambda gL}{\mu_0 \cos\theta}}$ (2) $2\sin\theta\sqrt{\frac{\pi\lambda gL}{\mu_0 \cos\theta}}$
(3) $2\sqrt{\frac{\pi gL}{\mu_0}\tan\theta}$ (4) $\sqrt{\frac{\pi\lambda gL}{\mu_0}\tan\theta}$

**47.** A current $I$ flows in an infinitely long wire with cross–section in the form of a semicircular ring of radius $R$. The magnitude of the magnetic induction along its axis is:

(1) $\frac{\mu_0 I}{\pi^2 R}$ (2) $\frac{\mu_0 I}{2\pi^2 R}$

(3) $\frac{\mu_0 I}{2\pi R}$ (4) $\frac{\mu_0 I}{4\pi R}$

**48.** A steady current '$I$' flows in a small square loop of wire of side L in a horizontal plane. The loop is now folded about its middle such that half of it lies in a vertical plane. Let $\vec{\mu}_1$ and $\vec{\mu}_2$ respectively denote the magnetic moments of the current loop before and after folding. Then:

(1) $\vec{\mu}_2 = 0$

(2) $\vec{\mu}_1$ and $\vec{\mu}_2$ are in the same direction

(3) $\frac{|\vec{\mu}_1|}{|\vec{\mu}_2|} = \sqrt{2}$

(4) $\frac{|\vec{\mu}_1|}{|\vec{\mu}_2|} = \frac{1}{\sqrt{2}}$

**49.** At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit:

(i) electrons (ii) protons

(iii) $He^{2+}$ (iv) Neutrons

The emission at the instant can be

(1) i, ii, iii

(2) i, ii, iii, iv

(3) iv

(4) ii, iii, iv

**50.** **Statement 1:** A uniformly distributed current flows through a solid long metallic cylinder along its length. It produces magnetic field only outside the cylinder.

**Statement 2:** A thin long cylindrical tube carrying uniformly distributed current along its length does not produce a magnetic field inside it. Moreover, a solid cylinder can be supposed to be made up of many thin cylindrical tubes.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**51.** **Statement–1:** Two charged particles are released from rest in gravity free space. After some time, one particle will exert a non-zero magnetic force on the other particle in addition to electrostatic force.

**Statement–2:** A moving charge produces magnetic field. Also a magnetic force may act on a charged particle moving in an external magnetic field.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**52.** A charged particle moves through a magnetic field perpendicular to its direction. Then :

(1) the momentum changes but the kinetic energy is constant

(2) both momentum and kinetic energy of the particle are not constant

(3) both, momentum and kinetic energy of the particle are constant

(4) kinetic energy changes but the momentum is constant

**53.** A charged particle having non zero velocity is subjected to certain conditions given in Column I. Column-II gives possible trajectories of the particle. Match the conditions in column-I with the results in Coulmn-II

| Column-I | | Column-II | |
|---|---|---|---|
| I | In only uniform electric field | P | the path of the charged particle may be a straight line |
| II | In only uniform magnetic field | Q | the path of the charged particle may be a parabola |
| III | In uniform magnetic and uniform electric field such that both are parallel | R | the path of the charged particle may be a circle |
| | | S | the path of the charged particle may be a helix with uniform or non uniform pitch |

(1) I-P, Q; II-P, R, S; III-P, S
(2) I-P; II-P, Q; III-P, S
(3) I-P, Q; II-P, S; III-P, S
(4) I-P; II-P, R, S; III-P

**54.** Two identical conducting wires *AOB* and *COD* are placed at right angles to each other. The wire *AOB* carries an electric current $I_1$ and *COD* carries a current $I_2$. The magnetic field on a point lying at a distance *d* vertically above *O*, in a direction perpendicular to the plane of the wires *AOB* and *COD*, will be given by

(1) $\frac{\mu_0}{2\pi}\left(\frac{I_1+I_2}{d}\right)^{1/2}$ (2) $\frac{\mu_0}{2\pi d}\left(I_1^2+I_2^2\right)^{1/2}$

(3) $\frac{\mu_0}{2\pi d}(I_1+I_2)$ (4) $\frac{\mu_0}{2\pi d}\left(I_1^2+I_2^2\right)$

**55.** A uniformly distributed current *I* flows along the length of an infinitely long, straight, thin walled pipe. Then:
(1) the magnetic field is zero only on the axis of the pipe
(2) the magnetic field is different at different points inside the pipe
(3) the magnetic field at any point inside the pipe is zero
(4) the magnetic field at all points inside the pipe is the same, but not zero

## *Integer Type Questions (56 to 69)*

**56.** The charge on a particle is 100 times that of electron. It is revolving in a circular path of radius 0.8 m at a frequency of $10^{11}$ revolutions per second. The magnetic field at the centre of path will be $10^{-x}$ $\mu_0$. Find magnitude of *x*.

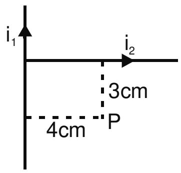
**57.** The magnetic flux density at a point at a distance *d* from a long straight current carrying conductor is *B*, then its value at distance $\frac{d}{2}$ will be *xB*. Find *x*.

**58.** A current *i* is flowing in a straight conductor wire of length *L*. The magnetic induction at a point at perpendicular distance $\frac{L}{4}$ from its centre will be $\frac{x\mu_0 i}{\sqrt{5}\pi L}$. Find *x*.

**59.** Two parallel wires *P* and *Q* carry electric currents of 10 A and 2A respectively in mutually opposite directions. The distance between the wires is 10 cm. If the wire *P* is of infinite length and wire *Q* is 2m long, then the force acting on *Q* will be $x \times 10^{-5}$. Find *x*.

**60.** The ratio of magnetic inductions at the centre of a circular coil of radius *a* and on its axis at a distance equal to $\sqrt{15}a$ will be

**61.** Two insulated wires one of infinite length and other of semi-infinite length are lying mutually at right angles to each other as shown in figure. Currents of 2A and 1.5A respectively are flowing in them. The value of magnetic induction at point $P$ will be $\frac{x}{10}\times10^{-5}T$. Find $x$.




**62.** Two identical wires $A$ and $B$, each of length $l$, carry the same current $I$. Wire $A$ is bent into a circle of radius $R$ and wire $B$ is bent to form a square of side '$a$'. If $B_A$ and $B_B$ are the values of magnetic field at the centres of the circle and square respectively, then the ratio $\frac{B_A}{B_B}$ is $\frac{5\sqrt{2}}{x}$. Find $x$. (Use $\pi^2 = 10$)

**63.** If in a circular coil $A$ of radius $R$, current $i$ is flowing and in another coil $B$ of radius $2R$ a current $2i$ is flowing, then the ratio of the magnetic fields, $B_A$ and $B_B$ produced at the centre by them will be:

**64.** An electric charge $+q$ moves with velocity $\vec{v} = 3\hat{i} + 4\hat{j} + \hat{k}$, in an electric & magnetic field given by: $\vec{E} = 3\hat{i} + \hat{j} + \hat{k}$ and $\vec{B} = \hat{i} + \hat{j} - \hat{k}$. The y-component of the force experienced by $+q$ is $xq$. Find $x$.

**65.** Two long conductors, separated by a distance $d$ carry currents $I_1$ and $I_2$ in the same direction. They exert a force $F$ on each other. Now the current in one of them is increased to 6 times and its direction is reversed. The distance is also increased to $3d$. The magnitude of the force between them is $xF$. Find $x$.

**66.** Two parallel, long wires carry currents $i_1$ and $i_2$ with $i_1 > i_2$. When the current are in the same direction, the magnetic field at a point midway between the wire is 10 μT. If the direction of $i_2$ is reversed, the field becomes 30μT. The ratio $i_1/i_2$ is

**67.** The velocities of two identical charged particles entering a uniform magnetic field are in the ratio 1 : 3. Their path becomes circular in the magnetic field. The ratio of radii of their circular paths will be $x$. Find $6x$.

**68.** A thin circular disk of radius $R$ is uniformly charged with density $\sigma > 0$ per unit area. The disk rotates about its axis with a uniform angular speed $\omega$. The magnetic moment of the disk is $\frac{\sigma\pi R^4\omega}{x}$. Find $x$.

**69.** A current I flows along the length of an infinitely long, straight, thin walled pipe. Then $\oint \vec{B}.\vec{dl}$ inside the pipe.

CHAPTER

17

# MAGNETISM AND MATTER

## Single Option Correct Type Questions (01 to 20)

**1.** Given below are two statements:

**Statement-I:** The diamagnetic property depends on temperature strongly.

**Statement-II:** The induced magnetic dipole moment in a diamagnetic sample is always opposite to the magnetizing field.

In the light of given statement, choose the correct answer from the options given below:

(1) Statement-I is false but Statement-II is true
(2) Both Statement-I and Statement-II are true.
(3) Both Statement-I and Statement-II are false.
(4) Statement-I is true but Statement-II is false.

**2.** Given below are two statements: One is labelled as Assertion (A) and other is labelled as Reason (R).

**Assertion (A):** Non-polar materials do not have any permanent dipole moment.

**Reason (R):** When a non-polar material is placed in an electric field, the centre of the positive charge distribution of it's individual atom or molecule coincides with the centre of the negative charge distribution.

In the light of above statements, choose the most appropriate answer from the options given below:

(1) Both (A) and (R) are correct and (R) is the correct explanation of (A).
(2) Both (A) and (R) are correct and (R) is not the correct explanation of (A).
(3) (A) is correct but (R) is not correct.
(4) (A) is not correct but (R) is correct.

**3.** A soft ferromagnetic material is placed in an external magnetic field. The magnetic domains:

(1) Decrease in size and change orientation.
(2) Increases in size but no change in orientation.
(3) May increase or decrease in size and change its orientation.
(4) Have no relation with external magnetic field

**4.** **Statement-I:** The ferromagnetic property depends on temperature. At high temperature, ferromagnet becomes paramagnet

**Statement-II:** At high temperature, the domain wall area of a ferromagnetic substance increases.

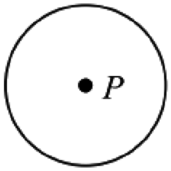
In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Both Statement-I and Statement-II are false
(2) Statement-I is true but Statement-II is false
(3) Statement-I is false but Statement-II is true
(4) Both Statement-I and Statement-II are true

**5.** In a ferromagnetic material, below the curie temperature, a domain is defined as:

(1) a macroscopic region with zero magnetization.
(2) a macroscopic region with saturation magnetization.
(3) a macroscopic region with randomly oriented magnetic dipoles.
(4) a macroscopic region with consecutive magnetic dipoles oriented in opposite direction.

**6.** A perfectly diamagnetic sphere has a small spherical cavity at its centre which is filled with a paramagnetic substance. The whole system is placed in a uniform magnetic field B Then the field inside the paramagnetic substance is




(1) Much larger than $|\vec{B}|$ and parallel to $|\vec{B}|$

(2) $|\vec{B}|$

(3) Much larger than $|\vec{B}|$ and opposite to $|\vec{B}|$

(4) Zero

**7.** Consider a circular coil of wire carrying constant current I, forming a magnetic dipole. The magnetic flux through an infinite plane, that contains the circular coil and excluding the circular coil area, is given by $\phi$ . The magnetic flux through the area is given by $\phi_0$ Which of the following is correct? [ $\phi_i$ == flux going inside, $\phi_0$ = flux coming out]

(1) $\phi_i = -\phi_0$ (2) $\phi_i > \phi_0$

(3) $\phi_i = \phi_0$ (4) $\phi_i < \phi_0$

**8.** Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

**Assertion A:** A bar magnet dropped through a metallic cylindrical pipe takes more time to come down compared to a non-magnetic bar with same geometry and mass.

**Reason R:** For the magnetic bar, Eddy currents are produced in the metallic pipe which oppose the motion of the magnetic bar.

In the light of the above statements, choose the correct answer from the options given below

(1) Both A and R are true but R is not the correct explanation of A

(2) A is true but R is false

(3) Both A and R are true and R is the correct explanation of A

(4) A is false but R is true

**9.** A bar magnet is released from rest along the axis of a very long vertical copper tube. After some time the magnet will

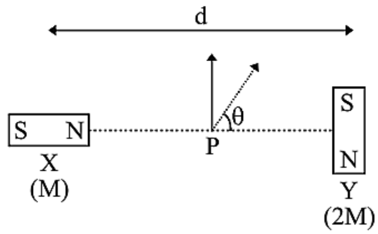
(1) Move down with almost constant speed

(2) Oscillate inside the tube

(3) Move down with an acceleration greater than $g$

(4) Move down with an acceleration equal to $g$

**10.** Two magnetic dipoles $X$ and $Y$ are placed at a separation d, with their axes perpendicular to each other. The dipole moment of $Y$ is twice that of $X$. A particle of charge $q$ is passing through their mid-point $P$, at angle $\theta = 45°$ with the horizontal line as shown in the figure. What would be the magnitude of force on the particle at that instant? ($d$ is much larger than the dimensions of the dipole)




(1) $\sqrt{2}\left(\frac{\mu_0}{4\pi}\right)\frac{M}{(d/2)^2}\times qv$

(2) $\left(\frac{\mu_0}{4\pi}\right)\frac{2M}{(d/2)^3}\times qv$

(3) $\left(\frac{\mu_0}{4\pi}\right)\frac{M}{(d/2)^3}\times qv$

(4) 0

**11.** The number of turns of the coil of a moving coil galvanometer is increased (maintaining same area) in order to increase current sensitivity by 50%. The percentage change in voltage sensitivity of the galvanometer will be:

(1) 100% (2) 50%

(3) 75% (4) 0%

**12.** A hoop and a solid cylinder of same mass and radius are made of a permanent magnetic material with their magnetic moment parallel to their respective axes. But the magnetic moment of hoop is twice of solid cylinder. They are placed in a uniform magnetic field in such a manner that their magnetic moments make a small angle with the field. If the oscillation periods of hoop and cylinder are $T_h$ and $T_C$ respectively, then:

(1) $T_h = T_C$ (2) $T_h = 2T_C$
(3) $T_h = 1.5T_C$ (4) $T_h = 0.5\ T_C$

**13.** The magnetic moment of a diamagnetic atom is

(1) Much greater than one
(2) 1
(3) Between zero and one
(4) Equal to zero

**14.** Nickel shows ferromagnetic property at room temperature. If the temperature is increased beyond Curie temperature, then it will show

(1) Paramagnetism
(2) Anti-ferromagnetism
(3) No magnetic property
(4) Diamagnetism

**15.** Curie temperature is the one above which

(1) Paramagnetic substance changes to ferromagnetic
(2) Paramagnetic changes to diamagnetic
(3) Diamagnetic changes to paramagnetic
(4) Ferromagnetic changes to paramagnetic

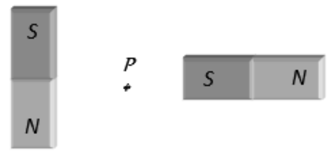
**16.** Domain formation is the necessary feature of

(1) Ferromagnetism (2) Paramagnetism
(3) Diamagnetism (4) All of these

**17.** The force between two magnetic poles is $F$. If the distance between the poles and pole strengths of each pole are doubled, then the force experienced is

(1) $2F$ (2) $F/2$
(3) $F/4$ (4) $F$

**18.** Two equal bar magnets are kept as shown in the figure. The direction of resultant magnetic field, indicated by arrow head at the point P is (approximately)

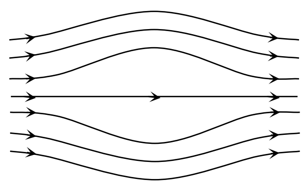



(1) → (2) ↗
(3) ↘ (4) ↓

**19.** A paramagnetic liquid is taken in a U-tube and arranged so that one of its limbs is kept between pole pieces of the magnet. The liquid level in the limb

(1) Goes down
(2) Rises up
(3) Remains same
(4) First goes down and then rises

**20.** The given figure represents a material which is



(1) Paramagnetic (2) Diamagnetic
(3) Ferromagnetic (4) None of these

## Integer Type Questions (21 to 29)

**21.** A bar magnet having a magnetic moment of $2.0 \times 10^5\ JT^{-1}$, is placed along the direction of uniform magnetic field of magnitude $B = 14 \times 10^{-5}\ T$. The work done in rotating the magnet slowly through 60° from the direction of field is $xJ$. Find $x$

**22.** A paramagnetic sample shows a net magnetisation of 6 A/m when it is placed in an external magnetic field of 0.4 T at a temperature of 4 K. When the sample is placed in an external magnetic field of 0.3 *T* at a temperature of 24 *K*, then the magnetisation will be $\frac{3}{x}$ A/m. Find $x$

**23.** A bar magnet having a magnetic moment 5.0 $Am^2$ is placed in parallel position relative to a magnetic field of 0.4 *T*. The amount of work done in turning the magnet from parallel to antiparallel position relative to the field direction is

**24.** Two bar magnets oscillate in a horizontal plane in uniform magnetic field with time periods of 3s and 4s respectively. If their moments of inertia are in the ratio of 3 : 2, then the ratio of their magnetic moments will be $x$ : 3. Find $x$

**25.** A small bar magnet placed with its axis at 30° with an external field of 0.06 T experiences a torque of 0.018 Nm. The minimum work (in J) required to rotate it from its stable to unstable equilibrium position is $7.2\times10^{-x}$. Find $x$

**26.** For a moving coil galvanometer, the deflection in the coil is 0.05 rad when a current of 10mA is passed through it. If the torsional constant of the suspension wire is $4.0\times10^{-5}$, the magnetic field is 0.01 T and the number of turns in the coil is 200, the area of each turn (in $cm^2$) is:

**27.** A long solenoid with 1000 turns/m has a core material with relative permeability 500 and volume 103 $cm^3$. If the core material is replaced by another material having relative permeability of 750 with same volume maintaining same current of 0.75 A in the solenoid, the fractional change in the magnetic moment of the core would be approximately $\left(\frac{x}{500}\right)$. Find the value of $x$.

**28.** The time period of a freely suspended bar magnet in a field is 2 s. It is cut into two equal parts along its axis, then the time period of individual part is

**29.** Force between two identical short bar magnets whose centers are $r$ metre apart is 8.1 N, when their axes are along the same line. If separation is increased to 3 $r$, the force between them would become $1/x$ *N*. Find $x$

# CHAPTER 18

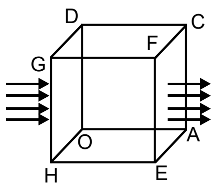
# ELECTROMAGNETIC INDUCTION

## *Single Option Correct Type Questions (01 to 60)*

**1.** The horizontal component of earth's magnetic field is $3 \times 10^{-5}$ Wb/$m^2$. The magnetic flux linked with a coil of area 1 $m^2$ and having 5 turns, whose plane is normal to the magnetic field, will be

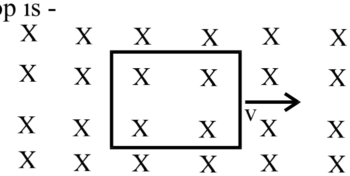
(1) $3 \times 10^{-5}$ Wb (2) $5 \times 10^{-5}$ Wb
(3) $15 \times 10^{-5}$ Wb (4) $1 \times 10^{-5}$ Wb

**2.** A cube of side a is placed in a magnetic field *B*. The net magnetic flux emerging out of the cube will be -




(1) $Ba^2$ (2) $-Ba^2$
(3) $2Ba^2$ (4) zero

**3.** A conducting square loop of side $\ell$ and resistance *R* moves in its plane with a uniform velocity *v* perpendicular to one of its sides. A uniform and constant magnetic field *B* exists along the perpendicular to the plane of the loop as shown in figure. The current induced in the loop is -




(1) $B\ell\upsilon/R$ clockwise

(2) $B\ell\upsilon/R$ anticlockwise

(3) $2B\ell\upsilon/R$ anticlockwise

(4) zero

**4.** When the current changes from +2 *A* to –2 *A* in 0.05 second, an emf of 8 V is induced in a coil. The coefficient of self-induction of the coil is :

(1) 0.2 H (2) 0.4 H
(3) 0.8 H (4) 0.1 H

**5.** Two different coils have self-inductance $L_1$ = 8 mH, $L_2$ = 2 mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same rate. At a certain instant of time, the power given to the two coils is the same. At that time the current, the induced voltage and the energy stored in the first coil are $i_1$, $V_1$ and $W_1$ respectively. Corresponding values for the second coil at the same instant are $i_2$, $V_2$ and $W_2$ respectively. Then which of the following is **incorrect** :

(1) $\frac{i_1}{i_2} = \frac{1}{4}$

(2) $\frac{i_1}{i_2} = 4$

(3) $\frac{W_2}{W_1} = 4$

(4) $\frac{V_2}{V_1} = \frac{1}{4}$

**6.** Self-inductance of a solenoid depend on -

(1) the number of turns *N* of the coil
(2) the area of cross-section *A* and length $\ell$ of the coil.
(3) the permeability of the core of the coil
(4) all the above

**7.** A conducting ring lies fixed on a horizontal plane. If a charged non magnetic particle is released from a point (on the axis) at some height from the plane, then :

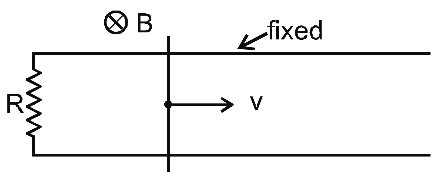
(1) an induced current will flow in clockwise or anticlockwise direction in the loop depending upon the nature of the charge

(2) the acceleration of the particle will decrease as it comes down

(3) the rate of production of heat in the ring will increase as the particle comes down

(4) no heat will be produced in the ring.

**8.** **STATEMENT-1 :** A resistance R is connected between the two ends of the parallel smooth conducting rails. A conducting rod lies on these fixed horizontal rails and a uniform constant magnetic field B exists perpendicular to the plane of the rails as shown in the figure. If the rod is given a velocity v and released as shown in figure, it will stop after some time. The total work done by magnetic field is negative **.**




**STATEMENT-2 :** If force acts opposite to direction of velocity its work done is negative.

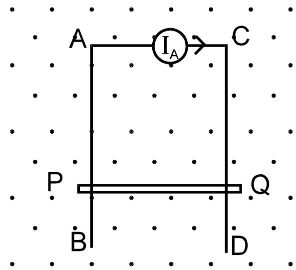
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True

**9.** *AB* and *CD* are fixed conducting smooth rails placed in a vertical plane and joined by a constant current source at its upper end. *PQ* is a conducting rod which is free to slide on the rails. A horizontal uniform magnetic field exists in space as shown. If the rod *PQ* is released from rest then,



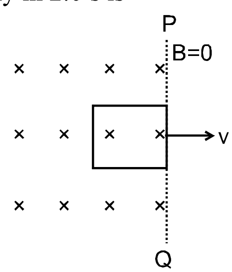

(1) The rod *PQ* may move downward with constant acceleration

(2) The rod *PQ* may move upward with constant acceleration

(3) The rod will move downward with decreasing acceleration and finally acquire a constant velocity

(4) either 1 or 2.

**10.** Figure shows a square loop of side 0.5 *m* and resistance 10 Ω. The magnetic field on left side of line *PQ* has a magnitude $B = 1.0T$. The work done in pulling the loop out of the field uniformly in 2.0 s is




(1) $3.125 \times 10^{-3}$ J

(2) $6.25 \times 10^{-4}$ J

(3) $1.25 \times 10^{-2}$ J

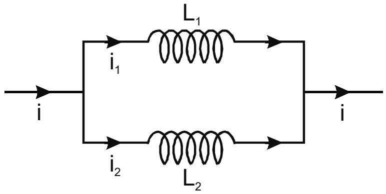
(4) $5.0 \times 10^{-4}$ J

**11.** A straight conductor of length 0.4 m is moved in a magnetic field of 0.9 weber/m$^2$ with a velocity of 7 m/s. The maximum emf induced in the conductor will be -

(1) 2.52 V (2) 25 V

(3) 2.8 V (4) 63 V

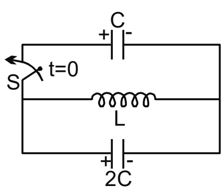
**12.** Two inductors $L_1$ and $L_2$ are connected in parallel and a time varying current i flows as shown. The ratio of currents $i_1/i_2$ at any time $t$ is ($i_1$ and $i_2$ are varying with time)




(1) $L_1/L_2$ (2) $L_2/L_1$

(3) $\frac{L_1^2}{(L_1+L_2)^2}$ (4) $\frac{L_2^2}{(L_1+L_2)^2}$

**13.** In the given $LC$ circuit if initially capacitor $C$ has charge $Q$ on it and $2C$ has charge $2Q$ .The polarities are as shown in the figure. Then after closing switch $S$ at $t = 0$




(1) energy will get equally distributed in both the capacitor just after closing the switch.

(2) initial rate of growth of current in inductor will be $2Q/3CL$

(3) maximum energy in the inductor will be $3Q^2/2C$

(4) none of these

**14.** A bar magnet is released from rest coaxially along the axis of a very long, vertical copper tube. After some time the magnet

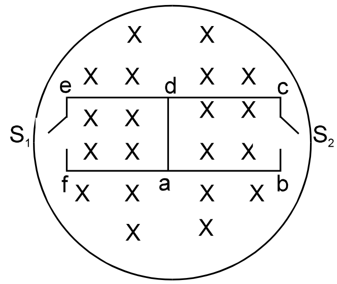
(1) will stop in the tube

(2) will move with almost constant speed

(3) will move with an acceleration g

(4) will oscillate

**15.** The magnetic field in the cylindrical region shown in figure increases at a constant rate of 10.0 mT/s Each side of the square loop abcd and defa has a length of 2.00 cm and resistance of 2.00 Ω . Correctly match the current in the wire 'ad' in four different situations as listed in column-I with the values given in column-II.




| Column-I | | Column-II | |
|---|---|---|---|
| I | the switch $S_1$ is closed but $S_2$ is open | P | $5 \times 10^{-7}$ A, d to a |
| II | $S_1$ is open but $S_2$ is closed | Q | $5 \times 10^{-7}$ A, a to d |
| III | both $S_1$ and $S_2$ are open | R | $2.5 \times 10^{-8}$ A, d to a |
| IV | both $S_1$ and $S_2$ are closed. | S | $2.5 \times 10^{-8}$ A, a to d |
| | | T | No current flows |

(1) I-Q; II-P; III-T; IV-T

(2) I-P; II-Q; III-T; IV-T

(3) I-Q; II-P; III-P; IV-Q

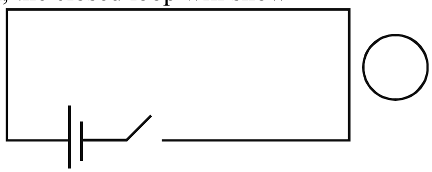
(4) I-Q; II-T; III-T; IV-P

**16.** A coil having $n$ turns and resistance $R\ \Omega$ is connected with a galvanometer of resistance $4R\Omega$. This combination is moved in time $t$ seconds from a magnetic field $W_1$ Weber to $W_2$ Weber. The induced current in the circuit is :

(1) $\frac{(W_2-W_1)}{5Rnt}$A (2) $\frac{n(W_2-W_1)}{5Rt}$A

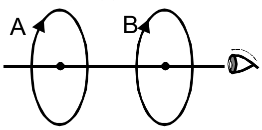
(3) $\frac{(W_2-W_1)}{Rnt}$A (4) $\frac{n(W_2-W_1)}{Rt}$A

**17.** Consider the situation shown in fig. If the switch is closed and after some time it is opened again, the closed loop will show



(1) an anticlockwise current-pulse
(2) a clockwise current-pulse
(3) an anticlockwise current-pulse and then a clockwise current-pulse
(4) a clockwise current-pulse and then an anticlockwise current-pulse

**18.** Two identical coils $A$ and $B$ are arranged coaxially as shown in the figure and the sign convention adopted is such that the direction of currents are taken as positive when they flow in the direction of arrows. Which of the following statement is correct-



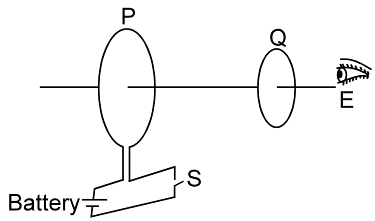

(1) If A carries a steady positive current and $A$ is moved towards $B$, then a positive current is induced in $B$.
(2) If A carries a steady positive current and $B$ is moved towards $A$, then a negative current is induced in $B$
(3) If both coils carry positive current, then the coils repel each other.
(4) If a positive current flowing in $A$ is switched off, then a negative current is induced momentarily in $B$

**19.** A conducting rod is moved with a constant velocity $\vec{v}$ in a magnetic field $\vec{B}$. A potential difference appears across the two ends

(1) if $\vec{v} \parallel \vec{\ell}$ (2) if $\vec{v} \parallel \vec{B}$

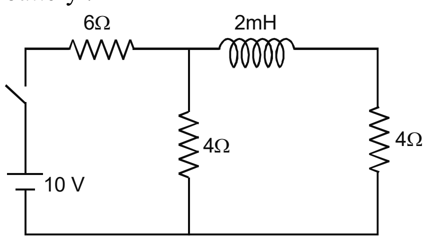
(3) if $\vec{\ell} \parallel \vec{B}$ (4) none of these

**20.** As shown in the fig. $P$ and $Q$ are two coaxial conducting loops separated by some distance. When the switch S is closed, a clockwise current $I_P$ flows in $P$ (as seen by $E$) and an induced current $I_{Q1}$ flows in $Q$. The switch remains closed for a long time. When S is opened, a current $I_{Q2}$ flows in $Q$. Then the directions of $I_{Q1}$ and $I_{Q2}$ (as seen by $E$) are



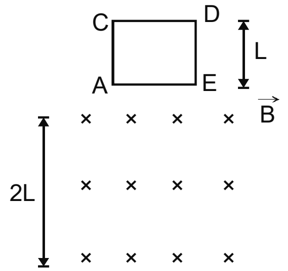

(1) respectively clockwise and anti-clockwise
(2) both clockwise
(3) both anti-clockwise
(4) respectively anti-clockwise and clockwise.

**21.** In the given circuit find the ratio of $i_1$ to $i_2$. Where $i_1$ is the initial (at $t = 0$) current, and $i_2$ is steady state (at $t = \infty$) current through the battery :



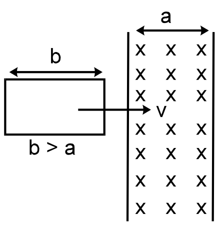

(1) 1.0
(2) 0.8
(3) 1.2
(4) 1.5

**22.** A square coil ACDE with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length $2L$. The acceleration of the coil is




(1) less than $g$ for all the time till the loop crosses the magnetic field completely
(2) less than $g$ when it enters the field and greater than $g$ when it comes out of the field
(3) $g$ all the time
(4) less than g when it enters and comes out of the field but equal to g when it is within the field

**23.** In the given arrangement, the loop is moved with constant velocity $v$ in a uniform magnetic field $B$ in a restricted region of width $a$. The time for which the emf is induced in the circuit is:




(1) $\frac{2b}{v}$

(2) $\frac{2a}{v}$

(3) $\frac{(a+b)}{v}$

(4) $\frac{2(a-b)}{v}$

**24.** A short circuited coil is placed in a time-varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved keeping the radius of the loop unchanged, the electrical power dissipated would be:
(1) halved
(2) the same
(3) doubled
(4) quadrupled

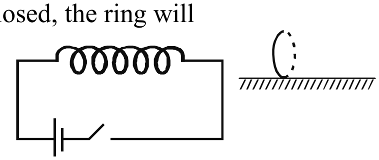
**25.** A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage $2V$. The current reaches half of its steady state value in :
(1) 0.05 s (2) 0.1 s
(3) 0.15 s (4) 0.3 s

**26.** A metal rod of length $L$ is placed normal to a magnetic field and rotated about its end in a circular path with frequency $f$. The potential difference between it ends will be -
(1) $\pi L^2 Bf$ (2) $BL/f$
(3) $\pi L^2 B/f$ (4) $fBL$

**27.** If the length and area of cross-section of an inductor remain same but the number of turns is doubled, its self-inductance will become -
(1) half (2) four times
(3) double (4) one-fourth

**28.** Tesla is a unit of -
(1) magnetic flux
(2) magnetic flux density
(3) electric flux
(4) self inductance

**29.** Fig. shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a frictionless track, the axis of the ring being along the axis of the solenoid. As the switch is closed, the ring will



(1) remain stationary
(2) move towards the solenoid
(3) move away from the solenoid
(4) move towards the solenoid or away from it depending on which terminal (positive or negative) of the battery is connected to the left end of the solenoid.

**30.** A uniform magnetic field exists in region given by $\vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$ . A rod of length 5 $m$ is placed along y – axis is moved along $x$ – axis with constant speed 1 m/sec. Then induced e.m.f. in the rod will be

(1) zero (2) 25 V
(3) 20 V (4) 15 V

**31.** For the situation shown in the figure, flux through the square loop is :

(1) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{a}{2a-b}\right)$

(2) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{2b-a}\right)$

(3) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{b-a}\right)$

(4) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{2a}{b-a}\right)$

**32.** A small, conducting circular loop is placed inside a long solenoid carrying a current. The plane of the loop contains the axis of the solenoid. If the current in the solenoid is varied, the current induced in the loop is

(1) clockwise
(2) anticlockwise
(3) zero
(4) clockwise or anticlockwise depending on whether the resistance in increased or decreased.

**33.** An aeroplane having a distance of 50 m between the edges of its wings is flying horizontally with a speed of 720 km/hour. If the vertical component of the earth's magnetic field is 2 × $10^{-4}$ Wb/m$^2$, then the induced emf will be

(1) 2 mV (2) 2 V
(3) 200 V (4) 0.2 mV

**34.** Equivalent unit of self-inductance is -

(1) $\frac{\text{volt}\times\text{ampere}}{\text{second}}$

(2) $\frac{\text{volt}\times\text{second}}{\text{ampere}}$

(3) $\frac{\text{ampere}}{\text{volt}\times\text{second}}$

(4) $\frac{\text{ampere}\times\text{second}}{\text{volt}}$

**35.** $L$, $C$ and $R$ represent the physical quantities inductance, capacitance and resistance. Which of the following combinations have dimensions of time ?

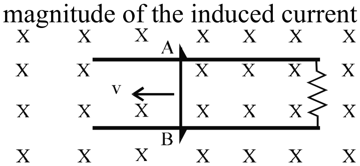
(1) $\frac{1}{RC}$ (2) $\frac{R}{L}$

(3) $\frac{1}{\sqrt{LC}}$ (4) $\sqrt{LC}$

**36.** An LR circuit with a battery is connected at $t$ = 0. Which of the following quantities is not zero just after the connection?

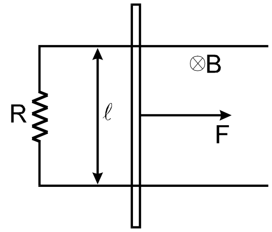
(1) current in the circuit
(2) magnetic field energy in the inductor
(3) power delivered by the battery
(4) emf induced in the inductor

**37.** Consider the situation shown in fig. The resistance less wire AB is sliding on the fixed rails with a constant velocity. If the wire AB is replaced by a resistance less semicircular wire, the magnitude of the induced current will



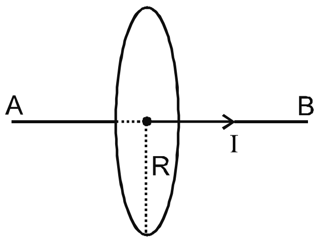

(1) increase
(2) remain the same
(3) decrease
(4) none of these

**38.** A constant force F is being applied on a rod of length '$\ell$' kept at rest on two parallel conducting rails connected at ends by resistance R in uniform magnetic field $B$ as shown.




(1) the power delivered by force will be constant with time
(2) the power delivered by force will be increasing first and then it will decrease
(3) the rate of power delivered by the external force will be increasing continuously
(4) the rate of power delivered by the external force will be decreasing continuously.

**39.** A long conductor AB lies along the axis of a circular loop of radius R. If the current in the conductor AB varies at the rate of I ampere/second, then the induced emf in the loop is

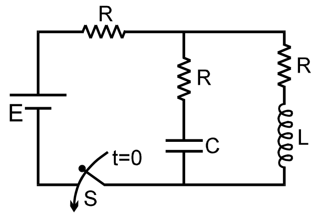



(1) $\frac{\mu_0 IR}{2}$ (2) $\frac{\mu_0 IR}{4}$
(3) $\frac{\mu_0 \pi IR}{2}$ (4) zero

**40.** Current, $I = I_0\sin\omega t$, of frequency $n_1$ is passed through a coil and then same amount of current of frequency $n_2$ is passed. If the magnitude of maximum induced emf's in the two cases are $\varepsilon_1$ and $\varepsilon_2$ respectively, then $\varepsilon_1 : \varepsilon_2$ will be -
(1) $n_2 : n_1$ (2) $n_1^2 : n_2^2$
(3) $n_1 : n_2$ (4) $n_2^2 : n_1^2$

**41.** Dimensions of coefficient of self-induction are -
(1) $MLT^{-2}A^{-2}$ (2) $ML^{-2}T^{-2}A^{-2}$
(3) $ML^2T^{-2}A^{-2}$ (4) $M^2LT^{-2}A^{-2}$

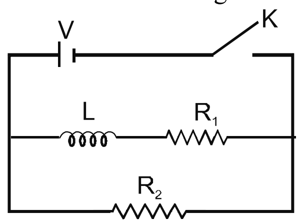
**42.** In the circuit shown in figure, switch $S$ is closed at $t = 0$. Then:




(1) after a long time interval, potential difference across capacitor and inductor will be equal.
(2) after a long time interval, charge on capacitor will be $E\,C$.
(3) after a long time interval, current in the inductor will be $E/R$.
(4) after a long time interval, current through battery will be same as initial current through it.

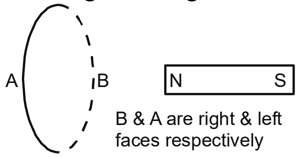
**43.** The unit of mutual inductance is -
(1) volt (2) weber
(3) tesla (4) henry

**44.** In the circuit shown below, the key $K$ is closed at $t = 0$. The current through the battery is :




(1) $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = 0 and $\frac{V}{R_2}$ at t = ∞
(2) $\frac{V}{R_2}$ at t = 0 and $\frac{V(R_1+R_2)}{R_1R_2}$ at t = ∞
(3) $\frac{V}{R_2}$ at t = 0 and $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = ∞
(4) $\frac{V(R_1+R_2)}{R_1R_2}$ at t = 0 and $\frac{V}{R_2}$ at t = ∞

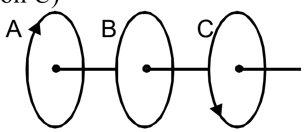
**45.** In the figure shown, the magnet is pushed towards the fixed ring along its axis and it passes through the ring.




(1) when magnet goes towards the ring the face *B* becomes south pole and the face *A* becomes north pole
(2) when magnet goes away from the ring the face *B* becomes north pole and the face *A* becomes south pole
(3) when magnet goes away from the ring the face *A* becomes north pole and the face *B* becomes south pole
(4) the face *A* will always be a north pole.

**46.** Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon :
(1) the rates at which currents are changing in the two coils
(2) relative position and orientation of the two coils
(3) the materials of the wires of the coils
(4) the currents in the two coils

**47.** Three identical coils *A*, *B* and *C* are placed coaxially with their planes parallel to each other. The coil *A* and *C* carry equal currents in opposite direction as shown. The coils *B* and *C* are fixed and the coil A is moved towards B with a uniform speed, then (consider no effect of A on *C*) -




(1) there will be induced current in coil B which will be opposite to the direction of current in A
(2) there will be induced current in coil B in the same direction as in A.
(3) there will be no induced current in B.
(4) current induced by coils A and C in coil B will be equal and opposite, therefore net current in B will be zero

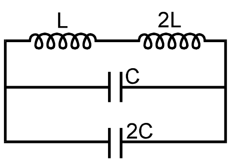
**48.** A wire of length 2m is moving with a velocity of 1 m/s normal to a magnetic field of 0.5 $Wb/m^2$. The emf induced in it will be
(1) 0.5 V (2) 0.1 V
(3) 2 V (4) 1 V

**49.** The resistance of a coil is 5 ohm and a current of 0.2 *A* is induced in it due to a varying magnetic field. The rate of change of magnetic flux in it will be -
(1) 0.5 Wb/s (2) 0.05 Wb/s
(3) 1 Wb/s (4) 20 Wb/s

**50.** A rod of length $\ell$ rotates with a uniform angular velocity ω about its perpendicular bisector. A uniform magnetic field B exists parallel to the axis of rotation. The potential difference between the two ends of the rod is
(1) zero (2) $\frac{1}{2}\omega B\ell^2$
(3) $B\omega\ell^2$ (4) $2B\omega\ell^2$

**51.** In an LR circuit current at $t = 0$ is 20 A. After 2s it reduces to 18 *A*. The time constant of the circuit is (in second):
(1) $\ell n\left(\frac{10}{9}\right)$ (2) 2
(3) $\frac{2}{\ell n\left(\frac{10}{9}\right)}$ (4) $2\ \ell n\left(\frac{10}{9}\right)$

**52.** The frequency of oscillation of current in the inductor is:




(1) $\frac{1}{3\sqrt{LC}}$ (2) $\frac{1}{6\pi\sqrt{LC}}$
(3) $\frac{1}{\sqrt{LC}}$ (4) $\frac{1}{2\pi\sqrt{LC}}$

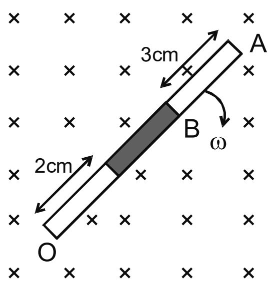
**53.** A metal conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 radian per second. If the horizontal component of earth's magnetic field is $0.2 \times 10^{-4}$ T, then the emf developed between the two ends of the conductor is :

(1) 5 μV (2) 50 μV
(3) 5 mV (4) 50 mV

**54.** A conductor of length $L$ is rotated about an axis passing through one end of it with an angular velocity ω in a normal and uniform magnetic field $B$. The emf induced between its end will be-

(1) $\omega BL^2$ (2) $\dfrac{\omega BL^2}{2}$
(3) $2\,\omega BL^2$ (4) $\omega BL$

**55.** A rod of length 10 c$m$ made up of conducting and non-conducting material (shaded part is non-conducting). The rod is rotated with constant angular velocity 10 rad/sec about point O, in constant magnetic field of 2 tesla as shown in the figure. The induced emf between the point A and B of rod will be




(1) 0.029 V (2) 0.1 V
(3) 0.051 V (4) 0.064 V

**56.** When current flowing in a coil changes from 3$A$ to 2$A$ in one millisecond, 5 volt emf is induced in it. The self-inductance of the coil will be -

(1) zero (2) 6H
(3) 5H (4) 5 mH

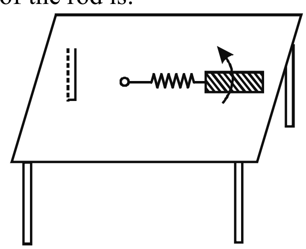
**57.** A long straight wire is placed along the axis of a circular ring of radius $R$. The mutual inductance of this system is

(1) $\dfrac{\mu_0 R}{2}$ (2) $\dfrac{\mu_0 \pi R}{2}$
(3) $\dfrac{\mu_0}{2}$ (4) 0

**58.** An infinitely long cylindrical conducting rod is kept along $+Z$ direction. A constant magnetic field is also present in $+Z$ direction. Then current induced will be

(1) 0
(2) along $+z$ direction
(3) along clockwise as seen from $+Z$
(4) along anticlockwise as seen from $+Z$

**59.** A metallic rod of length '$l$' is tied to a string of length $2l$ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field '$B$' in the region, the e.m.f. induced across the ends of the rod is:



(1) $\dfrac{2B\omega l^2}{2}$ (2) $\dfrac{3B\omega l^2}{2}$
(3) $\dfrac{4B\omega l^2}{2}$ (4) $\dfrac{5B\omega l^2}{2}$

**60.** A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is

(1) $9.1 \times 10^{-11}$ weber
(2) $6 \times 10^{-11}$ weber
(3) $3.3 \times 10^{-11}$ weber
(4) $6.6 \times 10^{-9}$ weber

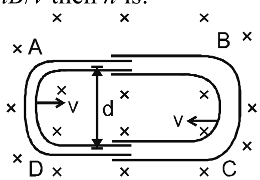
## *Integer Type Questions (61 to 75)*

**61.** A coil has an inductance of $2H$ and resistance of $4\Omega$. A 10 $V$ is applied across the coil. The energy stored in the magnetic field after the current has built up to its equilibrium value will be _____ $\times 10^{-2}$ J

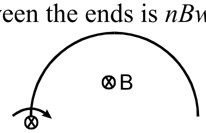
**62.** A boat is moving due east in a region where the earth's magnetic field is $5.0 \times 10^{-5}$ $NA^{-1}m^{-1}$ due north and horizontal. The boat carries a vertical aerial 2m long. If the speed of the boat is 1.50 $ms^{-1}$, the magnitude of the induced emf in the wire of aerial is $n \times 10^{-2}$ mV then n is

**63.** In a uniform magnetic field of induction $B$, a wire in the form of semicircle of radius $r$ rotates about the diameter of the circle with angular frequency $\omega$. If the total resistance of the circuit is $R$, the mean power generated per period of rotation is $\dfrac{(B\pi r^2\omega)^2}{nR}$ then $n$ is

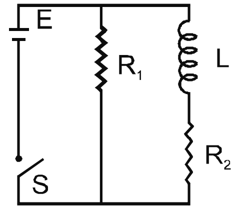
**64.** One conducting U tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field $B$ is perpendicular to the plane of the figure. If each tube moves towards the other at a constant speed v, then the emf induced in the circuit in terms of $B$, $\ell$ and $v$, where $\ell$ is the width of each tube is $nB\ell v$ then $n$ is:




**65.** A semicircular wire of radius $R$ is rotated with constant angular velocity $\omega$ about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength $B$. The induced e.m.f. between the ends is $nB\omega R^2$ then $n$ is



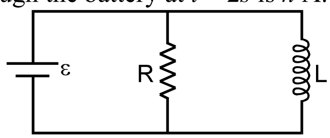

**66.** An inductor of inductance $L$ = 400 mH and resistors of resistances $R_1$ = 2 $\Omega$ and $R_2$ = 2 $\Omega$ are connected to a battery of emf 12 $V$ as shown in the figure. The internal resistance of the battery is negligible. The switch $S$ is closed at $t$ = 0. The potential drop across $L$ as a function of time is $ne^{-5t}$V then $n$ is



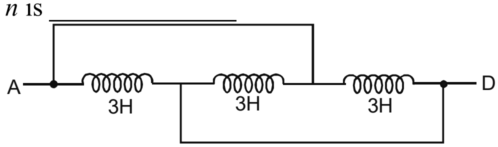

**67.** Two coils are at fixed locations. When coil 1 has no current and the current in coil 2 increases at the rate 15.0 A/s, the e.m.f. in coil 1 is 25.0 mV. When coil 2 has no current and coil 1 has a current of 3.6 A, flux linkage in coil 2 is $n$ mWb then $n$ is

**68.** An inductor coil stores energy $U$ when a current $i$ is passed through it and dissipates energy at the rate of $P$. The time constant of the circuit when this coil is connected across a battery of zero internal resistance is $\dfrac{nU}{P}$ sec then $n$ is

**69.** The battery shown in the figure is ideal. The values are $E = 10\ V$, $R = 5\ \Omega$, $L = 2H$. Initially the current in the inductor is zero. The current through the battery at $t = 2s$ is $n$ A. Then $n$ is



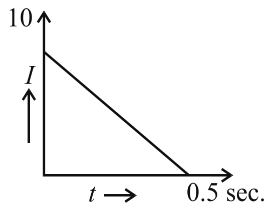

**70.** The net inductance between A and D is $n$H then $n$ is ______________




**71.** In an oscillating $LC$ circuit the maximum charge on the capacitor is $Q$. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is $\dfrac{Q}{\sqrt{n}}$ value of $n$ is:

**72.** A horizontal straight wire 20 m long extending from east to west falling with a speed of 5.0 m/s, at right angles to the horizontal component of the earth's magnetic field $0.30 \times 10^{-4}$ Wb/m$^2$. The instantaneous Value of the e.m.f. induced in the wire will be $x$ mV, then $x$ is

**73.** In a coil of resistance 100Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is $n$ Wb, then $n$ is




**74.** A conducting circular loop is placed in $X - Y$ plane in presence of magnetic field $\vec{B} = (3t^3\hat{j} + 3t^2\hat{k})$ in SI unit. If the radius of the loop is 1 $m$, the induced emf in the loop, at time, $t$ = 2 s is $n\pi$V. The value of $n$ is ___________

**75.** In a coil of resistance 8 Ω, the magnetic flux due to an external magnetic field varies with time as $\phi = \frac{2}{3}(9 - t^2)$. The value of total heat produced in the coil, till the flux becomes zero, will be _________J.

CHAPTER

19

# ALTERNATING CURRENT

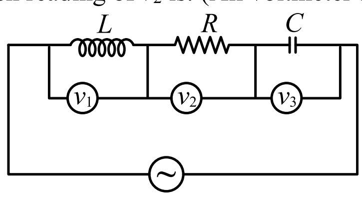
## Single Option Correct Type Questions (01 to 56)

**1.** The peak value of an alternating e.m.f given by $E = E_0 \cos \omega t$, is 10 volt and frequency is 50 Hz. At time $t$ = (1/600) sec, the instantaneous value of e.m.f is:

(1) 10 volt (2) $5\sqrt{3}$ volt

(3) 5 volt (4) 1 volt

**2.** If the readings of $v_1$ and $v_3$ are 100 volt each then reading of $v_2$ is: (All voltmeter are ideal)




(1) 0 volt

(2) 100 volt

(3) 200 volt

(4) Cannot be determined by given information.

**3.** The current in a circuit containing a capacitance $C$ and a resistance $R$ in series leads over the applied voltage of frequency $\frac{\omega}{2\pi}$ by:

(1) $\tan^{-1}\left(\frac{1}{\omega CR}\right)$

(2) $\tan^{-1}(\omega CR)$

(3) $\tan^{-1}\left(\omega \frac{1}{R}\right)$

(4) $\cos^{-1}(\omega CR)$

**4.** A power (step up) transformer with an 1: 8 turn ratio has 60 Hz, 120 V across the primary; the load in the secondary is $10^4$ Ω. The current in the secondary is:

(1) 96 A (2) 0.96 A

(3) 9.6 A (4) 96 mA

**5.** In an $LCR$ circuit, the capacitance is made one-fourth, when in resonance. Then what should be the change in inductance, so that the circuit remains in resonance?

(1) 4 times

(2) 1/4 times

(3) 8 times

(4) 2 times

**6.** R.M.S. value of current $i = 3 + 4 \sin(\omega t+\pi/3)$ is:

(1) 5 A

(2) $\sqrt{17}$ A

(3) $\frac{5}{\sqrt{2}}$ A

(4) $\frac{7}{\sqrt{2}}$ A

**7.** A 100 volt $AC$ source of angular frequency 500 rad/s is connected to an $LCR$ circuit with $L$ = 0.8 H, $C$ = 5 μF and $R$ = 10 Ω, all connected in series. The potential difference across the resistance is:

(1) $\frac{100}{\sqrt{2}}$ volt (2) 100 volt

(3) 50 volt (4) $50\sqrt{3}$

**8.** An $AC$ voltage is given by:

$$E = E_0 \sin \frac{2\pi t}{T}$$

Then the mean value of voltage calculated over time interval of T/2 seconds:

(1) Is always zero (2) Is never zero

(3) Is $(2E_0/\pi)$ always (4) May be zero

**9.** In a circuit, an inductance of 0.1 Henry and a resistance of 1Ω are connected in series with an $AC$ source of voltage $V = 5 \sin 10t$. The phase difference between the current and applied voltage will be:

(1) $\pi$ (2) $2\pi$

(3) $\pi/4$ (4) 0

**10.** An electric bulb (pure resistance) and a capacitor are connected in series with an $AC$ source. On increasing the frequency of the source, the brightness of the bulb:

(1) Increase

(2) Decreases

(3) Remains unchanged

(4) Sometimes increases and sometimes decreases

**11.** In a series $LR$ circuit, the voltage drop across inductor is 8 volt and across resistor is 6 volt. Then voltage applied and power factor of circuit respectively are:

(1) 14 V, 0.8

(2) 10 V, 0.8

(3) 10 V, 0.6

(4) 14 V, 0.6

**12.** An alternating voltage is given by: $e = e_1 \sin \omega t + e_2 \cos \omega t$. Then the root mean square value of voltage is given by:

(1) $\sqrt{e_1^2 + e_2^2}$ (2) $\sqrt{e_1 e_2}$

(3) $\sqrt{\frac{e_1 e_2}{2}}$ (4) $\sqrt{\frac{e_1^2 + e_2^2}{2}}$

**13.** The output of an $AC$ generator is given by: $E = E_m \sin(\omega t - \pi/4)$ and current is given by $i = i_m \sin(\omega t - 3\pi/4)$. The circuit contains a single element other than the generator. It is:

(1) A capacitor

(2) A resistor

(3) An inductor

(4) Not possible to decide due to lack of information

**14.** In an $AC$ circuit, a resistance of $R$ ohm is connected in series with an inductance $L$. If phase angle between voltage and current be 45°, the value of inductive reactance will be:

(1) $R/4$

(2) $R/2$

(3) $R$

(4) Cannot be found with the given data

**15.** A 0.21-H inductor and a 88-Ω resistor are connected in series to a 220-V, 50-Hz $AC$ source. The current in the circuit and the phase angle between the current and the source voltage are respectively.

Use $\pi = 22/7$.

(1) 2 A, $\tan^{-1} 3/4$

(2) 14.4 A, $\tan^{-1} 7/8$

(3) 14.4 A, $\tan^{-1} 8/7$

(4) 3.28 A, $\tan^{-1} 2/11$

**16.** EMF induced by a powerplant is given by $\varepsilon = 2 + 3 \sin \omega t + 3 \cos \omega t$ in volts. Then $RMS$ value of potential difference is:

(1) $\sqrt{13}$ volt (2) $\sqrt{22}$ volt

(3) $\sqrt{11}$ volt (4) None of these

**17.** The core of a transformer is laminated to reduce:

(1) Eddy current loss (2) Hysteresis loss

(3) Copper loss (4) Magnetic loss

**18.** If the frequency of the source e.m.f. in an $AC$ circuit is $n$, the power varies with a frequency:

(1) $n$ (2) $2n$

(3) $n/2$ (4) Zero

**19.** The voltage of an $AC$ source varies with time according to the equation, $V = 100 \sin 100\pi t \cos 100\pi t$. Where $t$ is in second and $V$ is in volt. Then:

(1) The peak voltage of the source is 100 volt

(2) The peak voltage of the source is $(100/\sqrt{2})$ volt

(3) The peak voltage of the source is 50 volt

(4) The frequency of the source is 50 Hz

**20.** What is the *rms* value of an alternating current which when passed through a resistor produces heat, which is thrice that produced by a current of 2 ampere in the same resistor in the same time interval?

(1) 6 ampere (2) 2 ampere

(3) $2\sqrt{3}$ ampere (4) 0.65 ampere

**21.** In an $LRC$ series circuit at resonance current in the circuit is $10\sqrt{2}$ A. If now frequency of the source is changed such that now current lags by 45° than applied voltage in the circuit. Which of the following is correct:

(1) Frequency must be increased and current after the change is 10 A

(2) Frequency must be decreased and current after the change is 10 A

(3) Frequency must be decreased and current is same as that of initial value

(4) The given information is insufficient to conclude anything

**22.** A resistor and a capacitor are connected to an AC supply of 200 volt, 50 Hz in series. The current in the circuit is 2 ampere. If the power consumed in the circuit is 100 watt, then the resistance in the circuit is:

(1) 100 Ω (2) 25 Ω

(3) $\sqrt{125 \times 75}$ Ω (4) 400 Ω

**23.** In an AC circuit the potential differences across an inductance and resistance joined in series are respectively 16 V and 20 V. The total potential difference across the circuit is:

(1) 20 V (2) 25.6 V

(3) 31.9 V (4) 53.5 V

**24.** In a step-up transformer the voltage in the primary is 220 V and the current is 5A. The secondary voltage is found to be 22000 V. The current in the secondary (neglect losses) is:

(1) 5 A (2) 50 A

(3) 500 A (4) 0.05 A

**25.** The value of power factor $\cos\phi$ in series $LCR$ circuit at resonance is:

(1) Zero (2) 1

(3) 1/2 (4) 1/2 ohm

**26.** The secondary coil of an ideal step down transformer is delivering 500 watt power at 12.5 A current. If the ratio of turns in the primary to the secondary is 5 : 1, then the current flowing in the primary coil will be:

(1) 62.5 A (2) 2.5 A

(3) 6 A (4) 0.4 A

**27.** A coil has an inductance of $\frac{2.2}{\pi} H$ and is joined in series with a resistance of 220 Ω. When an alternating e.m.f. of 220 V at 50 cps is applied to it, then the wattless component of the rms current in the circuit is:

(1) 5 ampere (2) 0.5 ampere

(3) 0.7 ampere (4) 7 ampere

**28.** Energy dissipates in $LCR$ circuit in:

(1) $L$ only (2) $C$ only

(3) $R$ only (4) All of these

**29.** A 300 Ω resistor is connected in series with a parallel-plate capacitor across the terminals of a 50.0 Hz ac generator. When the gap between the plates is empty, its capacitance is $\frac{70}{22}$ μF. The ratio of the rms current in the circuit when the capacitor is empty to that when ruby mica of dielectric constant $k = 5.0$ is inserted between the plates, is equal to:

(1) 0.1 (2) 0.34

(3) 0.6 (4) 2.9

**30.** In a step-up transformer the turns ratio is 10. If the frequency of the current in the primary coil is 50 Hz then the frequency of the current in the secondary coil will be:

(1) 500 Hz (2) 5 Hz
(3) 60 Hz (4) 50 Hz

**31.** The potential difference $V$ across and the current $I$ flowing through an instrument in an $AC$ circuit are given by:

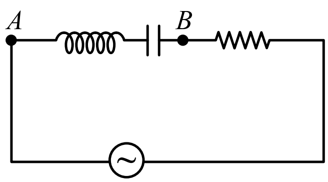
$V = 5 \cos \omega t$ volt

$I = 2 \sin \omega t$ ampere

The power dissipated in the instrument is:

(1) Zero (2) 5 watt
(3) 10 watt (4) 2.5 watt

**32.** An inductor $\left(L = \frac{1}{100\pi} H\right)$, a capacitor $\left(C = \frac{1}{500\pi} F\right)$ and a resistance $(3\Omega)$ is connected in series with an $AC$ voltage source as shown in the figure. The voltage of the $AC$ source is given as $V = 10 \cos(100\pi t)$ volt. What will be the potential difference between $A$ and $B$?

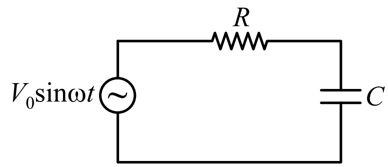



(1) $8 \cos(100\pi t - 127^\circ)$ volt
(2) $8 \cos(100\pi t - 53^\circ)$ volt
(3) $8 \cos(100\pi t - 37^\circ)$ volt
(4) $8 \cos(100\pi t + 37^\circ)$ volt

**33.** A 10 Ω resistance is connected across 220 $V$, 50 Hz $AC$ supply. The time taken by the current to change from its maximum value to the rms value is:

(1) 2.5 ms
(2) 4.5 ms
(3) 3.0 ms
(4) 1.5 ms

**34.** An $AC$ voltage source $V = V_0 \sin \omega t$ is connected across resistance $R$ and capacitance $C$ as shown in figure. It is given that $R = \frac{1}{\omega C}$. The peak current is $I_0$. If the angular frequency of the voltage source is changed to $\frac{\omega}{\sqrt{3}}$ then the new peak current in the circuit is:




(1) $\frac{I_0}{2}$ (2) $\frac{I_0}{\sqrt{2}}$
(3) $\frac{I_0}{\sqrt{3}}$ (4) $\frac{I_0}{3}$

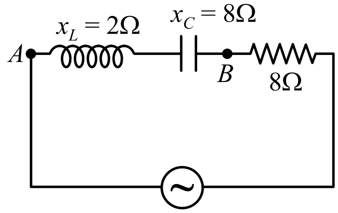
**35.** A sinusoidal $AC$ current flows through a resistor of resistance $R$. If the peak current is $I_p$, then average power dissipated is:

(1) $I_p^2 R \cos\theta$ (2) $\frac{1}{2} I_p^2 R$
(3) $\frac{4}{\pi} I_p^2 R$ (4) $\frac{1}{\pi^2} I_p^2 R$

**36.** For an $LCR$ series circuit with an $A.C.$ source of angular frequency ω.

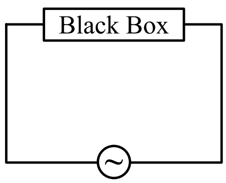
(1) Circuit will be capacitive if $\omega > \frac{1}{\sqrt{LC}}$
(2) Circuit will be inductive if $\omega = \frac{1}{\sqrt{LC}}$
(3) Power factor of circuit will by unity if capacitive reactance equals inductive reactance
(4) Current will be leading voltage if $\omega > \frac{1}{\sqrt{LC}}$

**37.** An inductor ($x_L = 2\Omega$) a capacitor ($x_C = 8\Omega$) and a resistance ($8\Omega$) is connected in series with an $AC$ source. The voltage output of $AC$ source is given by $v = 10 \cos 100\,\pi t$. Find the impedance of the circuit.



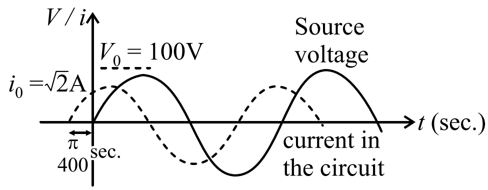

(1) 10 Ω (2) 20 Ω
(3) 30 Ω (4) 5 Ω

**38.** A voltage source $V = V_0 \sin(100\,t)$ is connected to a black box in which there can be either one element out of $L$, $C$, $R$ or any two of them connected in series.




$V = V_0 \sin(100t)$

At steady state. the variation of current in the circuit and the source voltage are plotted together with time, using an oscilloscope, as shown




The element(s) present in black box is/are:

(1) Only $C$ (2) $L$ and $C$
(3) $L$ and $R$ (4) $R$ and $C$

**39.** A transformer is used to light a 140 watt, 24 volt lamp from 240 V $AC$ mains. The current in the main cable is 0.7 amp. The efficiency of the transformer is:

(1) 48% (2) 63.8%
(3) 83.3% (4) 90%

**40.** From a metallic charged body a current is drawn. The rate of increase of current at an instant is equal to the charge on the body at that instant.If the initial charge on the body is $Q$

(1) The minimum time it will take for the charge to become zero is $\frac{\pi}{2}$ sec.
(2) The minimum time it will take for the charge to become zero is 2 sec.
(3) The value of the current when the charge on the body is $Q/2$ is $Q\sqrt{\frac{7}{2}}$
(4) The value of the current when the charge on the body is $Q/2$ is $\frac{Q}{\sqrt{7}}$.

**41.** The impedance of a series circuit consists of 3 ohm resistance and 4 ohm reactance. The power factor of the circuit is:

(1) 0.4 (2) 0.6
(3) 0.8 (4) 1.0

**42.** A series $LCR$ circuit containing a resistance of 120 ohm has angular resonance frequency $4 \times 10^3$ rad $s^{-1}$. At resonance, the voltage across resistance and inductance are 60V and 40 V respectively. The values of $L$ and $C$ are respectively:

(1) 20 mH, 25/8 μF
(2) 2 mH, 1/35 μF
(3) 20 mH, 1/40 μF
(4) 2 mH, 25/8 μF

**43.** The average power delivered to a series AC circuit is given by (symbols have their usual meaning):

(1) $E_{rms} I_{rms}$ (2) $E_{rms} I_{rms} \cos\phi$
(3) $E_{rms} I_{rms} \sin\phi$ (4) Zero

**44.** If a resistance of $30\Omega$, a capacitor of reactance $20\Omega$, and an inductor of inductive reactance $60\Omega$ are connected in series to a 100 V, 50 Hz power source, then:

(1) A current of 2.0 A flows
(2) A current of 3.33 A flows
(3) Power factor of the circuit is zero
(4) Power factor of the circuit is 2/5

**45.** The phase difference between the alternating current and emf is $\pi/2$. Which of the following cannot be the constituent of the circuit?

(1) $C$ alone (2) $R, L$
(3) $L, C$ (4) $L$ alone

**46.** An $AC$ voltage source of variable angular frequency $\omega$ and fixed amplitude $V$ connected in series with a capacitance $C$ and an electric bulb of resistance $R$ (inductance zero). When $\omega$ is increased:

(1) The bulb glows dimmer
(2) The bulb glows brighter
(3) Total impedance of the circuit is unchanged
(4) Total impedance of the circuit increases

**47.** A 10 μF capacitor is connected with an $AC$ source $E = 200\sqrt{2}\ \sin(100\,t)$ V through an $AC$ ammeter (it reads *rms* value). What will be the reading of the ammeter?

(1) 100 mA (2) 300 mA
(3) 500 mA (4) 200 mA

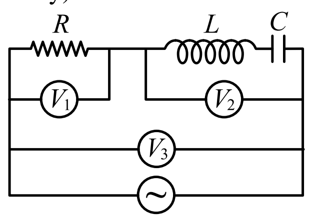
**48.** In an $L$-$R$ series circuit ($L = \frac{175}{11}$ mH and $R = 12\Omega$), a variable emf source ($V = V_0 \sin \omega t$) of $V_{rms} = 130\sqrt{2}$ V and frequency 50 Hz is applied. The current amplitude in the circuit and phase of current with respect to voltage are respectively. (Use $\pi = 22/7$)

(1) 14.14A, 30°
(2) $10\sqrt{2}$ A, $\tan^{-1}\frac{5}{12}$
(3) 10 A, $\tan^{-1}\frac{5}{12}$
(4) 20 A, $\tan^{-1}\frac{5}{12}$

**49.** The overall efficiency of a transformer is 90%. The transformer is rated for an output of 9000 watt. The primary voltage is 1000 volt. The ratio of turns in the primary to the secondary coil is 5 : 1. The iron losses at full load are 700 watt. The primary coil has a resistance of 1 ohm. The voltage in secondary coil is:

(1) 1000 volt (2) 5000 volt
(3) 200 volt (4) Zero volt

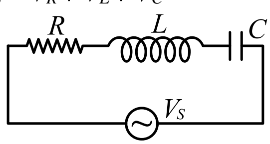
**50.** A resistor $R$, an inductor $L$, a capacitor $C$ and voltmeters $V_1$, $V_2$ and $V_3$ are connected to an oscillator in the circuit as shown in the adjoining diagram. When the frequency of the oscillator is increased, upto resonance frequency, the voltmeter reading (at resonance frequency) is zero in the case of:




(1) Voltmeter $V_1$
(2) Voltmeter $V_2$
(3) Voltmeter $V_3$
(4) All the three voltmeters

**51.** **STATEMENT-1:** In a series $R, L, C$ circuit if $V_R$, $V_L$, and $V_C$ denote rms voltage across $R$, $L$ and $C$ respectively and $V_S$ is the *rms* voltage across the source, then

$V_S = V_R + V_L + V_C$




**STATEMENT-2:** In $AC$ circuits, kirchoff voltage law is correct at every instant of time

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**52.** **STATEMENT-1:** An inductor is connected to an ac source. When the magnitude of current decreases in the circuit, energy is absorbed by the ac source.
**STATEMENT-2:** When current through an inductor decrease, the energy stored in inductor decreases.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**53.** **STATEMENT-1:** Average power consumed in an ac circuit is equal to average power consumed by resistors in the circuit.
**STATEMENT-2:** Average power consumed by capacitor and inductor is zero
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

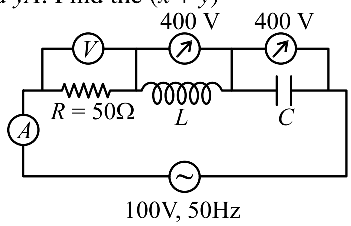
**54.** **STATEMENT-1:** The electrostatic energy stored in capacitor plus magnetic energy stored in inductor will always be zero in a series *LCR* circuit driven by *AC* voltage source under condition of resonance.
**STATEMENT-2:** The complete voltage of ac source appears across the resistor in a series *LCR* circuit driven by *AC* voltage source under condition of resonance.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is **NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**55.** A resistor $R$, an inductor $L$ and a capacitor $C$ are connected in series to an oscillator of frequency $n$. If the resonant frequency is $n_r$, then the current lags behind voltage, when:
(1) $n = 0$  (2) $n < n_r$
(3) $n = r_r$  (4) $n > n_r$

**56.** An $AC$ voltage of $V = 220\sqrt{2}\ \sin\left(100\pi t + \frac{\pi}{2}\right)$ is applied across a $DC$ voltmeter, its reading will be:
(1) $220\sqrt{2}$ V  (2) $\sqrt{2}$ V
(3) 220 V  (4) Zero

## Integer Type Questions (57 to 70)

**57.** In the series *LCR* circuit as shown in figure, the *AC* voltmeter and *AC* ammeter readings are $xV$ and $yA$. Find the $(x + y)$




**58.** A circuit has a resistance of 12 ohm and an impedance of 15 ohm. The power factor of the circuit will be $x$. Find $10x$.

**59.** By what percentage the impedance in an *AC* series circuit should be increased so that the power factor changes from (1/2) to (1/4) (when $R$ is constant)?

**60.** A coil of inductance 5.0 mH and negligible resistance is connected to an alternating voltage $V = 10 \sin (100\ t)$. The peak current in the circuit will be (in A)

**61.** An *LCR* series circuit with 100 Ω resistance is connected to an *AC* source of 200 V and angular frequency 300 radians per second. When only the capacitance is removed, the current lags behind the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60º. Then power dissipated in *LCR* circuit is (in watt)

**62.** Find the rms value of current $i = 2 + 4\cos 100\pi t$ is $x\sqrt{3}$. Find $x$.

**63.** The peak value of an alternating current is 5 A and its frequency is 60 Hz. the current take to reach the peak value starting from zero is $\frac{x}{240}$ sec. Find $x$.

**64.** An arc lamp requires a direct current of 10A at 80 V to function. if it is connected to a 220 V(rms), 50 Hz $AC$ supply, the series inductor needed for it to work safely is nearly (in mH)

**65.** A pure resistive circuit element $X$ when connected to an $AC$ supply of peak voltage 200 V gives a peak current of 5 A which is in phase with the voltage. A second circuit element $Y$, when connected to the same $AC$ supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of $X$ and $Y$ is connected to the same supply, the *rms* value of current is $\frac{x}{2}$. Find $x$.

**66.** A direct current of 2 A and an alternating current having a maximum value of 2 A flow through two identical resistances. The ratio of heat produced in the two resistances in the same time interval will be:

**67.** The self-inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz, it should be connected to a capacitance of (in μF) (given $\pi^2 = 10$).

**68.** The alternating current is given by

$$i = \left\{\sqrt{42}\sin\left(\frac{2\pi}{T}t\right) + 10\right\} A$$

The *r.m.s.* value of this current is _____ A

**69.** An $AC$ voltage source $V = 200\sqrt{2}\sin 100\,t$ is connected across a circuit containing an $AC$ ammeter (it reads *rms* value) and capacitor of capacity 1 μF. The reading of ammeter is (in mA)

**70.** A series combination of resistor of resistance 100 Ω, inductor of inductance 1$H$ and capacitor of capacitance 6.25 μF is connected to an $AC$ source. The quality factor of the circuit will be:

CHAPTER

# 20

# ELECTROMAGNETIC WAVES

## Single Option Correct Type Questions (01 to 58)

**1.** If $\vec{E}$ and $\vec{K}$ represent electric field and propagation vectors of the *EM* waves in vacuum, then magnetic field vector is given by: ($\omega$ – angular frequency, $\mu_0$ = magnetic permeability of vacuum)

(1) $\frac{1}{\omega}(\vec{K}\times\vec{E})$  (2) $\omega(\vec{K}\times\vec{E})$

(3) $\omega(\vec{E}\times\vec{K})$  (4) $\frac{\mu_0}{E^2}(\vec{K}\times\vec{E})$

**2.** Identify the correct statements from the following descriptions of various properties of electromagnetic waves.

(A) In a plane electromagnetic wave electric field and magnetic field must be perpendicular to each other and direction of propagation of wave should be along electric field or magnetic field.

(B) The energy in electromagnetic wave is divided equally between electric and magnetic fields.

(C) Both electric field and magnetic field are parallel to each other and perpendicular to the direction of propagation of wave.

(D) The electric field, magnetic field and direction of propagation of wave must be perpendicular to each other.

(E) The ratio of amplitude of magnetic field to the amplitude of electric field is equal to speed of light.

Choose the most appropriate answer from the options given below:

(1) (D) only

(2) (B) and (D) only

(3) (B), (D) and (E) only

(4) (A), (B) and (E) only

**3.** An EM wave propagating in *x*-direction has a wavelength of 8 mm. The electric field vibrating in y-direction has maximum magnitude of 60 Vm$^{-1}$. Choose the correct equations for electric and magnetic field if the EM wave is propagating in vacuum

(1) $E_y = 60\sin\left[\frac{\pi}{4}\times10^3(x-3)\times10^8 t\right]\hat{j}\,Vm^{-1}$

$B_z = 2\sin\left[\frac{\pi}{4}\times10^3(x-3)\times10^8 t\right]\hat{k}T$

(2) $E_y = 60\sin\left[\frac{\pi}{4}\times10^3(x-3\times10^8 t)\right]\hat{j}Vm^{-1}$

$B_z = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^3(x-3\times10^8 t)\right]\hat{k}T$

(3) $E_y = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^3(x-3\times10^8 t)\right]\hat{j}\,Vm^{-1}$

$B_z = 60\sin\left[\frac{\pi}{4}\times10^3(x-3\times10^8 t)\right]\hat{k}T$

(4) $E_y = 2\times10^{-7}\sin\left[\frac{\pi}{4}\times10^4(x-4\times10^8 t)\right]\hat{j}Vm^{-1}$

$B_z = 60\sin\left[\frac{\pi}{4}\times10^4(x-4\times10^8 t)\right]\hat{k}T$

**4.** Given below are two statements:

**Statement-I:** A time varying electric field is a source of changing magnetic field and vice-versa. Thus a disturbance in electric or magnetic field creates EM waves.

**Statement-II:** In a material medium, the EM wave travels with speed $v = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$.

In the light of the above statements, choose the correct answer from the options given below

(1) Both Statement-I and Statement-II are true.

(2) Both Statement-I and Statement-II are false.

(3) Statement-I is correct but Statement-II is false.

(4) Statement-I is incorrect but Statement-II is true.

**5.** A linearly polarized electromagnetic wave in vacuum is $\vec{E} = 3.1\cos[(1.8)z - (5.4\times10^6 t)]\hat{i}\ N/C$ is incident normally on a perfectly reflecting wall at $z = a$. Choose the correct option

(1) The frequency of electromagnetic wave is $54 \times 10^4$ Hz.

(2) The transmitted wave will be $\vec{E}' = 3.1\cos[(1.8)z - (5.4\times10^6 t)]\hat{i}\ N/C$

(3) The reflected wave will be $\vec{E}'' = 3.1\cos[(1.8)z + (5.4\times10^6 t)]\hat{i}\ N/C$

(4) The wavelength is 5.4 m

**6.** A plane electromagnetic wave is propagating along the direction $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$ with its polarization along the direction $\hat{k}$. The correct form of the magnetic field of wave would be (here $B_0$ is an appropriate constant)

(1) $B_0 \frac{(\hat{i}+\hat{j})}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(2) $B_0 \frac{(\hat{i}-\hat{j})}{\sqrt{2}} \cos\left(\omega t + k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(3) $B_0 \frac{(\hat{i}-\hat{j})}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(4) $B_0 \hat{k} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

**7.** The electric field of a plane electromagnetic wave is given by

$$\vec{E} = E_0 \frac{(\hat{i}+\hat{j})}{\sqrt{2}} \cos(kz + \omega t)$$

At $t = 0$, a positively charged particle is at the point $(x, y, z) = \left(0, 0, \frac{\pi}{k}\right)$. If its instantaneous velocity at $(t = 0)$ is $v_0\hat{k}$, the force acting on it due to the wave is:

(1) zero

(2) parallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

(3) parallel to $\hat{k}$

(4) antiparallel to $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

**8.** A plane electromagnetic wave having a frequency $f = 23.9$ GHz propagates along the positive z-direction in free space. The peak value of the electric field is 60 V/m. Which among the following is the acceptable magnetic field component in the electromagnetic wave?

(1) $\vec{B} = 2\times10^{-7}\sin(0.5\times10^3 z + 1.5\times10^{11} t)\hat{i}$ T

(2) $\vec{B} = 2\times10^{-7}\sin(1.5\times10^3 x + 0.5\times10^{11} t)\hat{j}$ T

(3) $\vec{B} = 2\times10^{-7}\sin(0.5\times10^3 z - 1.5\times10^{11} t)\hat{i}$ T

(4) $\vec{B} = 60\sin(0.5\times10^3 x + 1.5\times10^{11} t)\hat{k}$ T

**9.** An electromagnetic wave is represented by the electric field $\vec{E} = E_0 \hat{n} \sin[\omega t + (6y - 8z)]$. Taking unit vectors in $x$, $y$ and $z$ directions to be $\hat{i}, \hat{j}, \hat{k}$, the direction of propagation $\hat{s}$ is

(1) $\hat{s} = \left(\frac{4\hat{j} - 3\hat{k}}{5}\right)$

(2) $\hat{s} = \left(\frac{-3\hat{i} - 4\hat{j}}{5}\right)$

(3) $\hat{s} = \left(\frac{-3\hat{j} + 4\hat{k}}{5}\right)$

(4) $\hat{s} = \left(\frac{-4\hat{k} + 3\hat{j}}{5}\right)$

**10.** Which of the following Maxwell's equations is valid for time varying conditions but not valid for static conditions:

(1) $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$  (2) $\oint \vec{E} \cdot \vec{ds} = \frac{Q}{\epsilon_0}$

(3) $\oint \vec{E} \cdot \vec{dl} = -\frac{d\phi_B}{dt}$  (4) $\oint \vec{B} \cdot \vec{dA} = 0$

**11.** Match List-I with List-II:

| List-I | | List-II | |
|---|---|---|---|
| A | Gauss's Law in Electrostatics | I | $\oint \vec{E} \cdot \vec{dl} = -\frac{d\phi_B}{dt}$ |
| B | Faraday's Law | II | $\oint \vec{B} \cdot \vec{dA} = 0$ |
| C | Gauss's Law in Magnetism | III | $\oint \vec{B} \cdot \vec{dl} = \mu_0 i_C + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$ |
| D | Ampere Maxwell Law | IV | $\oint \vec{E} \cdot \vec{ds} = \frac{q}{\epsilon_0}$ |

Choose the correct answer from the options given below:

(1) A-IV, B-I, C-II, D-III
(2) A-I, B-II, C-III, D-IV
(3) A-III, B-IV, C-I, D-II
(4) A-II, B-III, C-IV, D-I

**12.** The material filled between the plates of a parallel plate capacitor has resistivity 200Ωm. The value of capacitance of the capacitor is 2pF. If a potential difference of 40 V is applied across the plates of the capacitor, then the value of leakage current flowing out of the capacitor initially is: (given the value of relative permittivity of material is 50)

(1) 0.9 μA  (2) 9.0 mA
(3) 9.0 μA  (4) 0.9 mA

**13.** A plane electromagnetic wave of frequency 20 MHz propagates in free space along x-direction. At a particular space and time, $\vec{E} = 6.6\hat{j}\ V/m$. What is $\vec{B}$ at this point?

(1) $-2.2 \times 10^{-8}\hat{i}T$  (2) $2.2 \times 10^{-8}\hat{k}T$
(3) $-2.2 \times 10^{-8}\hat{k}T$  (4) $2.2 \times 10^{-8}\hat{i}T$

**14.** The amplitude of magnetic field in an electromagnetic wave propagating along $y$-axis is $6.0 \times 10^{-7}$ T. The maximum value of electric field in the electromagnetic wave is:

(1) $5 \times 10^{14}\ Vm^{-1}$  (2) $180\ Vm^{-1}$
(3) $2 \times 10^{15}\ Vm^{-1}$  (4) $6.0 \times 10^{-7}\ Vm^{-1}$

**15.** The electric field and magnetic field components of an electromagnetic wave going through vacuum is described by

$E_x = E_0 \sin(kz - \omega t)$

$B_y = B_0 \sin(kz - \omega t)$

Then the correct relation between $E_0$ and $B_0$ is given by

(1) $kE_0 = \omega B_0$  (2) $E_0 B_0 = \omega k$
(3) $\omega E_0 = kB_0$  (4) $E_0 = kB_0$

**16.** Given below are two statements:

**Statement-I:** Electromagnetic waves are not deflected by electric and magnetic field.

**Statement-II:** The amplitude of electric field and the magnetic field in electromagnetic waves are related to each other as

$E_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} B_0$

In the light of the above statements, choose the correct answer from the options given below:

(1) Statement-I is true but Statement-II is false
(2) Both Statement-I and Statement-II are true
(3) Statement-I is false but Statement-II is true
(4) Both Statement-I and Statement-II are false

**17.** The magnetic field of a plane electromagnetic wave is given by:
$\vec{B} = 2\times10^{-8}\sin(0.5\times10^{3}x + 1.5\times10^{11}t)\hat{j}$ T
The amplitude of the electric field would be:
(1) 6 $Vm^{-1}$ along $x$-axis
(2) 3$Vm^{-1}$ along $z$-axis
(3) 6 $Vm^{-1}$ along $z$-axis
(4) $2\times10^{-8}$ $Vm^{-1}$ along $z$-axis

**18.** Light wave travelling in air along $x$-direction is given by $E_y = 540\sin\left(\pi\times10^{4}(x - ct)\right)$ $Vm^{-1}$.
Then, the peak value of magnetic field of wave will be: (Given, $c = 3\times10^{8}$ $ms^{-1}$)
(1) $18\times10^{-7}$ T (2) $54\times10^{-7}$ T
(3) $54\times10^{-8}$ T (4) $18\times10^{-8}$ T

**19.** A plane electromagnetic wave travels in a medium of relative permeability 1.61 and relative permittivity 6.44. If magnitude of magnetic intensity is $H = 4.5\times10^{-2}$ $Am^{-1}$ at a point, what will be the approximate magnitude of electric field intensity at that point? (Given: Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ $NA^{-2}$, speed of light in vacuum $c = 3\times10^{8}$ $ms^{-1}$)
(1) 16.96 $Vm^{-1}$
(2) $2.25\times10^{-2}$ $Vm^{-1}$
(3) 8.48 $Vm^{-1}$
(4) $6.75\times10^{6}$ $Vm^{-1}$

**20.** A plane electromagnetic wave of frequency 500 MHz is travelling in vacuum along $y$-direction. At a particular point in space and time $\vec{B} = 8.0\times10^{-8}\hat{z}$ T. The value of electric field at this point is
(Speed of light = $3\times10^{8}$ $ms^{-1}$) $\hat{x}$, $\hat{y}$, $\hat{z}$ are unit vectors along $x$, $y$ and $z$ direction
(1) $24\hat{x}\ V/m$ (2) $2.6\hat{x}\ V/m$
(3) $-24\hat{x}\ V/m$ (4) $-2.6\hat{y}\ V/m$

**21.** The ratio of average electric energy density and total average energy density of electromagnetic wave is:
(1) $\frac{2}{3}$ (2) $\frac{1}{4}$
(3) $\frac{1}{2}$ (4) $\frac{1}{3}$

**22.** A light beam is described by $E = 800\sin\omega\left(t - \frac{x}{c}\right)$. An electron is allowed to move normal to the propagation of light beam with a speed of $3\times10^{7}$ $ms^{-1}$. What is the maximum magnetic force exerted on the electron?
(1) $1.28\times10^{-21}$ N (2) $1.28\times10^{-18}$ N
(3) $12.8\times10^{-17}$ N (4) $12.8\times10^{-18}$ N

**23.** A plane electromagnetic wave propagating along y-direction, can have the following pair of electric field ($\vec{E}$) and magnetic field ($\vec{B}$) components:
(1) $E_y$, $B_y$ or $E_z$, $B_z$ (2) $E_y$, $B_x$ or $E_x$, $B_y$
(3) $E_x$, $B_z$ or $E_z$, $B_x$ (4) $E_x$, $B_y$ or $E_y$, $B_x$

**24.** The electric field of a plane electromagnetic wave propagating along the $x$ direction in vacuum is $\vec{E} = E_0\cos(\omega t - kx)\hat{j}$. The magnetic field $\vec{B}$ at the moment $t = 0$ is
(1) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{j}$
(2) $\vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}$
(3) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)\hat{k}$
(4) $\vec{B} = \frac{E_0}{\sqrt{\mu_0\varepsilon_0}}\cos(kx)\hat{j}$

**25.** For a plane electromagnetic wave, the magnetic field at a point $x$ and time $t$ is

$\vec{B}(x, t) = [1.2\times10^{-7}\sin(0.5\times10^{3}x + 1.5\times10^{11}t)\hat{k}]$ T.

The instantaneous electric field $\vec{E}$ corresponding to $\vec{B}$ is
(speed of light $c = 3\times10^{8}$ $ms^{-1}$)
(1) $\vec{E}(x, t) = [36\sin(1\times10^{3}x + 1.5\times10^{11}t)\hat{i}]\ \frac{V}{m}$
(2) $\vec{E}(x, t) = [36\sin(0.5\times10^{3}x + 1.5\times10^{11}t)\hat{k}]\ \frac{V}{m}$
(3) $\vec{E}(x, t) = [-36\sin(0.5\times10^{3}x + 1.5\times10^{11}t)\hat{j}]\ \frac{V}{m}$
(4) $\vec{E}(x, t) = [36\sin(1\times10^{3}x + 1.5\times10^{11}t)\hat{j}]\ \frac{V}{m}$

**26.** *AC* voltage $V(t) = 20\sin\omega t$ of frequency 50 Hz is applied to a parallel plate capacitor. The separation between the plates is 2 mm and the area is 1 $m^2$. The amplitude of the oscillating displacement current for the applied *AC* voltage is __________.

[Take $\varepsilon_0 = 8.85\times10^{-12}$ F/m]

(1) 83.37 μA

(2) 55.58 μA

(3) 21.14 μA

(4) 27.79 μA

**27.** The magnetic field of a plane electromagnetic wave is

$\vec{B} = 3\times10^{-8}\ \sin[200\pi(y+ct)]\hat{i}\ T$

Where $c = 3\times10^8$ ms$^{-1}$ is the speed of light.

The corresponding electric field is

(1) $\vec{E} = 9\sin[200\pi(y+ct)]\hat{k}$ V/m

(2) $\vec{E} = -9\sin[200\pi(y+ct)]\hat{k}$ V/m

(3) $\vec{E} = 3\times10^{-8}\sin[200\pi(y+ct)]\hat{k}$ V/m

(4) $\vec{E} = -10^{-6}\sin[200\pi(y+ct)]\hat{k}$ V/m

**28.** The electric field of a plane electromagnetic wave is given by $\vec{E} = E_0(\hat{x}+\hat{y})\sin(kz-\omega t)$. Its magnetic field will be given by

(1) $\frac{E_0}{c}(\hat{x}-\hat{y})\cos(kz-\omega t)$

(2) $\frac{E_0}{c}(\hat{x}-\hat{y})\sin(kz-\omega t)$

(3) $\frac{E_0}{c}(-\hat{x}+\hat{y})\sin(kz-\omega t)$

(4) $\frac{E_0}{c}(\hat{x}-\hat{y})\sin(kz-\omega t)$

**29.** If the magnetic field in a plane electromagnetic wave is given by $\vec{B} = 3\times10^{-8}\sin(1.6\times10^3x+48\times10^{10}t)\hat{j}$ T, then what will be expression for electric field?

(1) $\vec{E} = (3\times10^{-8}\sin(1.6\times10^3x+48\times10^{10}t)\hat{j}$ V/m)

(2) $\vec{E} = (3\times10^{-8}\sin(1.6\times10^3x+48\times10^{10}t)\hat{i}$ V/m)

(3) $\vec{E} = (60\sin(1.6\times10^3x+48\times10^{10}t)\hat{k}$ V/m)

(4) $\vec{E} = (9\sin(1.6\times10^3x+48\times10^{10}t)\hat{k}$ V/m)

**30.** In a plane electromagnetic wave, the directions of electric field and magnetic field are represented by $\hat{k}$ and $2\hat{i}-2\hat{j}$ respectively. What is the unit vector along the direction of propagation of the wave?

(1) $\frac{1}{\sqrt{5}}(\hat{i}+2\hat{j})$ (2) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{k})$

(3) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$ (4) $\frac{1}{\sqrt{5}}(2\hat{i}+\hat{j})$

**31.** The electric fields of two plane electromagnetic plane waves in vacuum are given by $\vec{E}_1 = E_0\hat{j}\cos(\omega t-kx)$ and $\vec{E}_2 = E_0\hat{k}\cos(\omega t-ky)$. At $t = 0$, a particle of charge $q$ is at origin with a velocity $\vec{v} = (0.8c)\hat{j}$ ($c$ is the speed of the light in vacuum). The instantaneous force experienced by the particle is

(1) $E_0q(0.8\hat{i}+\hat{j}+0.2\hat{k})$

(2) $E_0q(-0.8\hat{i}+\hat{j}+\hat{k})$

(3) $E_0q(0.4\hat{i}-3\hat{j}+0.8\hat{k})$

(4) $E_0q(0.8\hat{i}-\hat{j}+0.4\hat{k})$

**32.** The electric field of a plane electromagnetic wave is given by $\vec{E} = E_0\hat{i}\cos(kz)\cos(\omega t)$. The corresponding magnetic field $\vec{B}$ is then given by

(1) $\vec{B} = \frac{E_0}{c}\hat{j}\sin(kz)\cos(\omega t)$

(2) $\vec{B} = \frac{E_0}{c}\hat{j}\sin(kz)\sin(\omega t)$

(3) $\vec{B} = \frac{E_0}{c}\hat{k}\sin(kz)\sin(\omega t)$

(4) $\vec{B} = \frac{E_0}{c}\hat{j}\cos(kz)\sin(\omega t)$

**33.** A plane electromagnetic wave of frequency 50 MHz travels in free space along the positive $x$-direction. At a particular point in space and time, $\vec{E} = 6.6\hat{j}$ V / m. The corresponding $\vec{B}$, at that point will be

(1) $18.9\times10^{-8}\hat{k}$ T (2) $2.2\times10^{-8}\hat{k}$ T

(3) $6.3\times10^{-8}\hat{k}$ T (4) $18.9\times10^{8}\hat{k}$ T

**34.** A plane electromagnetic wave travels in free space along the positive $x$-direction. The electric field component of the wave at a particular point of space and time is $E$ =6Vm$^{-1}$ along positive $y$-direction. Its corresponding magnetic field component, $B$ would be

(1) $6 \times 10^{-8}$ T along positive $z$-direction
(2) $6 \times 10^{-8}$ T along negative $x$-direction
(3) $2 \times 10^{-8}$ T along positive $z$-direction
(4) $2 \times 10^{-8}$ T along negative $y$-direction

**35.** The magnetic field of a plane electromagnetic wave is given by $\vec{B} = B_0\hat{i}[\cos(kz-\omega t)] + B_1\hat{j}$ $[\cos(kz + \omega t)]$ where $B_0 = 3 \times 10^{-5}$ T and $B_1 = 2 \times 10^{-6}$ T. The rms value of the force experienced by a stationary charge $Q = 10^{-4}$ C at $z = 0$ is closest to

(1) 0.9 N (2) 0.1 N

(3) $3 \times 10^{-2}$ N (4) 0.6 N

**36.** The electric field of a plane polarized electromagnetic wave in free space at time $t$ = 0 is given by an expression $\vec{E}(x, y) = 10\hat{j}\cos[6x+8z]$

The magnetic field $B(x, z, t)$ is given by ($c$ is the velocity of light)

(1) $\frac{1}{c}(6\hat{k}+8\hat{i})\cos[(6x-8z+10ct]$

(2) $\frac{1}{c}(6\hat{k}-8\hat{i})\cos[(6x+8z-10ct]$

(3) $\frac{1}{c}(6\hat{k}+8\hat{i})\cos[(6x+8z-10ct]$

(4) $\frac{1}{c}(6\hat{k}-8\hat{i})\cos[(6x-8z+10ct]$

**37.** An electromagnetic wave of intensity 50 Wm$^{-2}$ enters in a medium of refractive index '$n$' and relative magnetic permeability as unity without any loss of energy. The ratio of the magnitudes of electric fields, and the ratio of the magnitudes of magnetic fields of the wave before and after entering into the medium are respectively, given by

(1) $\left(\frac{1}{\sqrt{n}}, \frac{1}{\sqrt{n}}\right)$ (2) $\left(\sqrt{n}, \sqrt{n}\right)$

(3) $\left(\sqrt{n}, \frac{1}{\sqrt{n}}\right)$ (4) $\left(\frac{1}{\sqrt{n}}, \sqrt{n}\right)$

**38.** If the magnetic field of a plane electromagnetic wave is given by
(The speed of light = $3 \times 10^8$ m/s)

$$B = 100\times10^{-6}\sin\left[2\pi\times2\times10^{15}\left(t-\frac{x}{c}\right)\right] \text{T}$$

then the maximum electric field associated with it is

(1) $6 \times 10^4$ N/C (2) $3 \times 10^4$ N/C
(3) $4 \times 10^4$ N/C (4) $4.5 \times 10^4$ N/C

**39.** For the plane electromagnetic wave given by $\vec{E} = E_0 \sin(\omega t - kx)\hat{j}$ and $\vec{B} = B_0 \sin(\omega t - kx)\hat{k}$, the ratio of average electric energy density to average magnetic energy density is

(1) 1 (2) 1/2
(3) 2 (4) 4

**40.** The energy of an electromagnetic wave contained in a small volume oscillates with
(1) Zero frequency
(2) Half the frequency of the wave
(3) Double the frequency of the wave
(4) The frequency of the wave

**41.** A point source of 100 W emits light with 5% efficiency. At a distance of 5m from the source, the intensity produced by the electric field component is:

(1) $\frac{1}{2\pi}\frac{W}{m^2}$ (2) $\frac{1}{40\pi}\frac{W}{m^2}$

(3) $\frac{1}{10\pi}\frac{W}{m^2}$ (4) $\frac{1}{20\pi}\frac{W}{m^2}$

**42.** The electric field in an electromagnetic wave is given by $E = 56.5 \sin \omega(t - x/c)\ \text{NC}^{-1}$. Find the intensity of the wave if it is propagating along $x$-axis in the free space. (Given: $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2}$)

(1) $5.65\ \text{Wm}^{-2}$
(2) $4.24\ \text{Wm}^{-2}$
(3) $1.9 \times 10^{-7}\ \text{Wm}^{-2}$
(4) $56.5\ \text{Wm}^{-2}$

**43.** Sun light falls normally on a surface of area 36 $\text{cm}^2$ and exerts an average force of $7.2 \times 10^{-9}$ N within a time period of 20 minutes. Considering a case of complete absorption, the energy flux of incident light is

(1) $25.92 \times 10^2\ \text{W/cm}^2$
(2) $8.64 \times 10^{-6}\ \text{W/cm}^2$
(3) $6.0\ \text{W/cm}^2$
(4) $0.06\ \text{W/cm}^2$

**44.** For an electromagnetic wave travelling in free space, the relation between average energy densities due to electric ($U_e$) and magnetic ($U_m$) field is

(1) $U_e > U_m$ (2) $U_e = U_m$
(3) $U_e \neq U_m$ (4) $U_e < U_m$

**45.** Intensity of sunlight is observed as $0.092\text{Wm}^{-2}$ at a point in free space. What will be the peak value of magnetic field at that point? ($\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2}$)

(1) 5.88 T (2) $1.96 \times 10^{-8}$ T
(3) 8.31 T (4) $2.77 \times 10^{-8}$ T

**46.** A plane electromagnetic wave, has frequency of $2.0 \times 10^{10}$ Hz and its energy density is $1.02 \times 10^{-8}\ \text{J/m}^3$ in vacuum. The amplitude of the magnetic field of the wave is close to ($\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$ and speed of light $= 3 \times 10^8\ \text{ms}^{-1}$)

(1) 110 nT
(2) 140 nT
(3) 190 nT
(4) 160 nT

**47.** The dimension of $\frac{B^2}{2\mu_0}$, where $B$ is magnetic field and $\mu_0$ is the magnetic permeability of vacuum, is

(1) $\text{ML}^2\text{T}^{-1}$
(2) $\text{ML}^{-1}\text{T}^{-2}$
(3) $\text{ML}^2\text{T}^{-1}$
(4) $\text{MLT}^{-2}$

**48.** A 27 mW laser beam has a cross-sectional area of 10 $\text{mm}^2$. The magnitude of the maximum electric field in this electromagnetic wave is given by [Given: Electrical permittivity of space $\varepsilon_0 = 9 \times 10^{-12}$ F/m units, speed of light $c = 3 \times 10^8$ m/s]

(1) 2 kV/m
(2) 0.7 kV/m
(3) 1 kV/m
(4) 1.4 kV/m

**49.** The mean intensity of radiation on the surface of the Sun is about $10^8\ \text{W/m}^2$. The rms value of the corresponding magnetic field is closest to:

(1) 1 T (2) $10^2$ T
(3) $10^{-2}$ T (4) $10^{-4}$ T

**50.** Match List-I with List-II of Electromagnetic waves with corresponding wavelength range:

| List-I | | List-II | |
|---|---|---|---|
| (A) | Microwave | (I) | 400 nm to 1 nm |
| (B) | Ultraviolet | (II) | 1 nm to $10^{-3}$ nm |
| (C) | X-Ray | (III) | 1 mm to 700 nm |
| (D) | Infra-red | (IV) | 0.1 m to 1 mm |

Choose the correct answer from the options given below :

(1) (A)-(I), (B)-(IV), (C)-(II), (D)-(III)
(2) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)
(3) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(4) (A)-(IV), (B)-(I), (C)-(III), (D)-(II)

**51.** Match the List-I with List-II

| List-I | | List-II | |
|---|---|---|---|
| (A) | Microwaves | (I) | Radio active decay of the nucleus |
| (B) | Gamma rays | (II) | Rapid acceleration and deceleration of electron in aerials |
| (C) | Radio waves | (III) | Inner shell electrons |
| (D) | X-Rays | (IV) | Klystron valve |

(1) A-I, B-II, C-III, D- IV
(2) A -IV, B-I, C-II, D-III
(3) A -I, B-III, C- IV, D-II
(4) A -IV, B-III, C-II, D-I

**52.** Match List-I with List-II.

| List-I | | List-II | |
|---|---|---|---|
| (A) | Microwaves | (I) | Physiotherapy |
| (B) | UV rays | (II) | Treatment of cancer |
| (C) | Infra-red rays | (III) | Lasik eye surgery |
| (D) | X-Rays | (IV) | Aircraft navigation |

Choose the correct answer from the option given below:
(1) A-II, B-IV, C-III, D-I
(2) A-IV, B-I, C-II, D-III
(3) A-IV, B-III, C-I, D-II
(4) A-III, B-II, C-I, D-IV

**53.** Match List-I and List-II

| List-I | | List-II | |
|---|---|---|---|
| (A) | Ultraviolet rays | (P) | Study crystal |
| (B) | Microwaves | (Q) | Greenhouse effect |
| (C) | Infrared waves | (R) | Sterilizing surgical instrument |
| (D) | X-Rays | (S) | Radar system |

Choose the correct answer from the option given below:
(1) A-(R); B-(S); C-(Q); D-(P)
(2) A-(Q); B-(P); C-(S); D-(R)
(3) A-(R); B-(Q); C-(P); D-(S)
(4) A-(Q); B-(P); C-(R); D-(S)

**54.** Which is the correct ascending order of wavelength?
(1) $\lambda_{visible} < \lambda_{X\text{-}ray} < \lambda_{gamma\text{-}ray} < \lambda_{microwave}$
(2) $\lambda_{gamma\text{-}ray} < \lambda_{X\text{-}ray} < \lambda_{visible} < \lambda_{microwave}$
(3) $\lambda_{X\text{-}ray} < \lambda_{gamma\text{-}ray} < \lambda_{visible} < \lambda_{microwave}$
(4) $\lambda_{microwave} < \lambda_{visible} < \lambda_{gamma\ ray} < \lambda_{X\text{-}ray}$

**55.** Match List-I with List-II:

| List-I | | List-II | |
|---|---|---|---|
| (A) | UV rays | (I) | Diagnostic tool in medicine |
| (B) | X-rays | (II) | Water purification |
| (C) | Microwave | (III) | Communication, Radar |
| (D) | Infrared wave | (IV) | Improving visibility in foggy days |

Choose the correct answer from the options given below:
(1) (A) - (III), (B) - (II), (C) - (I), (D)- (IV)
(2) (A) - (II), (B) - (IV), (C) - (III), (D) - (I)
(3) (A) - (II), (B) - (I), (C) - (III), (D) - (IV)
(4) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

**56.** Match List-I with List-II

| List-I | | List-II | |
|---|---|---|---|
| (A) | Television signal | (P) | 03 KHz |
| (B) | Radio signal | (Q) | 20 KHz |
| (C) | High quality music | (R) | 02 MHz |
| (D) | Human speech | (S) | 06 MHz |

Choose the correct answer from the following options given below
(1) A-(P); B-(Q); C-(R); D-(S)
(2) A-(S); B-(R); C-(P); D-(Q)
(3) A-(S); B-(R); C-(Q); D-(P)
(4) A-(P); B-(Q); C-(S); D-(R)

**57.** The correct match between the entries in column I and column II are:

| List-I (Radiation) | | List-II (Wavelength) | |
|---|---|---|---|
| (A) | Microwave | (I) | 100 m |
| (B) | Gamma rays | (II) | $10^{-15}$ m |
| (C) | A.M. radio waves | (III) | $10^{-10}$ m |
| (D) | X-rays | (IV) | $10^{-3}$ m |

(1) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(2) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)
(3) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)
(4) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)

**58.** Choose the correct option relating wavelengths of different parts of electromagnetic wave spectrum
(1) $\lambda_{\text{x-rays}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{visible}}$
(2) $\lambda_{\text{visible}} > \lambda_{\text{x-rays}} > \lambda_{\text{radio waves}} > \lambda_{\text{micro waves}}$
(3) $\lambda_{\text{radio waves}} > \lambda_{\text{micro waves}} > \lambda_{\text{visible}} > \lambda_{\text{x-rays}}$
(4) $\lambda_{\text{visible}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{x-rays}}$

## *Integer Type Questions (59 to 71)*

**59.** The displacement current of 4.425 μA is developed in the space between the plates of parallel plate capacitor when voltage is changing at a rate of $10^6$ $Vs^{-1}$. The area of each plate of the capacitor is 40 $cm^2$. The distance between each plate of the capacitor is $x \times 10^{-3}$ m. The value of $x$ is, ______ (Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12}$ $C^2 N^{-1} m^{-2}$)

**60.** Electric field of a plane electromagnetic wave propagating through a non-magnetic medium is given by $E = 20\cos(2 \times 10^{10} t - 200x)$V/m. The dielectric constant of the medium is equal to: (Take $\mu_r = 1$)

**61.** Sea-water at a frequency $f = 9 \times 10^2$ Hz, has permittivity $\varepsilon = 80\,\varepsilon_0$ and resistivity $\rho = 0.25$ Ωm. Imagine a parallel plate capacitor is immersed in seawater and is driven by an alternating voltage source $V(t) = V_0 \sin(2\pi f t)$. Then the conduction current density become $10^x$ times the displacement current density after time $t = \frac{1}{800} s$. The value of $x$ is_____.

$\left(\text{Given} : \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2C^{-2}\right)$

**62.** An electromagnetic wave of frequency 3 GHz enters a dielectric medium of relative electric permittivity 2.25 from vacuum. The wavelength of this wave in that medium will be _________$\times 10^{-2}$ cm. [write answer to it's nearest integer] given, $\mu_{r,\text{medium}} = 1$

**63.** An electromagnetic wave of frequency 5 GHz, is travelling in a medium whose relative electric permittivity and relative magnetic permeability both are 2. Its velocity in the medium is_____$\times 10^7$ m/s.

**64.** A plane electromagnetic wave with frequency of 30 MHz travels in free space. At particular point in space and time, electric field is 6 V/m. The magnetic field at this point will be $x \times 10^{-8}$ T. The value of $x$ is _____.

**65.** A point source of light is placed at the centre of curvature of a hemispherical surface. The source emits a power of 24 W The radius of curvature of hemisphere is 10 cm and the inner surface is completely reflecting. The force on the hemisphere due to the light falling on it is –——— $\times 10^{-8}$ N.

**66.** The intensity of the light from a bulb incident on a surface is 0.22 W/$m^2$. The amplitude of the magnetic field in this light-wave is ________ $\times$ $10^{-9}$ T. [Write answer to closest possible integer]
(Given: Permittivity of vacuum $\varepsilon_0 = 8.85\times10^{-12}$ $C^2$ $N^{-1}$ $m^{-2}$, speed of light in vacuum $c = 3 \times 10^8$ $ms^{-1}$)

**67.** If $2.5 \times 10^{-6}$ N average force is exerted by a light wave on a non- reflecting surface of 30 $cm^2$ area during 40 minutes of time span, the energy flux of light just before it falls on the surface is ______ W / $cm^2$. (Round off to the Nearest Integer)

(Assume complete absorption and normal incidence conditions are there)

**68**. The electric field intensity produced by the radiation coming from a 100 W bulb at a distance of 3 m is $E$. The electric field intensity produced by the radiation coming from 60 W at the same distance is $\sqrt{\frac{x}{5}}E$. The value of $x$ = ______.

**69**. A radiation is emitted by 1000 W bulb and it generates an electric field and magnetic field at $P$, placed at a distance of 2 m from the bulb. The efficiency of the bulb is 1.25%. The value of peak electric field at $P$ is $x \times 10^{-1}$ V/m. Value of $x$ is ____________. (Rounded - off to the nearest integer) [Take $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$ N$^{-1}$ m$^{-2}$, $c = 3 \times 10^8$ ms$^{-1}$]

**70**. The electric field in an electromagnetic wave is given by $E = (50\ \text{NC}^{-1}) \sin\omega(t - x/c)$. The energy contained in a cylinder of volume $V$ is $5.5 \times 10^{-12}$ J. The value of $V$ is __________cm$^3$ (to it's nearest integer).
(Given $\epsilon_0 = 8.8 \times 10^{-12}$ C$^2$ N$^{-1}$m$^{-2}$)

**71**. The peak electric field produced by the radiation coming from the 8 W bulb at a distance of 10 m is $\left(\frac{x}{10}\sqrt{\frac{\mu_0 c}{10\pi}}\right)\frac{\text{V}}{\text{m}}$. The efficiency of the bulb is 10% and it is a point source. The value of $x$ is…….

CHAPTER

21

# RAY OPTICS

## Single Option Correct Type Questions (01 to 58)

**1.** The image of the clock in the mirror if read, indicates the time as 8 : 20. What is the time in the clock-

(1) 3 : 40 (2) 4 : 40
(3) 5 : 20 (4) 4 : 20

**2.** A ray of light incident on a plane mirror at an angle of incidence of 30º. The deviation produced by the mirror is-

(1) 30º (2) 60º
(3) 90º (4) 120º

**3.** A convex mirror has a focal length *f*. A real object is placed at a distance f in front of it from the pole, then it produces an image at-

(1) Infinity (2) *f*
(3) *f*/2 (4) 2*f*

**4.** An object is placed at a distance of 20 cm, in rarer medium, from the pole of a convex spherical refracting surface of radius of curvature 10 cm. If the refractive index of the rarer medium is 1 and of the refracting medium is 2, then the position of the image is at-

(1) (40/3) cm from the pole & inside the denser medium
(2) 40 cm from the pole & inside the denser medium.
(3) (40/3) cm from the pole & outside the denser medium
(4) 40 cm from the pole & outside the denser medium.

**5.** A plane mirror is moving with velocity $4\hat{i}+5\hat{j}+8\hat{k}$ . A point object in front of the mirror moves with a velocity $3\hat{i}+4\hat{j}+5\hat{k}$ . Here $\hat{k}$ is along the normal to the plane mirror and facing towards the object. The velocity of the image is :

(1) $-3\hat{i}-4\hat{j}+5\hat{k}$ (2) $3\hat{i}+4\hat{j}+11\hat{k}$
(3) $-3\hat{i}-4\hat{j}+11\hat{k}$ (4) $7\hat{i}+9\hat{j}+11\hat{k}$

**6.** A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will-

(1) Become zero
(2) Become infinite
(3) Become small, but non-zero
(4) Remain unchanged

**7.** A diverging lens with magnitude of focal length 25cm is placed at a distance of 15 cm from a converging lens of magnitude of focal length 20 cm. A beam of parallel light falls on the diverging lens. The final image formed is:

(1) real and at a distance of 6 cm from the convergent lens
(2) real and at a distance of 40 cm from convergent lens.
(3) virtual and at a distance of 40 cm from convergent lens
(4) real and at distance of 40 cm from the divergent lens.

**8.** The largest distance of the image of a real object from a convex mirror of focal length 10 cm can be-

(1) 20 cm

(2) Infinite

(3) 10 cm

(4) Depends on the position of the object

**9.** A thick plane mirror shows a number of images of the filament of an electric bulb. Of these, the brightest image is the-

(1) First

(2) Second

(3) Last

(4) Fourth

**10.** An object is placed at a distance of 5 cm from a convex lens of focal length 10 cm, then the image is-

(1) Real, diminished and at a distance of 10 cm from the lens.

(2) Real, enlarged and at a distance of 10 cm from the lens.

(3) Virtual, enlarged and at a distance of 10 cm from the lens.

(4) Virtual, diminished and at a distance of 10/3 cm from the lens.

**11.** There is a small black dot at the centre *C* of a solid glass sphere of refractive index μ. When seen from outside, the dot will appear to be located:

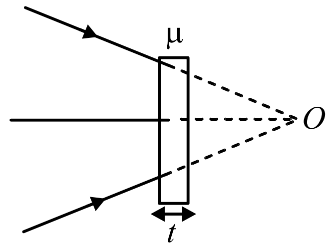
(1) Away from C for all values of μ

(2) at C for all values of μ

(3) At C for $\mu = 1.5$, but away from *C* for $\mu \neq 1.5$

(4) At C only for $\sqrt{2} \leq \mu \leq 1.5$

**12.** A beam of light is converging towards a point. A plane parallel plate of glass of thickness *t*, refractive index μ is introduced in the path of the beam. The convergent point is shifted by (assume near normal incidence):




(1) $t\left(1-\frac{1}{\mu}\right)$ away

(2) $t\left(1+\frac{1}{\mu}\right)$ away

(3) $t\left(1-\frac{1}{\mu}\right)$ nearer

(4) $t\left(1+\frac{1}{\mu}\right)$ nearer

**13.** A beaker contains water up to a height $h_1$ and kerosene of height $h_2$ above water so that the total height of (water + kerosene) is $(h_1 + h_2)$. Refractive index of water is $\mu_1$ and that of kerosene is $\mu_2$. The apparent shift in the position of the bottom of the beaker when viewed from above is:

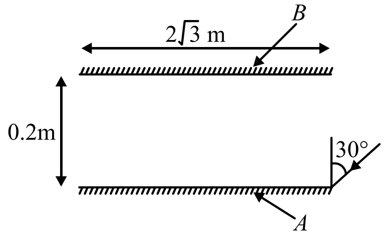
(1) $\left(1+\frac{1}{\mu_1}\right)h_1 - \left(1+\frac{1}{\mu_2}\right)h_2$

(2) $\left(1-\frac{1}{\mu_1}\right)h_1 + \left(1-\frac{1}{\mu_2}\right)h_2$

(3) $\left(1+\frac{1}{\mu_1}\right)h_2 - \left(1+\frac{1}{\mu_2}\right)h_1$

(4) $\left(1-\frac{1}{\mu_1}\right)h_2 + \left(1-\frac{1}{\mu_2}\right)h_1$

**14.** Two plane mirrors *A* & *B* are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle of 30º at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is:




(1) 28

(2) 30

(3) 32

(4) 34

**15.** A luminous point object is moving along the principal axis of a fixed concave mirror of focal length 12 cm towards it. When its distance from the mirror is 20 cm its velocity is 4 cm/s. The velocity of the image in cm/s at that instant is

(1) 6, towards the mirror

(2) 6, away from the mirror

(3) 9, away from the mirror

(4) 9, towards the mirror.

**16.** Critical angle of light passing from glass to air is minimum for

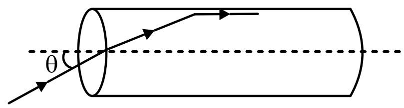
(1) Red

(2) Green

(3) Yellow

(4) Violet

**17.** A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure.




The incident angle (θ) for which the light ray grazes along the wall of the rod is:

(1) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$

(2) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$

(3) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

(4) $\sin^{-1}\left(\frac{1}{2}\right)$

**18.** A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

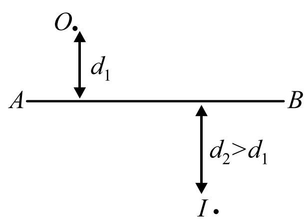
(1) Virtual and at a distance of 16 cm from mirror

(2) Real and at distance of 16 cm from the mirror

(3) Virtual and at a distance of 20 cm form the mirror

(4) Real and at a distance of 20 cm from the mirror

**19.** In the figure shown, the image of a real object is formed at point *I*. *AB* is the principal axis of the mirror. The mirror must be:



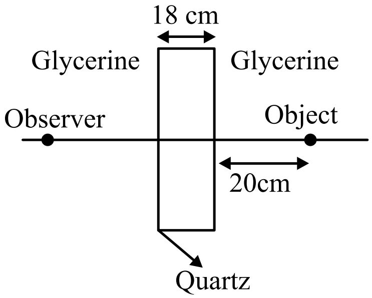

(1) concave and placed towards right of *I*

(2) concave and placed towards left of *O*

(3) convex and placed towards right of *I*

(4) convex and placed towards left of *I*.

**20.** Given that velocity of light in quartz = $1.5 \times 10^8$ m/s and velocity of light in glycerine = $(9/4) \times 10^8$ m/s. Now a slab made of quartz is placed in glycerine as shown. The shift of the object produced by slab is




(1) 6 cm
(2) 3.55 cm
(3) 9 cm
(4) 2 cm

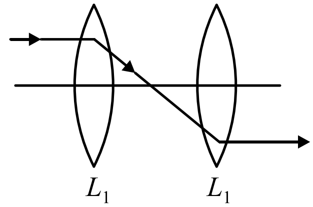
**21.** A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths $f_1$ and $f_2$ respectively. The correct relation between the focal length is:

(1) $f_1 = f_2 < f$
(2) $f_1 > f$ and $f_2$ becomes negative
(3) $f_2 > f$ and $f_1$ becomes negative
(4) $f_1$ and $f_2$ both become negative

**22.** An astronomical telescope has an eyepiece of focal-length 5 cm. If the angular magnification in normal adjustment is 10, when final image is at least distance of distinct vision (25cm) from eye piece, then angular magnification will be:

(1) 10 (2) 12
(3) 50 (4) 60

**23.** In the figure given below, there are two convex lens $L_1$ and $L_2$ having focal length of $f_1$ and $f_2$ respectively. The distance between $L_1$ and $L_2$ will be




(1) $f_1$ (2) $f_2$
(3) $f_1 + f_2$ (4) $f_1 - f_2$

**24.** Time taken to cross a 4 mm window glass of refractive index 1.5 will be-

(1) $2 \times 10^{-8}$ sec
(2) $2 \times 10^{8}$ sec
(3) $2 \times 10^{-11}$ sec
(4) $2 \times 10^{11}$ sec

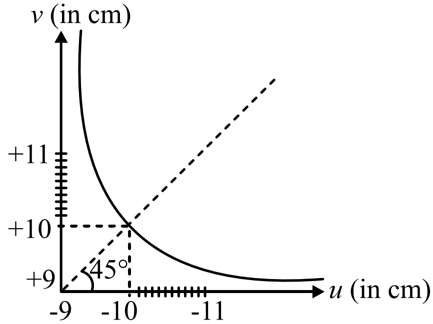
**25.** A car is fitted with a convex side–view mirror of focal length 20 cm. A second car 2.8 m behind the first car is overtaking the first car at a relative speed of 15 m/s. The speed of the image of the second car as seen in the mirror of the first one is:

(1) $\frac{1}{10}$ m/s (2) $\frac{1}{15}$ m/s
(3) 10 m/s (4) 15 m/s

**26.** A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be:

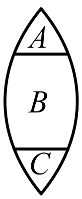
(1) only a reflected ray and no refracted ray
(2) only a refracted ray and no reflected ray
(3) a reflected ray and a refracted ray and the angle between them would be less than $180° - 2\theta$
(4) a reflected ray and a refracted ray and the angle between them would be greater than $180° - 2\theta$.

**27.** The graph between object coordinate $u$ and image coordinate $v$ for a lens is given below. The focal length of the lens is:




(1) $5 \pm 0.1$ (2) $5 \pm 0.05$
(3) $0.5 \pm 0.1$ (4) $0.5 \pm 0.05$

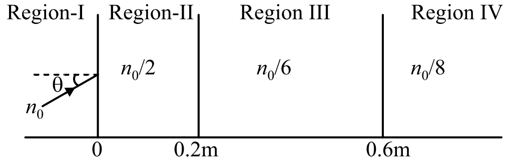
**28.** A thin symmetrical double convex lens of power $P$ is cut into three parts, as shown in the figure. Power of $A$ is:




(1) $2P$ (2) $P/2$
(3) $P/3$ (4) $P$

**29.** Which of the following is used in optical fibers?
(1) Total internal reflection
(2) Scattering
(3) Diffraction
(4) Refraction

**30.** A light beam is travelling from Region I to Region IV (Refer Figure). The refractive index in Regions I, II, III and IV are $n_0$, $\frac{n_0}{2}$, $\frac{n_0}{6}$ and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is

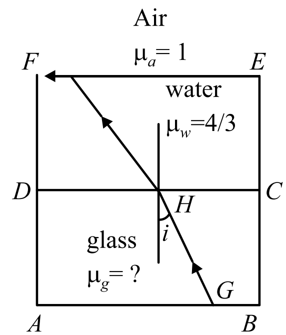



(1) $\sin^{-1}\left(\frac{3}{4}\right)$ (2) $\sin^{-1}\left(\frac{1}{8}\right)$
(3) $\sin^{-1}\left(\frac{1}{4}\right)$ (4) $\sin^{-1}\left(\frac{1}{3}\right)$

**31.** Which of the following can form erect, virtual, diminished image?
(1) plane mirror (2) concave mirror
(3) convex mirror (4) none of these

**32.** A ray of monochromatic light is incident on one refracting face of a prism of angle 75°. It passes through the prism and is incident on the other face at the critical angle. If the refractive index of the material of the prism is $\sqrt{2}$, the angle of incidence on the first face of the prism is
(1) 30° (2) 45°
(3) 60° (4) 0°

**33.** If ray of light ($GH$) is incident on the glass-water interface $DC$ at an angle '$i$'. It emerges in air along the water-air interface $EF$ (see figure). If the refractive index of water $\mu_w$ is 4/3, the refractive index of glass $\mu_g$ is:




(1) $\frac{3}{4\sin i}$ (2) $\frac{1}{\sin i}$
(3) $\frac{4\sin i}{3}$ (4) $\frac{4}{3\sin i}$

**34.** The image formed by an objective of a compound microscope is
(1) Virtual and diminished
(2) Real and diminished
(3) Real and enlarged
(4) Virtual and enlarged

**35.** A light wave travels from glass to water. The refractive index for glass and water are $\frac{3}{2}$ and $\frac{4}{3}$ respectively. The value of the critical angle will be:
(1) $\sin^{-1}\left(\frac{1}{2}\right)$ (2) $\sin^{-1}\left(\frac{9}{8}\right)$
(3) $\sin^{-1}\left(\frac{8}{9}\right)$ (4) $\sin^{-1}\left(\frac{5}{7}\right)$

**36.** A simple microscope has a focal length of 5 cm. The magnification at the least distance of distinct vision is-
(1) 1 (2) 5
(3) 4 (4) 6

**37.** A biconvex lens of focal length $f$ forms a circular image of radius $r$ of sun in focal plane. Then which option is correct :
(1) $\pi r^2 \propto f$
(2) $\pi r^2 \propto f^2$
(3) If lower half part is covered by black sheet, then area of the image is equal to $\pi r^2/2$
(4) If $f$ is doubled, intensity will increase

**38.** The focal length of a concave mirror is 20 cm. Determine where an object must be placed to form an image magnified two times when the image is real-
(1) 30cm from the mirror
(2) 10cm from the mirror
(3) 20cm from the mirror
(4) 15cm from the mirror

**39.** Let the $x$ - y plane be the boundary between two transparent media. Medium 1 in $z \geq 0$ has refractive index of $\sqrt{2}$ and medium 2 with $z < 0$ has a refractive index of $\sqrt{3}$. A ray of light in medium 1 given by the vector $\vec{A} = 6\sqrt{3}\,\hat{i} + 8\sqrt{3}\,\hat{j} - 10\hat{k}$ is incident on the plane of separation. The angle of refraction in medium 2 is:
(1) 30° (2) 45°
(3) 60° (4) 75°

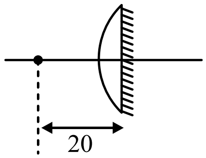
**40.** An object is placed at 24 cm distance above the surface of a lake. If water has refractive index of 4/3, then at what distance from lake surface, a fish will see the object-
(1) 32 cm above the surface of water
(2) 18 cm over the surface of water
(3) 6 cm over the surface of water
(4) 6 cm below the surface of water

**41.** A ray of light is incident at angle $i$ on a surface of a prism of small angle A and emerges normally from the opposite surface. If the refractive index of the material of the prism is $\mu$, the angle of incidence $i$ is nearly equal to:
(1) $A/\mu$ (2) $A/(2\mu)$
(3) $\mu A$ (4) $\mu A/2$

**42.** A convex lens of focal length 25 cm and a concave lens of focal length 20 cm are mounted coaxially separated by a distance $d$ cm. If the power of the combination is zero, $d$ is equal to
(1) 45 (2) 30
(3) 15 (4) 5

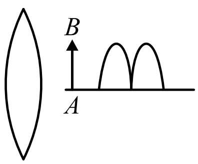
**43.** The refractive index of glass is 1.520 for red light and 1.525 for blue light. Let $D_1$ and $D_2$ be angles of minimum deviation for red and blue light respectively in a thin prism of this glass. Then,
(1) $D_1$ can be less than or greater than $D_2$ depending upon the angle of prism
(2) $D_1 > D_2$
(3) $D_1 < D_2$
(4) $D_1 = D_2$

**44.** A point object is placed at a distance of 20 cm from a thin plano-convex lens of focal length 15 cm. The plane surface of the lens is now silvered. The image created by the system is at:




(1) 60 cm to the left of the system.
(2) 60 cm to the right of the system.
(3) 12 cm to the left of the system.
(4) 12 cm to the right of the system.

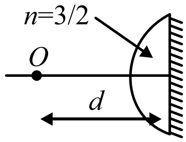
**45.** In the figure (i) a thin lens of focal length 10 cm is shown. The lens is cut into two equal parts, and the parts are arranged as shown in the figure (ii). An object $AB$ of height 1 cm is placed at distance of 7.5 cm from the arrangement. The height of the final image will be:




(1) 0.5 cm (2) 2 cm
(3) 1 cm (4) 4 cm

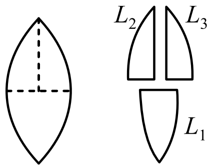
**46.** Inside water, an air bubble behave-
(1) Always like a converging lens
(2) Always like a diverging lens
(3) Always like a slab of equal thickness
(4) Sometimes concave and sometimes like a convex lens

**47.** A plano-convex lens of focal length 10 cm is silvered at its plane face. The distance $d$ at which an object must be placed in order to get its image on itself is:




(1) 5 cm (2) 20 cm
(3) 10 cm (4) 2.5 cm

**48.** A convex lens has power $P$. It is cut into two halves along its principal axis. Further one piece (out of the two halves) is cut into two halves perpendicular to the principal axis (as shown in figures). Choose the incorrect option for the reported pieces.




(1) Power of $L_1 = \frac{P}{2}$
(2) Power of $L_2 = \frac{P}{2}$
(3) Power of $L_3 = \frac{P}{2}$
(4) Power of $L_1 = P$

**49.** A green light is incident from the water to the air - water interface at the critical angle (θ). Select the correct statement.
(1) The entire spectrum of visible light will come out of the water at an angle of 90º to the normal.
(2) The spectrum of visible light whose frequency is less than that of green light will come out ot the air medium.
(3) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.
(4) The entire spectrum of visible light will come out of the water at various angles to the normal

**50.** A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, When the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take $g = 10\ m/s^2$]

(1) 9 m/s (2) 12 m/s
(3) 16 m/s (4) 21.33 m/s

**51.** A bubble in glass slab [$\mu = 1.5$] when viewed from one side appears at 5 cm and 2 cm from other side then thickness of slab is-

(1) 3.75 cm (2) 23 cm
(3) 10.5 cm (4) 1.5 cm

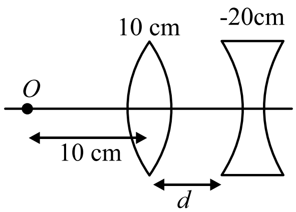
**52.** An object 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and film with its plane faces parallel to film. At what distance (from lens) should object shifted to be in sharp focus on film?

(1) 7.2 m (2) 2.4 m
(3) 3.2 m (4) 5.6 m

**53.** Two thin lenses of power $+5D$ and $-2D$ are placed in contact with each other. Focal length of the combination will behave like a-

(1) Convex lens of focal length 3m
(2) Concave lens of focal length 0.33m
(3) Convex lens of focal length 0.33m
(4) None of the above

**54.** What should be the value of distance d so that final image is formed on the object itself. (focal lengths of the lenses are written on the lenses).

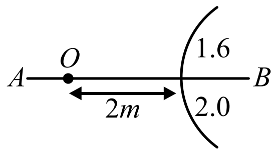



(1) 10 cm (2) 20 cm
(3) 5 cm (4) None of these

**55.** A point object is situated at the centre of a solid glass sphere of radius 6cm and refractive index 1.5. The distance of its virtual image from the surface of the sphere is.

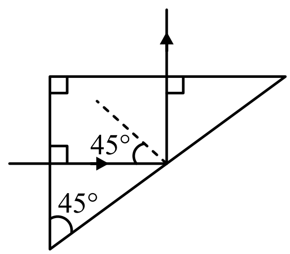
(1) 4 cm (2) 6 cm
(3) 9 cm (4) 12 cm

**56.** In the figure shown a point object $O$ is placed in air. A spherical boundary of radius of curvature 1.0 m separates two media. $AB$ is principal axis. The refractive index above $AB$ is 1.6 and below $AB$ is 2.0. The separation between the images formed due to refraction at spherical surface is:




(1) 12 m (2) 20 m
(3) 14 m (4) 10 m

**57.** A light ray is incident perpendicularly to one face to a 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index $n$ is




(1) $n < \frac{1}{\sqrt{2}}$ (2) $n > \sqrt{2}$

(3) $n > \frac{1}{\sqrt{2}}$ (4) $n < \sqrt{2}$

**58.** A lens behaves as a converging lens in air and a diverging lens in water. The refractive index of the material is (refractive index of water = 1.33)

(1) Equal to unity

(2) Equal to 1.33

(3) Between unity and 1.33

(4) Greater than 1.33

## Integer Type Questions (59 to 72)

**59.** If an object is placed symmetrically between two plane mirrors, inclined at an angle of 72°, then the total number of images formed is-

**60.** A man 180 cm high stands in front of a plane mirror. His eyes are at a height of 170 cm from the floor. Then the minimum length (in cm) of plane mirror for him to see his full length image is-

**61.** The image formed by convex mirror of focal length 30 cm is a quarter of the size of the object. Then the distance of the object from the mirror (in cm), is

**62.** Diameter of a plano - convex lens is 6 cm and thickness at the centre is 3 mm. If speed of light in material of lens is $2 \times 10^8$ m/s, the focal length of the lens (in cm) is:

**63.** A plano convex lens of refractive index 1.5 and radius of curvature 30 cm is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance (in cm) from this lens an object be placed in order to have a real image of the size of the object.

**64.** If two mirrors are kept at 60º to each other, then the number of images formed by them is

**65.** The magnitude of focal length of a plano-convex lens is 10 cm, then its magnitude of focal length (in cm) when its plane surface is polished (silvered) is:

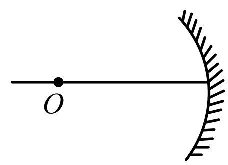
**66.** A thin linear object of size 1 mm is kept along the principal axis of a convex lens of focal length 10 cm. The object is at 15 cm from the lens. The length of the image (in mm) is:

**67.** A convex lens forms a real image 9 cm long on a screen. Without altering the position of the object and the screen, the lens is displaced and we get again a real image 4 cm long on the screen. Then the length (in cm) of the object is-

**68.** A biconvex lens with equal radii of curvature has refractive index 1.6 and focal length 10 cm. Its radius of curvature (in cm) will be:

**69.** A convex lens of power 4D and a concave lens of power 3D are placed in contact, the equivalent power of combination (in diopter):

**70.** An object '$O$' is placed at a distance of 100 cm in front of a concave mirror of radius of curvature 200 cm as shown in the figure. The object starts moving towards the mirror at a speed 2 cm/s. The position of the image from the mirror after 10 s will be at ________cm.




**71.** The difference of speed of light in the two media $A$ and $B$ ($v_A - v_B$) is $2.6 \times 10^7$ m/s. If the refractive index of medium $B$ is 1.47, then the ratio of refractive index of medium $B$ to medium A is $x$ : 100. Find $x$ (Given: speed of light in vacuum $c = 3 \times 10^8$ ms$^{-1}$)

**72.** Two convex lenses of focal length 20 cm each are placed coaxially with a separation of 60 cm between them. The image of the distant object formed by the combination is at _________ cm from the first lens.

# CHAPTER 22

# WAVE OPTICS

*Single Option Correct Type Questions (01 to 60)*

**1.** Ratio of intensities of two light waves is given by 4 : 1. The ratio of the amplitudes of the waves is :

(1) 2 : 1 (2) 1 : 2
(3) 4 : 1 (4) 1 : 4

**2.** In Young's double slit experiment, one of the slit is wider than the other, so that the amplitude of light from one slit is double of that from other slit. If $I_m$ be the maximum intensity, the resultant intensity $I$ when they interfere at phase difference $\phi$ is given by :

(1) $\frac{I_m}{9}(4 + 5\cos\phi)$

(2) $\frac{I_m}{3}\left(1+2\cos^2\frac{\phi}{2}\right)$

(3) $\frac{I_m}{5}\left(1+4\cos^2\frac{\phi}{2}\right)$

(4) $\frac{I_m}{9}\left(1+8\cos^2\frac{\phi}{2}\right)$

**3.** In a Young's double slit experiment, slits are separated by 0.5 mm, and the screen is placed 150 cm away. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes on the screen. The least distance from the common central maximum to the point where the bright fringes due to both the wavelengths coincide is:

(1) 15.6 mm (2) 1.56 mm
(3) 7.8 mm (4) 9.75 mm

**4.** Initially interference is observed with the entire experimental set up inside a chamber filled with air, Now the chamber is evacuated. With the same source of light used, a careful observer will find that

(1) The interference pattern is almost absent as it is very much diffused
(2) There is no change in the interference pattern
(3) The fringe width is slightly decreased
(4) The fringe width is slightly increased

**5.** A Young's double slit experiment is performed with white light, then which option is incorrect.

(1) The first constructive interference next to the central will be of red.
(2) The central maxima will be white
(3) The first constructive interference next to the central will be of violet
(4) There will not be a completely dark fringe.

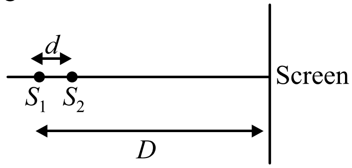
**6.** When an unpolarized light of intensity $I_0$ is incident on a polarizing sheet, the intensity of the light which does not get transmitted is :

(1) $\frac{1}{2}I_0$ (2) $\frac{1}{4}I_0$
(3) Zero (4) $I_0$

**7.** Two points white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm. Approximately, what is the maximum distance at which these dots can be resolved by the eye?
[Take wavelength of light = 500 nm]

(1) 9m (2) 3m
(3) 5m (4) 1m

**8.** Two coherent point sources $S_1$ and $S_2$ are separated by a small distance '$d$' as shown. The fringe obtained on the screen will be:




(1) point
(2) Straight line
(3) semi-circle
(4) concentric circles

**9.** Two beams, $A$ and $B$, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam $A$ has maximum intensity (and beam $B$ has zero intensity), a rotation of polaroid through 30º makes the two beams appear equally bright. If the initial intensities of the two beams are $I_A$ and $I_B$ respectively, then $\frac{I_A}{I_B}$ equals

(1) 3 (2) $\frac{3}{2}$
(3) 1 (4) $\frac{1}{3}$

**10.** On a hot summer night, the refractive index of air is smallest near the ground and increases with height from the ground. When a light beam is directed horizontally, the Huygens' principle leads us to conclude that as it travels, the light beam :
(1) becomes narrower
(2) goes horizontally without any deflection
(3) bends downwards
(4) bends upwards

**11.** Two sources of waves are called coherent if:-
(1) Both have the same amplitude of vibrations
(2) Both produce waves of the same wavelength
(3) Both produce waves of the same wavelength having constant phase difference
(4) Both produce waves having the same velocity

**12.** Yellow light emitted by sodium lamp in Young's double slit experiment is replaced by monochromatic blue light of the same intensity
(1) fringe width will decrease.
(2) fringe width will increase.
(3) fringe width will remain unchanged.
(4) fringes will become less intense.

**13.** A two slit Young's interference experiment is done with monochromatic light of wavelength 6000 Å. The slits are 2 mm apart. The fringes are observed on a screen placed 10 cm away from the slits. Now transparent plate of thickness 0.5 mm is placed in front of one of the slits and it is found that the interference pattern shifts by 5 mm. The refractive index of the transparent plate is:
(1) 1.2 (2) 0.6
(3) 2.4 (4) 1.5

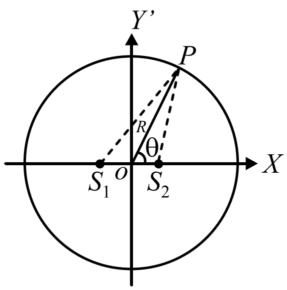
**14.** At two points $P$ and $Q$ on a screen in Young's double slit experiment, waves from slits $S_1$ and $S_2$ have a path difference of 0 and $\frac{\lambda}{4}$ respectively. The ratio of intensities at $P$ and $Q$ will be
(1) 2 : 1 (2) $\sqrt{2}$ : 1
(3) 4 : 1 (4) 3 : 2

**15.** In a Young's double slit experiment the intensity at a point $I$ where the corresponding path difference is one sixth of the wavelength of light used. If $I_0$ denotes the maximum intensity, the ratio $\frac{I}{I_0}$ is equal to

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$
(3) $\frac{\sqrt{3}}{2}$ (4) $\frac{3}{4}$

**16.** Diffraction and interference of light suggest:
(1) Nature of light is electro magnetic
(2) Wave nature
(3) Nature is quantum
(4) Nature of light is transverse

**17.** Two coherent sources of light $S_1$ and $S_2$, equidistant from the origin, are separated by a distance $2\lambda$ as shown. They emit light of wavelength $\lambda$. Interference is observed on a screen placed along the circle of large radius $R$. Point $P$ is seen to be a point of constructive interference. Then angle $\theta$ (other than 0° and 90°) is:




(1) 45°
(2) 30°
(3) 60°
(4) Not possible in the first quadrant

**18.** White light is incident normally on a glass plate (in air) of thickness 500 nm and refractive index of 1.5. The wavelength (in nm) in the visible region (400 nm - 700nm) that is strongly reflected by the plate is:

(1) 450
(2) 600
(3) 400
(4) 500

**19.** Visible light passing through a circular hole form a diffraction disc of radius 0.1 mm on a screen. If X-ray is passed through the same set-up, the radius of the diffraction disc will be:

(1) Zero (2) <0.1 mm
(3) 0.1 mm (4) > 0.1 mm

**20.** Let $S_1$ and $S_2$ be the two slits in Young's double slit experiment. If central maxima is observed at $P$ and angle $\angle S_1PS_2 = \theta$, then the fringe width for the light of wavelength $\lambda$ will be. (Assume $\theta$ to be a small angle)

(1) $\lambda/\theta$ (2) $\lambda\theta$
(3) $2\lambda/\theta$ (4) $\lambda/2\theta$

**21.** Young's experiment is performed in air and then performed in water, the fringe width:

(1) Will remain same
(2) Will decrease
(3) Will increase
(4) All the above types of waves

**22.** The Young's double slit experiment is performed with blue and with green light of wavelengths 4360 Å and 5460 Å respectively. If $X$ is the distance of 4th maximum from the central one, then:

(1) $X$(blue) = $X$(green)
(2) $X$(blue) > $X$(green)
(3) $X$(blue) < $X$(green)
(4) $\dfrac{X\,(blue)}{X(green)} = \dfrac{5460}{4360}$

**23.** In a Young's double slit experiment, the two slits act as coherent sources of waves of equal amplitude A and wavelength $\lambda$. In another experiment with the same arrangement the two slits are made to act as incoherent sources of waves of same amplitude and wavelength. If the intensity at the middle point of the screen in the first case is $I_1$ and in the second case is $I_2$, then the ratio $\dfrac{I_1}{I_2}$ is:

(1) 2
(2) 1
(3) 0.5
(4) 4

**24.** The contrast in the fringes in any interference pattern depends on:

(1) Fringe width
(2) Wavelength
(3) Intensity ratio of the sources
(4) Distance between the sources

**25.** **Statement-1:** Two coherent point sources of light having non-zero phase difference are separated by small distance. Then on the perpendicular bisector of line segment joining both the point sources, constructive interference cannot be obtained.

**Statement-2:** For two waves from coherent point sources to interfere constructively at a point, the magnitude of their phase difference at that point must be $2m\pi$ (where m is a non-negative integer).

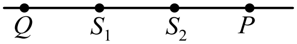
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**26.** **Statement-1:** Thin films such as soap bubble or a thin layer of oil on water show beautiful colours when illuminated by white light.

**Statement-2:** It happens due to the interference of light reflected from the upper surface of the thin film.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

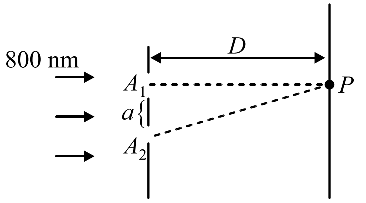
**27.** **Statement-1:** Two point coherent sources of light $S_1$ and $S_2$ are placed on a line as shown. P and Q are two points on that line. If at point P maximum intensity is observed then maximum intensity should also be observed at Q.




**Statement-2:** In the figure of statement 1, the distance $|S_1P - S_2P|$ is equal to distance $|S_2Q - S_1Q|$.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

**28.** In a Young's double slit experiment, two slits are illuminated with a light of wavelength 800 nm. The line joining $A_1P$ is perpendicular to $A_1A_2$ as shown in the figure below. If the first minimum is detected at $P$, the value of slits separation 'a' will be:




The distance of screen from slits is $D = 5$ cm

(1) 0.4 mm
(2) 0.5 mm
(3) 0.2 mm
(4) 0.1 mm

**29.** The ratio of intensities at two points $P$ and $Q$ on the screen in a Young's double slit experiment where phase difference between two wave of same amplitude are $\pi/3$ and $\pi/2$, respectively are

(1) 1:3
(2) 3:1
(3) 3:2
(4) 2:3

**30.** In Young's double slit experiment, the fringe width is 12 mm. If the entire arrangement is placed in water of refractive index 4/3, then the fringe width becomes (in mm):

(1) 16
(2) 9
(3) 48
(4) 12

**31.** Two polaroids $A$ and $B$ are placed in such a way that the pass-axis of polaroids are perpendicular to each other. Now, another polaroid $C$ is placed between $A$ and $B$ bisecting the angle between them. If intensity of unpolarised light is $I_0$ then intensity of transmitted light after passing through polaroid $B$ will be:

(1) $\frac{I_0}{4}$ (2) $\frac{I_0}{2}$

(3) $\frac{I_0}{8}$ (4) Zero

**32.** A beam of plane polarised light of large cross-sectional area and uniform intensity of 3.3 $Wm^{-2}$ falls normally on a polariser (cross sectional area $3 \times 10^{-4}$ $m^2$) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to

(1) $1.0 \times 10^{-5}$ J (2) $1.0 \times 10^{-4}$ J

(3) $5.0 \times 10^{-4}$ J (4) $1.5 \times 10^{-4}$ J

**33.** Unpolarized light of intensity $I$ is incident on a system of two polarizers, A followed by B. The intensity of emergent light is $I/2$. If a third polarizer C is placed between A and B, the intensity of emergent light is reduced to $I/3$. The angle between the polarizers A and C is θ. Then:

(1) $\cos\theta = \left(\frac{2}{3}\right)^{1/2}$ (2) $\cos\theta = \left(\frac{2}{3}\right)^{1/4}$

(3) $\cos\theta = \left(\frac{1}{3}\right)^{1/2}$ (4) $\cos\theta = \left(\frac{1}{3}\right)^{1/4}$

**34.** In the Young's double slit experiment, the distance between the slits varies in time as $d(t) = d_0 + a_0 \sin \omega t$; where $d_0$, ω and $a_0$ are constants. If the distance from the slits and screen is denoted as Δ, then the difference between the largest fringe width and the smallest fringe width obtained over time is given as:

(1) $\frac{\lambda\Delta}{d_0 + a_0}$ (2) $\frac{\lambda\Delta}{d_0^2} a_0$

(3) $\frac{2\lambda\Delta a_0}{(d_0^2 - a_0^2)}$ (4) $\frac{2\lambda\Delta(d_0)}{(d_0^2 - a_0^2)}$

**35.** Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter 0.1mm. If the diameter of the pinhole is slightly increased, it will affect the diffraction pattern such that:

(1) Its size increases, but intensity decreases
(2) Its size increases, and intensity increases
(3) Its size decreases, but intensity increases
(4) Its size decreases, and intensity decreases

**36.** A polarizer analyser set is adjusted such that the intensity of light coming out of the analyser is just 10% of the original intensity. Assuming that the polarizer – analyser set does not absorb any light, the angle by which the analyser need to be rotated further to reduce the output intensity to be zero is

(1) 45° (2) 90°

(3) 71.6° (4) 18.4°

**37.** Two light beams of intensities in the ratio of 9 : 4 are allowed to interfere. The ratio of the intensities of maxima and minima will be:

(1) 2:3 (2) 16:81

(3) 25:9 (4) 25:1

**38.** Interference fringes are observed on a screen by illuminating two thin slits 1mm apart with a light source (λ = 632.8 nm). The distance between the screen and the slits is 100 cm. If a bright fringe is observed on a screen at a distance of 1.27 mm from the central bright fringe, then the path difference between the waves, which are reaching this point from the slits is close is

(1) 1.27 μm
(2) 2.05 μm
(3) 2.87 μm
(4) 2 μm

**39.** In a Young's double slit experiment two slits are separated by 2 mm and the screen is placed one meter away. When a light of wavelength 500nm is used, the fringe width will be:
(1) 1 mm (2) 0.75 mm
(3) 0.25 mm (4) 0.50 mm

**40.** In a Young's double slit experiment, 16 fringes are observed in a certain segment of the screen when light of a wavelength 700 nm is used. If the wavelength of light is changed to 400 nm, the number of fringes observed in the same segment of the screen would be
(1) 28 (2) 24
(3) 30 (4) 18

**41.** A system of three polarizers $P_1$, $P_2$, $P_3$, is set up such that the pass axis of $P_3$ is crossed with respect to that of $P_1$. The pass axis of $P_2$ is inclined at 60° to the pass axis of $P_3$. When a beam of unpolarized light of intensity $I_0$ is incident on $P_1$, the intensity of light transmitted by the three polarizers is $I$. The ratio $(I_0/I)$ equals (nearly)
(1) 16.00 (2) 1.80
(3) 5.33 (4) 10.67

**42.** In a Young's double slit experiment, light of 500 nm is used to produce an interference pattern. When the distance between the slits is 0.05 mm, the angular width (in degree) of the fringes formed on the distance screen is close to:
(1) 0.17° (2) 1.7°
(3) 0.57° (4) 0.07°

**43.** Given below are two statements:
**Statement-I:** If the Brewster's angle for the light propagating from air to glass is $\theta_B$, then the angle for the light propagating from glass to air is $\frac{\pi}{2}-\theta_B$.
**Statement-II:** The Brewster's angle for the light propagating from glass to air is $\tan^{-1}(\mu_g)$ where $\mu_g$ is the refractive index of glass.
In the light of the above statements, choose the correct answer from the options given below:
(1) Both Statements-I and Statement-II are true.
(2) Statement-I is true but Statement-II is false.
(3) Both Statement-I and Statement-II are false
(4) Statement-I is false but Statement-II is true.

**44.** In a double-slit experiment, at a certain point on the screen the path difference between the two interfering waves is 1/8 of the wavelength. The ratio of the intensity of light at that point to that at the centre of a bright fringe is:
(1) 0.672 (2) 0.568
(3) 0.760 (4) 0.853

**45.** In Young's double slits experiment, the position of 5th bright fringe from the central maximum is 5 cm. The distance between slits and the screen is 1m and wavelength of monochromatic light used is 600nm. The separation between the slits is:
(1) 60 μm (2) 48 μm
(3) 12 μm (4) 36 μm

**46.** '$n$' polarizing sheets are arranged such that each makes an angle 45° with the preceding sheet. An unpolarized light of intensity $I$ is incident into this arrangement. The output intensity is found to be $\frac{I}{64}$. The value of $n$ will be:
(1) 3 (2) 6
(3) 5 (4) 4

**47.** If the source of light used in a Young's double slit experiment is changed from red to violet:
(1) The fringes will become brighter.
(2) Consecutive fringe lines will come closer
(3) The central bright fringe will become a dark fringe
(4) The intensity of minima will increase

**48.** Visible light of wavelength $6000 \times 10^{-8}$ cm falls normally on single slit and produces a diffraction pattern. It is found that the second diffraction minimum is at 60° from the central maximum. If the first minimum is produced at $\theta_1$ then $\theta_1$ is close to

(1) 25° (2) 30°
(3) 20° (4) 45°

**49.** In Young's double slit experiment, if the source of light changes from orange to blue then:

(1) The distance between consecutive fringes will decrease.
(2) The distance between consecutive fringes will increase.
(3) The central bright fringe will become a dark fringe.
(4) The intensity of the minima will increase.

**50.** A single slit of width $b$ is illuminated by a coherent monochromatic light of wavelength $\lambda$. If the second and fourth minima in the diffraction pattern at a distance 1 m from the slit are at 3 cm and 6 cm respectively from the central maximum, the width of the central maximum is

(1) 1.5 cm (2) 3.0 cm
(3) 4.5 cm (4) 6.0 cm

**51.** An unpolarised light beam of intensity $2I_0$ is passed through a polaroid $P$ and then through another polaroid $Q$ which is oriented in such a way that its passing axis makes an angle of 30° relative to that of $P$. The intensity of the emergent light is

(1) $\frac{I_0}{4}$ (2) $\frac{I_0}{2}$
(3) $\frac{3I_0}{4}$ (4) $\frac{3I_0}{2}$

**52.** In a Young's double slits experiment, the ratio of amplitude of light coming from slits is 2 : 1. The ratio of the maximum to minimum intensity in the interference pattern is :

(1) 9 : 4 (2) 9 : 1
(3) 2:1 (4) 25:9

**53.** In a Young double slit experiment, the separation between the slits is 0.15 mm. In the experiment, a source of light of wavelength 589 nm is used and the interference pattern is observed on screen kept 1.5 m away. The separation between the successive bright fringes on the screen is

(1) 4.9 mm (2) 3.9 mm
(3) 5.9 mm (4) 6.9 mm

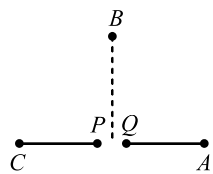
**54.** Using Young's double slit experiment, a monochromatic light of wavelength 5000 Å produces fringes of fringe width 0.5 mm. If another monochromatic light of wavelength 6000 Å is used and the separation between the slits is doubled, then the new fringe width will be

(1) 0.5 mm (2) 1.0 mm
(3) 0.6 mm (4) 0.3 mm

**55.** In a double - slit experiment, green light (5303 Å) falls on a double slit having a separation of 19.44 μm and a width of 4.05 μm. The number of bright fringes between the first and the second diffraction minima is

(1) 10 (2) 5
(3) 4 (4) 9

**56.** In the figure below, $P$ and $Q$ are two equally intense coherent sources emitting radiation of wavelength 20 m. The separation between $P$ and $Q$ is 5 m and the phase of $P$ is ahead of that of $Q$ by 90°. $A$, $B$ and $C$ are three distinct points of observation, each equidistant from the midpoint of $PQ$. The intensities of radiation at $A$, $B$, $C$ will be in the ratio



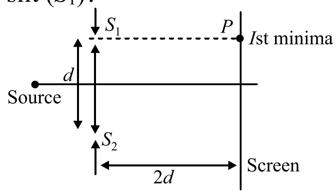

(1) 0 : 1 : 2
(2) 4: 1 : 0
(3) 2 : 1 : 0
(4) 0 : 1 : 4

**57.** The speed of electrons in a scanning electron microscope is $1 \times 10^7$ ms$^{-1}$. If the protons having the same speed are used instead of electrons, then the resolving power of scanning proton microscope will be changed by a factor of

(1) 1837 (2) $\sqrt{1837}$

(3) $\frac{1}{\sqrt{1837}}$ (4) $\frac{1}{1837}$

**58.** Consider a Young's double slit experiment as shown in figure. What should be the slit separation $d$ in terms of wavelength $\lambda$ such that the first minima occurs directly in front of the slit ($S_1$)?




(1) $\frac{\lambda}{2(\sqrt{5}-2)}$ (2) $\frac{\lambda}{(\sqrt{5}-2)}$

(3) $\frac{\lambda}{2(5-\sqrt{2})}$ (4) $\frac{\lambda}{(5-\sqrt{2})}$

**59.** In Young's double slit arrangement, slits are separated by a gap of 0.5 mm and the screen is placed at a distance of 0.5 m from them. The distance between the first and the third bright fringe formed when the slits are illuminated by a monochromatic light of 5890 Å is

(1) $1178 \times 10^{-9}$ m (2) $1178 \times 10^{-6}$ m

(3) $1178 \times 10^{-12}$ m (4) $5890 \times 10^{-7}$ m

**60.** The width of fringe is 2 mm on the screen in a double slits experiment for the light of wavelength of 400 nm. The width of the fringe for the light of wavelength 600 nm will be:

(1) 4 mm (2) 1.33 mm

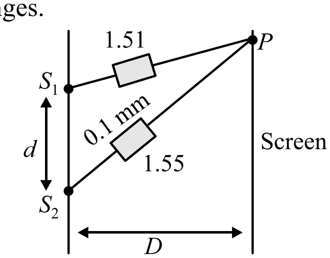
(3) 3 mm (4) 2 mm

### *Integer Type Questions (61 to 75)*

**61.** Two light waves of wavelengths 800 nm and 600 nm are used in Young's double slit experiment to obtain interference fringes on a screen placed 7 m away from plane of slits. If the two slits are separated by 0.35 mm, then shortest distance from the central bright maximum to the point where the bright fringes of the two wavelength coincide will be_________mm.

**62.** A fringe width of 6 mm was produced for two slits separated by 1 mm apart. The screen is placed 10 m away. The wavelength of light used is '$x$' nm. The value of '$x$' to the nearest integer is____.

**63.** In Young's double slit experiment, two slits $S_1$ and $S_2$ are '$d$' distance apart and the separation from slits to screen is $D$ (as shown in figure). Now if two transparent slabs of equal thickness 0.1 mm but refractive index 1.51 and 1.55 are introduced in the path of light beam ($\lambda$ = 4000Å) from $S_1$ and $S_2$ respectively. The central bright fringe spot will shift by_____ number of fringes.




**64.** In a double slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance from the plane of slits. If the screen is moved by $5 \times 10^{-2}$ m towards the slits, the change in fringe width is $3 \times 10^{-3}$ cm. If the distance between the slits is 1 mm, then the wavelength of the light will be __________nm.

**65.** A Young's double-slit experiment is performed using monochromatic light of wavelength $\lambda$. The intensity of light at a point on the screen, where the path difference is $\lambda$, is $K$ units. The intensity of light at a point where the path difference is $\frac{\lambda}{6}$ is given by $\frac{nK}{12}$, where $n$ is an integer. The value of n is:

**66.** A beam of light consisting of two wavelengths 7000Å and 5500Å is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the plane of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is $n \times 10^{-5}$. The value of $n$ is ____.

**67.** An unpolarised light is incident on the boundary between two dielectric media, whose dielectric constants are 2.8 (medium 1) and 6.8 (medium 2), respectively. To satisfy the condition, so that the reflected and refracted rays are perpendicular to each other, the angle of incidence should be $\tan^{-1}\left(1+\frac{10}{\theta}\right)^{1/2}$ the value of θ is _____.

**68.** The width of one of the two slits in a Young's double slit experiment is three times the other slit. If the amplitude of light coming from a slit is proportional to the slit width, the ratio of minimum to maximum intensity in the interference pattern is $x : 4$ where $x$ is___.

**69.** In a Young's double's slit experiment 15 fringes are observed on a small portion of the screen when light of wavelength 500 nm is used. Ten fringes are observed on the same section of the screen when another light source of wavelength λ is used. Then the value of λ is (in nm) __________.

**70.** A source of light is placed in front of a screen. Intensity of light on the screen is $I$. Two Polaroids $P_1$ and $P_2$ are so placed in between the source of light and screen that the intensity of light on screen is $\frac{I}{2}$. $P_2$ should be rotated by an angle of _______ (degrees) so that the intensity of light on the screen becomes $\frac{3I}{8}$.

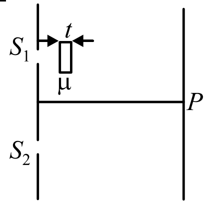
**71.** In young's double slit experiment performed using a monochromatic light of wavelength λ, when a glass plate (μ = 1.5) of thickness $x\lambda$ is introduced in the path of the one of the interfering beams, the intensity at the position where the central maximum occurred previously remains unchanged. The value of $x$ will be:

**72.** White light is passed through a double slit and interference is observed on a screen 1.5 m away. The separation between the slits is 0.3 mm. The first violet and red fringes are formed 2.0 mm and 3.5 mm away from the central white fringes. The difference in wavelengths of red and voilet light is__________nm.

**73.** In a Young's double slit experiment, the intensities at two points, for the path difference $\frac{\lambda}{4}$ and $\frac{\lambda}{3}$ (λ being the wavelength of light used) are $I_1$ and $I_2$ respectively. If $I_0$ denotes the intensity produced by each one of the individual slits, then $\frac{I_1+I_2}{I_0} =$ ______.

**74.** An unpolarized light beam is incident on the polarizer of a polarization experiment and the intensity of light beam emerging from the analyzer is measured as 100 Lumens. Now, if the analyzer is rotated around the horizontal axis (direction of light) by 30° in clockwise direction, the intensity of emerging light will be _______ Lumens.

**75.** As shown in the figure, in Young's double slit experiment, a thin plate of thickness $t = 10$ mm and refractive index μ = 1.2 is inserted in front of slit $S_1$. The experiment is conducted in air (μ = 1) and uses a monochromatic light of wavelength $l = 500$ nm. Due to the insertion of the plate, central maxima is shifted by a distance of $x\beta_0$. $\beta_0$ is the fringe-width before the insertion of the plate. The value of the $\frac{x}{1000}$ is_______.



CHAPTER

23

# DUAL NATURE OF MATTER AND RADIATION

### Single Option Correct Type Questions (01 to 54)

1. If a source of electromagnetic radiation having power 15 $kW$ produces $10^{16}$ photons per second, the radiation that belongs to a part of spectrum is.
(Take Planck constant $h = 6 \times 10^{-34}$ $Js$)
(1) Micro waves (2) Ultraviolet rays
(3) Gamma rays (4) Radio waves

2. Given below are two statements:
**Statements I**: Two photons having equal linear momenta have equal wavelengths
**Statements II**: If the wavelength of photon is decreased, then the momentum and energy of a photon will also decrease.
In the light of the above statements, choose the correct answer from the options given below
(1) Both Statement-I and Statement-II are false
(2) Statement-I is false but Statement-II is true
(3) Both statement-I and Statement-II are true
(4) Statement-I is true but statement-II is false.

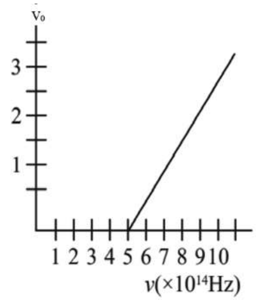
3. *A* 2 $mW$ laser operates at a wavelength of 500 $nm$. The number of photons that will be emitted per second is
[Given Planck's constant $h = 6.6 \times 10^{-34}$ $Js$]
(1) $2 \times 10^{16}$ (2) $1.5 \times 10^{16}$
(3) $5 \times 10^{15}$ (4) $1 \times 10^{16}$

4. If the two metals $A$ and $B$ are exposed to radiation of wavelength 350 $nm$. The work functions of metals $A$ and $B$ are 4.8 $eV$ and 2.2 $eV$. Then choose the correct option
(1) Metal $B$ will not emit photo-electrons
(2) Both metals $A$ and $B$ will emit photo-electrons
(3) Both metals $A$ and $B$ will not emit photoelectrons
(4) Metal $A$ will not emit photo-electrons

5. A metallic surface is illuminated with radiation of wavelength $\lambda$, the stopping potential is $V_0$. If the same surface is illuminated with radiation of wavelength $2\lambda$, the stopping potential becomes $\frac{V_0}{4}$. The threshold wavelength for this metallic surface will be
(1) $\frac{\lambda}{4}$ (2) $4\lambda$
(3) $\frac{3}{2}\lambda$ (4) $3\lambda$

6. In photo electric effect
A. The photocurrent is proportional to the intensity of the incident radiation.
B. Maximum Kinetic energy with which photoelectrons are emitted depends on the intensity of incident light.
C. Max. K.E with which photoelectrons are emitted depends on the frequency of incident light.
D. The emission of photoelectrons require a minimum threshold intensity of incident radiation.
E. Max. K.E of the photoelectrons is independent of the frequency of the incident light.
Choose the correct answer from the options given below:
(1) A and C only (2) A and E only
(3) B and C only (4) A and B only

7. The variation of stopping potential ($V_0$) as a function of the frequency ($v$) of the incident light for a metal is shown in figure. The work function of the surface is




(1) 18.6 $eV$ (2) 2.98 $eV$
(3) 2.07 $eV$ (4) 1.36 $eV$

8. Given below are two statements:
**Statement-I:** Out of microwaves, infrared rays and ultraviolet rays, ultraviolet rays are the most effective for the emission of electrons from a metallic surface.
**Statement-II:** Above the threshold frequency, the maximum kinetic energy of photoelectrons is inversely proportional to the frequency of the incident light.
In the light of above statements, choose the correct answer from the options given below
(1) Statement-I is true but Statement-II is false
(2) Both Statement-I and Statement-II are true
(3) Statement-I is false but Statement-II is true
(4) Both Statement-I and Statement-II are false

9. The threshold wavelength for photoelectric emission from a material is 5500 Å. Photoelectrons will be emitted, when this material is illuminated with monochromatic radiation from a
(A) 75 $W$ infra-red lamp
(B) 10 $W$ infra-red lamp
(C) 75 $W$ ultra-violet lamp
(D) 10 $W$ ultra-violet lamp
Choose the correct answer from the options given below:
(1) B and C only (2) A and D only
(3) C only (4) C and D only

10. The kinetic energy of emitted electron is $E$ when the light incident on the metal has wavelength $\lambda$. To double the kinetic energy, the incident light must have wavelength:
(1) $\frac{hc}{E\lambda - hc}$ (2) $\frac{hc\lambda}{E\lambda + hc}$
(3) $\frac{h\lambda}{E\lambda + hc}$ (4) $\frac{hc\lambda}{E\lambda - hc}$

11. Let $K_1$ and $K_2$ be the maximum kinetic energies of photoelectrons emitted when two monochromatic beams of wavelength $\lambda_1$ and $\lambda_2$, respectively are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then:
(1) $K_1 > \frac{K_2}{3}$ (2) $K_1 < \frac{K_2}{3}$
(3) $K_1 = \frac{K_2}{3}$ (4) $K_2 = \frac{K_1}{3}$

12. Given below are two statements: one is labelled as Assertion (A) and other is labelled as Reason (R).
**Assertion (A):** The photoelectric effect does not takes place, if the energy of the incident radiation is less than the work function of a metal.
**Reason (R):** Kinetic energy of the photoelectrons is zero, if the energy of the incident radiation is equal to the work function of a metal.
In the light of the above statements, choose the most appropriate answer from the options given below.
(1) Both A and R are correct and R is the correct explanation of A
(2) Both A and R are correct but R is not the correct explanation of A
(3) A is correct but R is not correct
(4) A is not correct but R is correct

**13.** A metal exposed to light of wavelength 800 *nm* and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500 *nm* is used. The work function of the metal is: (Take $hc$ = 1230 *eV -nm*).

(1) 1.537 *eV* (2) 2.46 *eV*
(3) 0.615 *eV* (4) 1.23 *eV*

**14.** Two streams of photons, possessing energies equal to five and ten times the work function of metal are incident on the metal surface successively. The ratio of maximum velocities of the photoelectron emitted, in the two cases respectively, will be

(1) 1:2 (2) 1:3
(3) 2:3 (4) 3:2

**15.** The light of two different frequencies whose photons have energies 3.8 *eV* and 1.4 *eV* respectively, illuminate a metallic surface, whose work function is 0.6 *eV*, successively. The ratio of maximum speed of emitted electrons for the two frequencies respectively will be:

(1) 1:1
(2) 2:1
(3) 4:1
(4) 1:4

**16.** Two identical photocathodes receive the light of frequencies $f_1$ and $f_2$ respectively. If the velocities of the photo-electrons coming out are $v_1$ and $v_2$ respectively, then

(1) $v_1^2 - v_2^2 = \frac{2h}{m}[f_1 - f_2]$

(2) $v_1^2 + v_2^2 = \frac{2h}{m}[f_1 + f_2]$

(3) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{\frac{1}{2}}$

(4) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{\frac{1}{2}}$

**17.** The radiation corresponding to $3 \rightarrow 2$ transition of a hydrogen atom falls on a gold surface to generate photoelectrons. These electrons are passed through a magnetic field of $5 \times 10^{-4}$ *T*. Assume that the radius of the largest circular path followed by these electrons is 7 *mm*, the work function of the metal is:
(Mass of electron = $9.1 \times 10^{-31}$ *kg*)

(1) 0.82 *eV* (2) 1.88 *eV*
(3) 1.36 *eV* (4) 0.16 *eV*

**18.** When light of a given wavelength is incident on a metallic surface, the minimum potential needed to stop the emitted photoelectrons is 6.0 *V*. This potential drops to 0.6 *V* if another source with wavelength four times that of the first one and intensity half of the first one is used. What are the wavelength of the first source and the work function of the metal, respectively? [Take $\frac{hc}{e} = 1.24 \times 10^{-6}\ J\,mC^{-1}$]

(1) $1.72 \times 10^{-7}$ *m*, 1.20 *eV*
(2) $1.72 \times 10^{-7}$ *m*, 5.60 *eV*
(3) $3.78 \times 10^{-7}$ *m*, 5.20 *eV*
(4) $3.78 \times 10^{-7}$ *m*, 1.20 *eV*

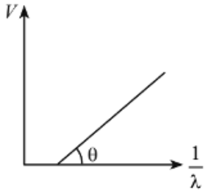
**19.** An electron and proton are separated by a large distance. The electron starts approaching the proton with energy 3 *eV*. The proton captures the electron and forms a hydrogen atom in second excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4000Å. What is the maximum kinetic energy of the emitted photoelectron ?

(1) 1.41 *eV* (2) 7.61 *eV*
(3) 3.3 *eV* (4) None of these

**20.** In a photoelectric experiment ultraviolet light of wavelength 280 *nm* is used with lithium cathode having work function $\phi = 2.5$ *eV*. If the wavelength of incident light is switched to 400 *nm*, find out the change in the stopping potential. ($h = 6.63 \times 10^{-34}$ *Js*, $c = 3\times10^8\ ms^{-1}$)

(1) 1.3 *V* (2) 1.1 *V*
(3) 0.6 *V* (4) 1.9 *V*

**21.** In photoelectric effect experiment, the graph of stopping potential $V$ versus reciprocal of wavelength obtained is shown in the figure. As the intensity of incident radiation is increased:




(1) Slope of the straight line get more steep
(2) Straight line shifts to left
(3) Straight line shifts to right
(4) Graph does not change

**22.** Radiation, with wavelength 6561 Å falls on a metal surface to produce photoelectrons. The electrons are made to enter a uniform magnetic field of $3 \times 10^{-4}$ $T$. If the radius of the largest circular path followed by the electrons is 10 $mm$, the work function of the metal is close to
(1) 1.8 $eV$ (2) 0.8 $eV$
(3) 1.6 $eV$ (4) 1.1 $eV$

**23.** A metal plate of area $1 \times 10^{-4}$ $m^2$ is illuminated by a radiation of intensity 16 $mW/m^2$. The work function of the metal is 5 $eV$. The energy of the incident photons is 10 $eV$ and only 10% of it produces photo electrons. The number of emitted photo electrons per second and their maximum energy, respectively, will be:
[$1\ eV = 1.6 \times 10^{-19}\ J$]
(1) $10^{14}$ and 10 $eV$ (2) $10^{12}$ and 5 $eV$
(3) $10^{11}$ and 5 $eV$ (4) $10^{10}$ and 5 $eV$

**24.** When a certain photosensitive surface is illuminated with monochromatic light of frequency $v$, the stopping potential for the photo current is $-V_0/2$. When the surface is illuminated by monochromatic light of frequency $v/2$, the stopping potential is $-V_0$. The threshold frequency for photoelectric emission is:
(1) $\frac{5v}{3}$ (2) $\frac{4}{3}v$
(3) $2\ v$ (4) $\frac{3v}{2}$

**25.** The magnetic field associated with a light wave is given, at the origin, by $B = B_0$ [sin($3.14 \times 10^7$) $ct$ + sin($6.28 \times 10^7$)$ct$]
If this light falls on a silver plate having a work function of 4.7 $eV$, what will be the maximum kinetic energy of the photo electrons? [given, Planck's constant $h = 6.6 \times 10^{-34}$ Js]
(1) 6.82 $eV$ (2) 12.5 $eV$
(3) 8.52 $eV$ (4) 7.67 $eV$

**26.** In a photoelectric effect experiment the threshold wavelength of light is 380 $nm$. If the wavelength of incident light is 260 $nm$, the maximum kinetic energy of emitted electrons will be [Take $hc$ = 1237 $eV$ –$nm$]
(1) 1.5 $eV$ (2) 4.5 $eV$
(3) 15.1 $eV$ (4) 3.0 $eV$

**27.** In a photoelectric experiment, the wavelength of the light incident on a metal is changed from 300 nm to 400 nm. The decrease in the stopping potential is close to $\left(\frac{hc}{e} = 1240\ nm - V\right)$
(1) 0.5 $V$ (2) 1.5 $V$
(3) 1.0 $V$ (4) 2.0 $V$

**28.** A proton moving with one tenth of velocity of light has a certain de Broglie wavelength of λ. An alpha particle having certain kinetic energy has the same de-Broglie wavelength λ. The ratio of kinetic energy of proton and that of alpha particle is:
(1) 2:1 (2) 4:1
(3) 1:2 (4) 1:4

**29.** Electron beam used in an electron microscope, accelerated by a voltage of 20 $kV$ has a de-Broglie wavelength of
$\lambda_0$. If the voltage is increased to 40 $kV$ then the de-Broglie wavelength associated with the electron beam would be:
(1) $3\lambda_0$ (2) $9\lambda_0$
(3) $\frac{\lambda_0}{2}$ (4) $\frac{\lambda_0}{\sqrt{2}}$

**30.** An $\alpha$-particle, a proton and an electron have the same kinetic energy. Which one of the following is correct in case of their De-Broglie wavelength:

(1) $\lambda_\alpha > \lambda_p > \lambda_e$ (2) $\lambda_\alpha < \lambda_p < \lambda_e$
(3) $\lambda_\alpha = \lambda_p = \lambda_e$ (4) $\lambda_\alpha > \lambda_p < \lambda_e$?

**31.** If the ratio of de-Broglie wavelength of an $\alpha$-particle and a proton, accelerated from rest by the same potential is $\frac{1}{\sqrt{m}}$, then the value of $m$ is

(1) 4 (2) 16
(3) 8 (4) 2

**32.** The ratio of the de-Broglie wavelengths of proton and electron having same kinetic energy is:
(Assume $m_p = m_e \times 1849$)

(1) 1:43 (2) 1:30
(3) 1:63 (4) 2:43

**33.** An electron accelerated through a potential difference $V_1$ has a de-Broglie wavelength of $\lambda$. When the potential is changed to $V_2$, its de-Broglie wavelength increases by 50%. The value of $\left(\frac{V_1}{V_2}\right)$ is equal to:

(1) 3 (2) $\frac{9}{4}$
(3) $\frac{3}{2}$ (4) 4

**34.** A proton and an $\alpha$-particle are accelerated from rest by $2V$ and $4V$ potentials, respectively. The ratio of their de-Broglie wavelength is:

(1) 4:1 (2) 2:1
(3) 8:1 (4) 16:1

**35.** The kinetic energy of an electron, $\alpha$-particle and a proton are given as $4K$, $2K$ and $K$ respectively. The de-Broglie wavelength associated with electron ($\lambda_e$), $\alpha$-particle ($\lambda_\alpha$) and the proton ($\lambda_p$) are as follows:

(1) $\lambda_\alpha = \lambda_p < \lambda_e$ (2) $\lambda_\alpha > \lambda_p < \lambda_e$
(3) $\lambda_\alpha < \lambda_p < \lambda_e$ (4) $\lambda_\alpha = \lambda_p > \lambda_e$

**36.** A proton, a neutron, an electron and a $\alpha$-particle have same energy. If $\lambda_p$ , $\lambda_n$ , $\lambda_e$ and $\lambda_\alpha$ are the de-Broglie's wavelengths of proton, neutron, electron and an $\alpha$-particle respectively, then choose the correct relation from the following

(1) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ (2) $\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$
(3) $\lambda_e < \lambda_n = \lambda_p > \lambda_\alpha$ (4) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

**37.** A nucleus of mass M at rest splits into two parts having masses $\frac{M'}{3}$ and $\frac{2M'}{3}$ $(M' < M)$, The ratio of de Broglie wavelength of two parts will be:

(1) 1:2 (2) 2:1
(3) 1:1 (4) 2:3

**38.** An electron (mass m) with an initial velocity $\vec{v} = v_0\hat{i}(v_0 > 0)$ is moving in an electric field $\vec{E} = -E_0\hat{i}(E_0 > 0)$ where $E_0$ is constant. If at $t = 0$ de Broglie wavelength is $\lambda_0 = \frac{h}{mv_0}$, then its de Broglie wavelength after time $t$ is given by:

(1) $\lambda_0$ (2) $\lambda_0\left(1+\frac{eE_0t}{mv_0}\right)$
(3) $\lambda_0 t$ (4) $\frac{\lambda_0}{\left(1+\frac{eE_0t}{mv_0}\right)}$

**39.** The equation $\lambda = \frac{1.227}{x}$ $nm$ can be used to find the de-Brogli wavelength of an electron. In this equation $x$ stands for:
Where $m$ = mass of electron
$P$ = momentum of electron
$K$ = kinetic energy of electron
$V$ = Accelerating potential in volts for electron

(1) $\sqrt{mK}$ (2) $\sqrt{K}$
(3) $\sqrt{P}$ (4) $\sqrt{V}$

**40.** An electron of mass $m_e$ and a proton of mass $m_p$ are accelerated through the same potential difference. The ratio of the de-Broglie wavelength associated with the electron to that with the proton is:

(1) $\frac{m_p}{m_e}$ (2) 1

(3) $\frac{m_e}{m_p}$ (4) $\sqrt{\frac{m_p}{m_e}}$

**41.** The de-Broglie wavelength of a particle having kinetic energy $E$ is λ. How much extra energy must be given to this particle so that the de-Broglie wavelength reduces to 75% of the initial value?

(1) $\frac{1}{9}E$ (2) $E$

(3) $\frac{16}{9}E$ (4) $\frac{7}{9}E$

**42.** Consider two separate ideal gases of electrons and protons having same number of particles. The temperature of both the gases are same. The ratio of the uncertainty in determining the position of an electron to that of a proton is proportional to:

(1) $\sqrt{\frac{m_e}{m_p}}$ (2) $\sqrt{\frac{m_p}{m_e}}$

(3) $\frac{m_p}{m_e}$ (4) $\left(\frac{m_p}{m_e}\right)^{\frac{3}{2}}$

**43.** The temperature of an ideal gas in 3-dimensions is 300 $K$. The corresponding de-Broglie wavelength of the electron approximately at 300 $K$, is:
[$m_e$ = mass of electron = $9 \times 10^{-31}$ $kg$
$h$ = Planck constant = $6.6 \times 10^{-34}$ $Js$
$k_B$ = Boltzmann constant = $1.38 \times 10^{-23}$ $JK^{-1}$]

(1) 3.25 $nm$ (2) 6.26 $nm$

(3) 2.26 $nm$ (4) 8.46 $nm$

**44.** A moving proton and electron have the same de-Broglie wavelength. If $K$ and $P$ denote the $K.E.$ and momentum respectively. Then choose the correct option:

(1) $K_p = K_e$ and $P_p = P_e$
(2) $K_p < K_e$ and $P_p < P_e$
(3) $K_p < K_e$ and $P_p = P_e$
(4) $K_p > K_e$ and $P_p = P_e$

**45.** The de-Broglie wavelength associated with an electron and a proton were calculated by accelerating them through same potential of 100 $V$. What should nearly be the ratio of their wavelengths? ($m_p = 1.00727$ $u$, $m_e = 0.00055$ $u$)

(1) 1860 : 1
(2) $(1860)^2$ : 1
(3) 41.4 : 1
(4) 43 : 1

**46.** The de Broglie wavelength of a proton and α-particle are equal. The ratio of their velocities is:

(1) 4:2
(2) 4:3
(3) 4:1
(4) 1:4

**47.** A particle moving with kinetic energy $E$ has de-Broglie wavelength λ. If energy $\Delta E$ is added to its energy, the wavelength become λ/2. Value of $\Delta E$, is

(1) 4 $E$
(2) 3 $E$
(3) 2 $E$
(4) $E$

**48.** In a Frank-hertz experiment, an electron of energy 5.6 $eV$ passes through mercury vapour and emerges with an energy 0.7 $eV$. The minimum wavelength of photons emitted by mercury atoms is close to

(1) 1700 $nm$
(2) 2020 $nm$
(3) 220 $nm$
(4) 250 $nm$

**49.** An electron (mass $m$) with initial velocity $\vec{v} = v_0\hat{i} + v_0\hat{j}$ is in an electric field $\vec{E} = -E_0\hat{k}$. If $\lambda_0$ is initial de-Broglie wavelength of electron, its de-Broglie wavelength at time t is given by

(1) $\dfrac{\lambda_0}{\sqrt{1+\dfrac{e^2E_0^2t^2}{2m^2v_0^2}}}$ (2) $\dfrac{\lambda_0}{\sqrt{2+\dfrac{e^2E_0t^2}{m^2v_0^2}}}$

(3) $\dfrac{\lambda_0\sqrt{2}}{\sqrt{1+\dfrac{e^2E_0t^2}{m^2v_0^2}}}$ (4) $\dfrac{\lambda_0}{\sqrt{1+\dfrac{e^2E_0t^2}{m^2v_0^2}}}$

**50.** A nucleus $A$, with a finite de-broglie wavelength $\lambda_A$, undergoes spontaneous fission into two nuclei $B$ and $C$ of equal mass. $B$ flies in the same direction as that of $A$, while $C$ flies in the opposite direction with a velocity equal to half of that of $B$. The de-Broglie wavelengths $\lambda_B$ and $\lambda_C$ of $B$ and $C$ are respectively:

(1) $2\lambda_A, \lambda_A$ (2) $\lambda_A, 2\lambda_A$

(3) $\lambda_A, \dfrac{\lambda_A}{2}$ (4) $\dfrac{\lambda_A}{2}, \lambda_A$

**51.** A particle $A$ of mass '$m$' and charge '$q$' is accelerated by a potential difference of 50 $V$. Another particle $B$ of mass '4 $m$' and charge '$q$' is accelerated by a potential difference of 2500 $V$. The ratio of de-Broglie wavelength $\dfrac{\lambda_A}{\lambda_B}$ is close to

(1) 10.00 (2) 0.07

(3) 14.14 (4) 4.47

**52.** A particle '$P$' is formed due to a completely inelastic collision of particles '$x$' and '$y$' having de-Broglie wavelengths '$\lambda_x$' and '$\lambda_y$' respectively. If $x$ and $y$ were moving in opposite directions, then the de-Broglie wavelength of '$P$' is

(1) $\lambda_x + \lambda_y$ (2) $\dfrac{\lambda_x\lambda_y}{\lambda_x - \lambda_y}$

(3) $\dfrac{\lambda_x\lambda_y}{|\lambda_x - \lambda_y|}$ (4) $\lambda_x - \lambda_y$

**53.** An electron moving with speed v and a photon moving with speed c, have same D-Broglie wavelength. The ratio of kinetic energy of electron to that of photon is:

(1) $\dfrac{v}{2c}$ (2) $\dfrac{2c}{v}$

(3) $\dfrac{v}{3c}$ (4) $\dfrac{3c}{v}$

**54.** An $\alpha$ particle and a carbon 12 atom has same kinetic energy $K$. The ratio of their de-Broglie wavelengths $(\lambda_\alpha : \lambda_{C_{12}})$ is

(1) $1:\sqrt{3}$ (2) $\sqrt{3}:1$

(3) 3 : 1 (4) $2:\sqrt{3}$

## Integer Type Questions (55 to 69)

**55.** $A$ Hydrogen-like atom has atomic number $Z$. Photons emitted in the electronic transitions from level $n = 4$ to level $n = 3$ in these atoms are used to perform photoelectric effect experiment on a target metal. The maximum kinetic energy of the photoelectrons generated is 1.95 $eV$. If the photoelectric threshold wavelength for the target metal is 310 $nm$, the value of $Z$ is__________.

[Given: $hc$ = 1240 $eV$-$nm$ and $Rhc$ = 13.6 $eV$, where $R$ is the Rydberg constant, $h$ is the Planck's constant and $c$ is the speed of light in vacuum]

**56.** When light of frequency twice the threshold frequency is incident on the metal plate, the maximum velocity of emitted electron is $v_1$. When the frequency of incident radiation is increased to five times the threshold value, the maximum velocity of emitted electron becomes $v_2$. If $v_2 = xv_1$, the value of $x$ will be _______.

**57.** The stopping potential for photoelectrons emitted from a surface illuminated by light of wavelength 6630 Å is 0.42 $V$. If the threshold frequency is $x \times 10^{13}/s$, where $x$ is (nearest integer).
(Given, speed of light = $3 \times 10^8$ $m/s$, Planck's constant = $6.63 \times 10^{-34}$ $Js$)

**58.** A certain metallic surface is illuminated by monochromatic radiation of wavelength λ. The stopping potential for photoelectric current for this radiation is 3 $V_0$. If the same surface is illuminated with a radiation of wavelength 2λ, the stopping potential is $V_0$. The threshold wavelength of this surface for photoelectric effect is $x\lambda$. Find $x$.

**59.** Two stream of photons, possessing energies equal to twice and ten times the work function of metal are incident on the metal surface successively. The value of ratio of maximum velocities of the photoelectrons emitted in the two respective cases is $x : y$. The value of $x + y$ is _________.

**60.** The surface of a metal is illuminated alternately with photons of energies $E_1 = 4$ $eV$ and $E_2 = 2.5$ $eV$ respectively. The ratio of maximum speeds of the photoelectrons emitted in the two cases is 2. The work function of the metal (in $eV$) is __________.

**61.** When radiation of wavelength λ is used to illuminate a metallic surface, the stopping potential is $V$. When the same surface is illuminated with radiation of wavelength 3λ, the stopping potential is $\frac{V}{4}$. If the threshold wavelength for the metallic surface is $n\lambda$ then value of $n$ will be

**62.** A beam of electromagnetic radiation of intensity $6.4 \times 10^{-5}$ $W/cm^2$ is comprised of wavelength, λ = 310 $nm$. It falls normally on a metal (work function $\phi = 2$ $eV$) of surface area 1 $cm^2$. If one in $10^3$ photons ejects an electron, total number of electrons ejected is $10^x$. ($hc$ = 1240 $eVnm$, 1 $eV$ = $1.6 \times 10^{-19}$ $J$), then $x$ is _________.

**63.** A particle of mass $9.1 \times 10^{-31}$ $kg$ travels in a medium with a speed of $10^6$ $m/s$ and a photon of a radiation of linear momentum $10^{-27}$ $kg$ $m/s$ travels in vacuum. The wavelength of photon is ________times the wavelength of the particle.

**64.** The work functions of Aluminium and Gold are 4.1 $eV$ and 5.1 $eV$ respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is $x$ : 1. Find $x$.

**65.** The difference between threshold wavelengths for two metal surfaces $A$ and $B$ having work function $\varphi_A = 9$ $eV$ and $\varphi_B = 4.5$ $eV$ in $nm$ is (Given, $hc$ = 1242 $eV$ $nm$)

**66.** The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wavelength 491 $nm$ is 0.710 $V$. When the incident wavelength is changed to a new value, the stopping potential is 1.43 $V$. The new wavelength (in nm) to the nearest integer value is:

**67.** When radiation of wavelength λ is incident on a metallic surface, the stopping potential of ejected photoelectrons is 4.8 $V$. If the same surface is illuminated by radiation of double the previous wavelength, then the stopping potential becomes 1.6 $V$. The threshold wavelength of the metal is $x\lambda$. Find $x$.

**68.** When photon of energy 4.0 $eV$ strikes the surface of a metal $A$, the ejected photoelectrons have maximum kinetic energy $T_A$ $eV$ and de-Broglie wavelength $\lambda_A$. The maximum kinetic energy of photoelectrons liberated from another metal $B$ by photon of energy 4.50 $eV$ is $T_B = (T_A - 1.5)eV$. If the de-Broglie wavelength of these photoelectrons are related as $\lambda_B = 2\lambda_A$, the work function (in eV) of metal $B$ is ____.

**69.** The de Broglie wavelength of an electron having kinetic energy $E$ is λ. If the kinetic energy of electron becomes $\frac{E}{4}$, then its de-Broglie wavelength will be $x\lambda$. Find $x$.

# CHAPTER 24

# ATOMS

## Single Option Correct Type Questions (01 to 57)

**1.** The angular momentum for the electron in Bohr's orbit is $L$. If the electron is assumed to revolve in second orbit of hydrogen atom, then the change in angular momentum will be:

(1) $\frac{L}{2}$ (2) Zero

(3) $L$ (4) $2L$

**2.** A small particle of mass $m$ moves in such a way that its potential energy $U = \frac{1}{2}m\omega^2 r^2$ where $\omega$ is constant and $r$ is the distance of the particle from origin. Assuming Bohr's quantization of momentum and circular orbit, the radius of $n^{th}$ orbit will be proportional to.

(1) $\sqrt{n}$ (2) $n$

(3) $n^2$ (4) $\frac{1}{n}$

**3.** In Bohr's atomic model of hydrogen, let *K, P* and *E* are the kinetic energy, potential energy and total energy of the electron respectively. Choose the correct option when the electron undergoes transitions to a higher level:

(1) All *K, P* and *E* increase.

(2) *K* decreases, *P* and *E* increase.

(3) *P* decreases, *K* and *E* increase.

(4) *K* increases, *P* and *E* decrease.

**4.** If an electron is moving in the $n^{th}$ orbit of the hydrogen atom, then its velocity ($\upsilon_n$) for the $n^{th}$ orbit is given as:

(1) $\nu_n \propto \frac{1}{n}$ (2) $\nu_n \propto n^2$

(3) $\nu_n \propto n$ (4) $\nu_n \propto \frac{1}{n^2}$

**5.** A photon is emitted in transition from $n = 4$ to $n = 1$ level in hydrogen atom. The corresponding wavelength for this transition is (given, $h = 4 \times 10^{-15}$ eVs):

(1) 94.1 nm (2) 941 nm

(3) 97.4 nm (4) 99.3 nm

**6.** Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its (i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level.

(1) 3 : 4 (2) 1 : 4

(3) 4 : 3 (4) 4 : 1

**7.** Hydrogen atom from excited state comes to the ground state by emitting a photon of wavelength $\lambda$. The value of principal quantum number '$n$' of the excited state will be: ($R$: Rydberg constant)

(1) $\sqrt{\frac{\lambda}{\lambda - 1/\lambda}}$ (2) $\sqrt{\frac{\lambda R}{\lambda R - 1}}$

(3) $\sqrt{\frac{\lambda}{\lambda R - 1}}$ (4) $\sqrt{\frac{\lambda^2 R^2}{\lambda^2 R^2 - 1}}$

**8.** The ratio of the speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to

(where *e, h,* and *c* have their usual meanings in cgs system)

(1) $2\pi hc / e^2$ (2) $er^2h / 2\pi c$

(3) $e^2c / 2\pi h$ (4) $2\pi e^2 / hc$

**9.** An electron of a hydrogen like atom, having $Z = 4$, jumps from $4^{th}$ energy state to $2^{nd}$ energy state, The energy released in this process, will be:
(Given $Rch = 13.6$ eV)
Where, $R$ = Rydberg constant
$c$ = Speed of light in vacuum
$h$ = Planck's constant
(1) 13.6 eV (2) 10.5 eV
(3) 3.4 eV (4) 40.8 eV

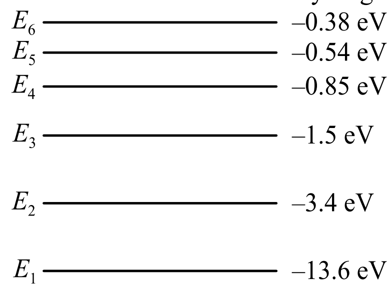
**10.** The radius of electron's second stationary orbit in Bohr's atom is $R$. The radius of $3^{rd}$ orbit will be:
(1) $R / 3$ (2) $2.25\ R$
(3) $3R$ (4) $9R$

**11.** Imagine that the electron in a hydrogen atom is replaced by a muon (μ). The mass of muon particle is 207 times that of an electron and charge is equal to the charge of an electron. The ionization potential of this hydrogen atom will be:
(1) 13.6 eV (2) 2815.2 eV
(3) 331.2 eV (4) 27.2 eV

**12.** A $He^+$ ion is in its first excited state. Its ionization energy is:
(1) 6.04 eV (2) 13.60 eV
(3) 54.40 eV (4) 48.36 eV

**13.** A particle of mass $m$ moves in a circular orbit in a central potential field $U(r) = \frac{1}{2}kr^2$. If Bohr's quantization conditions are applied, radii of possible orbits and energy levels vary with quantum number $n$ as:
(1) $r_n \propto \sqrt{n}, E_n \propto n$
(2) $r_n \propto \sqrt{n}, E_n \propto \frac{1}{n}$
(3) $r_n \propto n, E_n \propto n$
(4) $r_n \propto n^2, E_n \propto \frac{1}{n^2}$

**14.** In Figure, $E_1$ to $E_6$ represent some of the energy levels of an electron in the hydrogen atom




Which one of the following transitions produces a photon of wavelength in the ultraviolet region of the electromagnetic spectrum?
(1) $E_2 - E_1$ (2) $E_3 - E_2$
(3) $E_4 - E_3$ (4) $E_6 - E_4$

**15.** The energy of an electron in an excited hydrogen atom is −3.4 eV. Then, according to Bohr's Theory, the angular momentum of this electron, in Js, is:
(1) $2.11 \times 10^{-34}$ (2) $3 \times 10^{-34}$
(3) $1.055 \times 10^{-34}$ (4) $0.5 \times 10^{-34}$

**16.** The ratio for the speed of the electron in the $3^{rd}$ orbit of $He^+$ to the speed of the electron in the $3^{rd}$ orbit of hydrogen atom will be:
(1) 1 : 1 (2) 1 : 2
(3) 4: 1 (4) 2 : 1

**17.** The wavelength of the second line of Balmer series in the hydrogen spectrum is 4861 Å. The wavelength of the first line of Balmer series is
(1) $\frac{27}{20} \times 4861$ Å (2) $\frac{20}{27} \times 4861$ Å
(3) $20 \times 4861$ Å (4) 4861 Å

**18.** A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of electron of the hydrogen atom will increase by the value of: (Given, Planck's constant = $6.6 \times 10^{-34}$ Js).
(1) $2.10 \times 10^{-34}$ Js
(2) $1.05 \times 10^{-34}$ Js
(3) $3.15 \times 10^{-34}$ Js
(4) $4.2 \times 10^{-34}$ Js

**19**. The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, $\lambda_1/\lambda_2$, of the photons emitted in this process is:
(1) 20/7 (2) 7/5
(3) 9/7 (4) 27/5

**20**. As the electron in Bohr orbit of hydrogen atom passes from state $n = 2$ to $n = 1$, the $KE$ ($K$) and $PE$ ($U$) change as:
(1) $K$ two-fold, $U$ also two-fold
(2) $K$ four-fold, $U$ also four-fold
(3) $K$ four-fold, $U$ two-fold
(4) $K$ two-fold, $U$ four-fold

**21**. The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from $n = 2$ to $n = 1$ state is:
(1) 121.8 nm (2) 194.8 nm
(3) 490.7 nm (4) 913.3 nm

**22**. When an electron jumps from $n_1^{th}$ orbit to $n_2^{th}$ orbit, the energy radiated is given by ($E_1$ denotes the energy in $n_1^{th}$ orbit and $E_2$ denotes the energy in $n_2^{th}$ orbit):
(1) $hv = E_1 / E_2$ (2) $hv = E_2 / E_1$
(3) $hv = E_1 - E_2$ (4) $hv = E_2 - E_1$

**23**. Consider a spectral line resulting from the transition $n = 5$ to $n = 1$, in the atoms and ions given below. The shortest wavelength is produced by:
(1) Helium atom
(2) Deuterium atom
(3) Singly ionized helium
(4) Ten times ionized sodium atom

**24**. A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980 Å. The radius of the atom in the excited state, in terms of Bohr radius $a_0$, will be ($hc$ = 12500 eV – Å)
(1) 25 $a_0$ (2) 9 $a_0$
(3) 16 $a_0$ (4) 4 $a_0$

**25**. In Bohr's model of hydrogen atom, let $PE$ represent potential energy and $TE$ the total energy. In going to a higher orbit,
(1) $PE$ increases, $TE$ decreases
(2) $PE$ decreases, $TE$ increases
(3) $PE$ increases, $TE$ increases
(4) $PE$ decreases, $TE$ decreases

**26**. Taking the wavelength of first Balmer line in hydrogen spectrum ($n = 3$ to $n = 2$) as 660 nm, the wavelength of the 2nd Balmer line ($n = 4$ to $n = 2$) will be:
(1) 889.2 nm
(2) 642.7 nm
(3) 488.9 nm
(4) 388.9 nm

**27**. If potential energy between a proton and an electron is given by $|U| = ke^2/2R^3$, where $e$ is the charge of electron and $R$ is the radius of atom, then radius of Bohr's orbit is given by ($h$ = Planck's constant, $k$ = constant)
(1) $\dfrac{ke^2m}{h^2}$ (2) $\dfrac{6\pi^2}{n^2}\dfrac{ke^2m}{h^2}$
(3) $\dfrac{2\pi}{n}\dfrac{ke^2m}{h^2}$ (4) $\dfrac{4\pi^2ke^2m}{n^2h^2}$

**28**. According to Bohr atom model, in which of the following transitions will the frequency of emitted radiation be maximum?
(1) $n = 3$ to $n = 2$
(2) $n = 4$ to $n = 3$
(3) $n = 2$ to $n = 1$
(4) $n = 5$ to $n = 4$

**29**. The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region?
(1) Paschen series
(2) Balmer series
(3) Lyman series
(4) Brackett series

**30**. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is:
(1) 802 nm
(2) 823 nm
(3) 1882 nm
(4) 1648 nm

**31**. In a hydrogen atom the electron makes a transition from $(n + 1)^{th}$ level to the nth level. If $n >> 1$, the frequency of radiation emitted is proportional to:
(1) $\frac{1}{n}$ (2) $\frac{1}{n^2}$
(3) $\frac{1}{n^3}$ (4) $\frac{1}{n^4}$

**32**. The radius of the Bohr orbit in the ground state of hydrogen atom is 0.5 Å. The radius of the orbit of the electron in the third excited state of $He^+$ will be:
(1) 8 Å (2) 4 Å
(3) 0.5 Å (4) 0.25 Å

**33**. The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 Å. The wavelength of the second spectral line in the Balmer series of singly ionized helium atom is:
(1) 1215 Å (2) 1640 Å
(3) 2430 Å (4) 4687 Å

**34**. Hydrogen ion and singly ionized helium atom are accelerated, from rest, through the same potential difference. The ratio of final speeds of hydrogen and helium ions is close to:
(1) 2 : 1 (2) 1 : 2
(3) 10 : 7 (4) 5 : 7

**35**. A hydrogen-like atom emits radiations of frequency $2.7 \times 10^{15}$ Hz when it makes a transition from $n = 2$ to $n = 1$. The frequency emitted in a transition from $n = 3$ to $n = 1$ will be
(1) $1.8 \times 10^{15}$ Hz (2) $3.2 \times 10^{15}$ Hz
(3) $4.7 \times 10^{5}$ Hz (4) $6.9 \times 10^{15}$ Hz

**36**. An electron in the ground state of hydrogen has an angular momentum $L_1$ and an electron in the first excited state of lithium has an angular momentum $L_2$. Then
(1) $L_1 = L_2$ (2) $L_1 = 4L_2$
(3) $L_2 = 2L_1$ (4) $L_1 = 2L_2$

**37**. Speed of an electron in Bohr's $7^{th}$ orbit for Hydrogen atom is $3.6 \times 10^6$ m/s. The corresponding speed of the electron in $3^{rd}$ orbit, in m/s is:
(1) $1.8 \times 10^6$ (2) $7.5 \times 10^6$
(3) $3.6 \times 10^6$ (4) $8.4 \times 10^6$

**38**. The angular momentum of an electron in a hydrogen atom is proportional to:
(1) $1/\sqrt{r}$ (2) $1 / r$
(3) $\sqrt{r}$ (4) $r^2$

**39**. A particular hydrogen like ion emits radiation of frequency $2.92 \times 10^{15}$ Hz when it makes transition from $n = 3$ to $n = 1$. The frequency in Hz of radiation emitted in transition from $n = 2$ to $n = 1$ will be:
(1) $2.46 \times 10^{15}$
(2) $4.38 \times 10^{15}$
(3) $6.57 \times 10^{15}$
(4) $0.44 \times 10^{15}$

**40**. The ionization potential of $H$ atoms is 13.6 V. The energy difference between $n = 2$ and $n = 3$ level is nearest to
(1) 1.9 eV (2) 2.3 eV
(3) 3.4 eV (4) 4.5 eV

**41**. An excited $He^+$ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm, in making a transition to ground state. The quantum number $n$, corresponding to its initial excited state is:
For photon of wavelength λ, energy
$$E = \frac{1240eV}{\lambda(\text{in nm})}$$
(1) $n = 4$ (2) $n = 6$
(3) $n = 5$ (4) $n = 7$

**42.** Imagine an atom made of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength [given in terms of the Rydberg constant $R$ for the hydrogen atom] equal to

(1) $\frac{9}{5R}$ (2) $\frac{36}{5R}$

(3) $\frac{18}{5R}$ (4) $\frac{4}{R}$

**43.** The time period of revolution of electron in its ground state orbit in a hydrogen atom is $1.6 \times 10^{-16}$ s. The frequency of revolution of the electron in its first excited state (in $s^{1}$) is:

(1) $6.2 \times 10^{25}$ (2) $5.6 \times 10^{12}$

(3) $7.8 \times 10^{14}$ (4) $1.6 \times 10^{14}$

**44.** The ratio of maximum to minimum possible radiation energy in Lymen series of Bohr's hypothetical hydrogen atom is equal to

(1) 2 (2) 4

(3) 4 / 3 (4) 3 / 2

**45.** In a hydrogen like atom, when an electron jumps from the $M$-shell to the $L$-shell the wavelength of emitted radiation is $\lambda$. If an electron jumps from $N$-shell to the $L$-shell the wavelength of emitted radiation will be:

(1) $\frac{27}{20}\lambda$ (2) $\frac{16}{25}\lambda$

(3) $\frac{25}{16}\lambda$ (4) $\frac{20}{27}\lambda$

**46.** The wavelength of radiation required to excite the electron from first orbit to third orbit in a doubly ionized lithium atom will be:

(1) 134.25 Å (2) 125.5 Å

(3) 113.7 Å (4) 110 Å

**47.** If $\lambda_1$ and $\lambda_2$ are the wavelengths of the third member of Lyman and first member of the Paschen series respectively, then the value of $\lambda_1 : \lambda_2$ is:

(1) 1 : 3 (2) 7 : 108

(3) 1 : 9 (4) 7 : 135

**48.** If the series limit wavelength of the Lyman series for hydrogen atom is 912 Å, then the series limit wavelength for the Balmer series for the hydrogen atom is:

(1) 912 Å/2

(2) 912 Å

(3) $912 \times 2$ Å

(4) $912 \times 4$ Å

**49.** The energy required to ionize a hydrogen like ion in its ground state is 9 Rydbergs. What is the wavelength of the radiation emitted when the electron in this ion jumps from the second excited state to the ground state:

(1) 11.4 nm (2) 24.2 nm

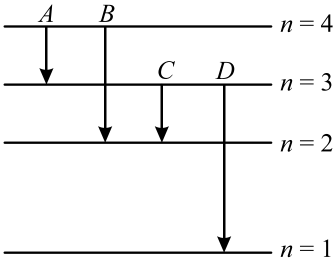
(3) 35.8 nm (4) 8.6 nm

**50.** The orbital velocity of an electron in the ground state is $v$. If the electron is excited to energy state $-0.54$ eV, its orbital velocity will be:

(1) $v$ (2) $\frac{v}{3}$

(3) $\frac{v}{5}$ (4) $\frac{v}{7}$

**51.** The energy levels of a hydrogen atom are shown below. The transition corresponding to emission of shortest wavelength is:




(1) $C$ (2) $D$

(3) $B$ (4) $A$

**52.** In a hydrogen atom, the electron is in $n^{th}$ excited state. It comes down to first excited state by emitting 10 different wavelengths. The value of $n$ is:
(1) 6 (2) 7
(3) 8 (4) 9

**53.** In which of the following systems will the radius of the first orbit ($n$=1) be minimum?
(1) Doubly ionized lithium
(2) Singly ionized helium
(3) Deuterium atom
(4) Hydrogen atom

**54.** The recoil speed of a hydrogen atom after it emits a photon in going from $n = 5$ state to $n = 1$ state will be: ($m_p = 1.67 \times 10^{-27}$ kg)
(1) 4.17 m/s
(2) 2.19 m/s
(3) 4.34 m/s
(4) 3.25 m/s

**55.** Two electrons are revolving around a nucleus at distances '$r$' and '$4r$'. The ratio of their period is:
(1) 1 : 4
(2) 4 : 1
(3) 8 : 1
(4) 1 : 8

**56.** Radiation coming from transition $n = 2$ to $n = 1$ of hydrogen atoms fall of $He^+$ ions in $n = 1$ and $n = 2$ states. The possible transition of helium ions as they absorb energy from the radiation is:
(1) $n = 1 \rightarrow n = 4$
(2) $n = 2 \rightarrow n = 4$
(3) $n = 2 \rightarrow n = 5$
(4) $n = 2 \rightarrow n = 3$

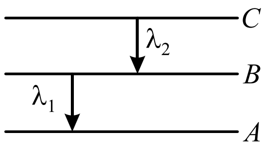
**57.** Which level of the single electron carbon ion has the same energy as the ground state energy of hydrogen atom?
(1) 6
(2) 8
(3) 4
(4) 1

*Integer Type Questions (58 to 71)*

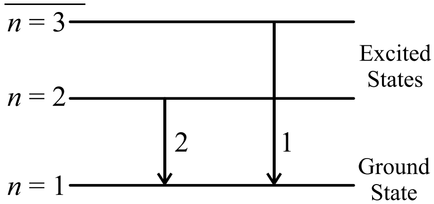
**58.** A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. The number of spectral lines emitted will be:

**59.** The ratio of wavelength of spectral lines $H_\alpha$ and $H_\beta$ in the Balmer series is $\frac{x}{20}$. The value of $x$ is:

**60.** As per given figure $A$, $B$ and $C$ are the first, second and third excited energy level of hydrogen atom respectively. If the ratio of the two wavelengths $\left(\frac{\lambda_1}{\lambda_2}\right)$ is $\frac{7}{4n}$, then the value of $n$ will be:




**61.** For hydrogen atom, $\lambda_1$ and $\lambda_2$ are the wavelengths corresponding to the transitions 1 and 2 respectively as shown in the figure. The ratio of $\lambda_1$ and $\lambda_2$ is $\frac{x}{32}$. The value of $x$ is _______.




**62.** A beam of monochromatic light is used to excite the electron in $Li^{++}$ from the first orbit to the third orbit. The wavelength of monochromatic light is found to be $x \times 10^{-10}$ m. The value of $x$ (to the closest integer) is
[Given $hc$ = 1242 eV nm]

**63.** $\frac{x}{x+4}$ is the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its:
(i) Third permitted energy level to the second level and
(ii) The highest permitted energy level to the second permitted level.
The value of $x$ will be _______.

**64.** $X$ different wavelengths may be observed in the spectrum from a hydrogen sample if the atoms are excited from its ground state to states with principal quantum number $n = 6$? The value of $X$ is_______.

**65.** The first three spectral of $H$-atom in the Balmer series are given as $\lambda_1$, $\lambda_2$, $\lambda_3$. Considering the Bohr atomic model, the wavelengths of first and third spectral lines $\left(\frac{\lambda_1}{\lambda_3}\right)$ are related by a factor of approximately '$x$' $\times 10^{-1}$. The value of $x$ to the nearest integer is_______.

**66.** If the binding energy of ground state electron in a hydrogen atom is 13.6 eV, then, the energy required to remove the electron from the second excited state of $Li^{2+}$ will be $x \times 10^{-1}$ eV. The value of $x$ is:

**67.** A light of energy 12.75 eV is incident on a hydrogen atom in its ground state. The atom absorbs the radiation and reaches to one of its excited states. The angular momentum of the atom in the excited state is $\frac{x}{\pi} \times 10^{-17}$ eVs. The value of $x$ is ____ (Use $h = 4.14 \times 10^{-15}$ eVs, $c = 3 \times 10^8$ ms$^{-1}$).

**68.** The radius of 2$^{nd}$ orbit of $He^+$ of Bohr's model is $r_1$ and that of fourth orbit of $Be^{3+}$ is represented as $r_2$. Now the ratio $r_2 / r_1$ is $x : 1$. The value of $x$ is ________.

**69.** The radius of fifth orbit of the $Li^{++}$ is ____ $\times 10^{-12}$ m. Take Bohr radius of hydrogen atom = 0.51Å

**70.** A monochromatic light is incident on a hydrogen sample in ground state. Hydrogen atoms absorb a fraction of light and subsequently emit radiation of six different wavelengths. The frequency of incident light is $x \times 10^{15}$ Hz. The value of $x$ is. (Given $h = 4.25 \times 10^{-15}$ eVs)

**71.** $\sqrt{d_1}$ and $\sqrt{d_2}$ are the impact parameters corresponding to scattering angles 60° and 90° respectively, when an α particle is approaching a gold nucleus. For $d_1 = x\, d_2$, the value of $x$ will be ________.

CHAPTER

25

# NUCLEUS

## Single Option Correct Type Questions (01 to 39)

**1.** Let $E$,$G$ and $N$ represents the magnitude of electromagnetic, gravitational and nuclear forces between two protons at a given separation (1 fermi). Then which of the following is correct

(1) $N < E < G$ (2) $E > N > G$

(3) $G > N > E$ (4) $N > E > G$

**2.** Masses of nucleus, neutron and protons are $M$, $m_n$ and $m_p$ respectively. If nucleus has been divided into neutrons and protons, then

(1) $M = (A - Z)\ m_n + Zm_p$

(2) $M = Zm_n + (A - Z)\ m_p$

(3) $M < (A - Z)\ m_n + Zm_p$

(4) $M > (A - Z)m_n + Zm_p$

**3.** If mass of the fissionable material is less than the critical mass, then

(1) fission and chain reactions both are impossible

(2) fission is possible but chain reaction is impossible

(3) fission is impossible but chain reaction is possible

(4) fission and chain reaction both are possible.

**4.** **STATEMENT–1 :** In spontaneous fission, the energy is always released.

**STATEMENT–2 :** Spontaneous fission occurs to lower the binding energy of reactant nuclei.

(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1

(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1

(3) Statement-1 is True, Statement-2 is False

(4) Statement-1 is False, Statement-2 is True.

**5.** Fusion reaction is possible at high temperature because -

(1) atoms are ionised at high temperature

(2) molecules break-up at high temperature

(3) nuclei break-up at high temperature

(4) kinetic energy is high enough to overcome repulsion between nuclei.

**6.** When $U^{238}$ nucleus originally at rest, decays by emitting an alpha particle having a speed u, the recoil speed of the residual nucleus is :

(1) $\frac{4u}{238}$ (2) $\frac{2u}{234}$

(3) $\frac{4u}{234}$ (4) $\frac{2u}{238}$

**7.** If the binding energy per nucleon in ${}_{3}^{7}Li$ and ${}_{2}^{4}He$ nuclei are 5.60 $MeV$ and 7.06 $MeV$ respectively, then in the reaction

$${}_{1}^{1}p + {}_{3}^{7}Li \rightarrow 2\ {}_{2}^{4}He$$

energy of proton must be :

(1) 39.2 MeV

(2) 28.24 MeV

(3) 17.28 MeV

(4) 1.46 MeV

**8.** A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1. The ratio of their nuclear radii will be :
(1) $2^{1/3} : 1$
(2) $1 : 3^{1/2}$
(3) $3^{1/2} : 1$
(4) $1 : 2^{1/3}$

**9.** Two lithium $^6Li$ nuclei in a lithium vapour at room temperature do not combine to form a carbon $^{12}C$ nucleus because
(1) a lithium nucleus is more tightly bound than a carbon nucleus
(2) carbon nucleus is an unstable particle
(3) it is not energetically favourable
(4) Coulomb repulsion does not allow the nuclei to come very close

**10.** If $M_o$ is the mass of an oxygen isotope $_8O^{17}$, $M_p$ and $M_N$ are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is :
(1) $(8M_P - M_o)C^2$
(2) $(8M_P + 9M_N - M_o)C^2$
(3) $M_oC^2$
(4) $(M_o - 17M_N)C^2$

**11.** The mass number of a nucleus is
(1) always less than its atomic number
(2) always more than its atomic number
(3) equal to its atomic number
(4) sometimes more than and sometimes equal to its atomic number

**12.** Which of the following materials is used for controlling nuclear fission in nuclear reactor :
(1) heavy water
(2) graphite
(3) cadmium
(4) Berillium oxide

**13.** In gamma ray emission from a nucleus :
(1) both the neutron number and the proton number change
(2) there is no change in the proton number and the neutron number
(3) only the neutron number changes
(4) only the proton number changes

**14.** The binding energies of two nuclei $P^n$ and $Q^{2n}$ are $x$ and $y$ joules. If $2x > y$ then the energy released in the reaction $P^n + P^n \rightarrow Q^{2n}$, will be
(1) $2x + y$ (2) $2x - y$
(3) $-(2x - y)$ (4) $x + y$

**15.** The $Q$-value of a nuclear reaction and kinetic energy of the projectile particle, $K_p$ are related as: [$K_P \rightarrow$ kinetic energy of parent nucleus]
(1) $Q = K_p$ (2) $(K_P + Q) < 0$
(3) $Q < K_P$ (4) $(K_P + Q) > 0$

**16.** Atomic reactor is based on
(1) controlled chain reaction
(2) uncontrolled chain reaction
(3) nuclear fission
(4) nuclear fusion

**17.** As the mass number $A$ increases, the binding energy per nucleon in a nucleus
(1) increases
(2) decreases
(3) remains the same
(4) varies in a way that depends on the actual value of $A$.

**18.** For a nucleus $^A_ZX$ having mass number $A$ and atomic number $Z$
(A) The surface energy per nucleon $(b_s) = a_1 A^{2/3}$
(B) The Coulomb contribution to the binding energy $b_c = -a_2 \dfrac{Z(Z-1)}{A^{4/3}}$
(C) The volume energy $b_v = a_3A$
(D) Decrease in the binding energy is proportional to surface area.
(E) While estimating the surface energy, it is assumed that each nucleon interacts with 12 nucleons, ($a_1$ , $a_2$ and $a_3$ are constants)

Choose the most appropriate answer from the options given below:
(1) (C), (D) only
(2) (B), (C), (E) only
(3) (A), (B), (C), (D)
(4) (B), (C) only

**19.** This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

**Statement-1 :** Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.

**Statement-2 :**

For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing *Z*.

(1) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1

(2) Statment-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1

(3) Statement-1 is true, Statement-2 is false

(4) Statement-1 is false, Statement-2 is true

**20.** $_{92}U^{235}$ nucleus absorbs a slow neutron and undergoes fission into $_{54}Xe^{139}$ and $_{38}Sr^{94}$ nuclei. The other particles produced in this fission process are

(1) 1 $\beta$ and 1 $\alpha$

(2) 2 $\beta$ and 1 neutron

(3) 2 neutrons

(4) 3 neutrons

**21.** A nucleus of mass $M + \Delta m$ is at rest and, decays into two daughter nuclei of equal mass $M/2$ each. The speed of daughter nuclei is

(1) $c\dfrac{\Delta m}{M+\Delta m}$  (2) $c\sqrt{\dfrac{2\Delta m}{M}}$

(3) $c\sqrt{\dfrac{\Delta m}{M}}$  (4) $c\sqrt{\dfrac{\Delta m}{M+\Delta m}}$

**22.** For uranium nucleus how does its mass vary with volume?

(1) $m \propto V$

(2) $m \propto 1/V$

(3) $m \propto \sqrt{V}$

(4) $m \propto V^2$

**23.** The ratio of mass densities of nuclei of $^{40}Ca$ and $^{16}O$ is close to:

(1) 1  (2) 2

(3) 0.1  (4) 5

**24.** The correct statement is :

(1) The nucleus $^{6}_{3}Li$ can emit an alpha particle

(2) The nucleus $^{210}_{84}Po$ can emit a proton

(3) Deuteron and alpha particle can undergo complete fusion.

(4) The nuclei $^{70}_{30}Zn$ and $^{82}_{34}Se$ can undergo complete fusion.

**25.** Given below are two statements: one is labelled as

Assertion A and the other is labelled as Reason R.

**Assertion A**: The nuclear density of nuclides $^{5}_{10}B$, $^{6}_{3}Li$, $^{56}_{26}Fe$, $^{20}_{10}Ne$ and $^{209}_{83}Bi$ can be arranged as $\rho_{Bi} > \rho_{Fe} > \rho_{Ne} > \rho_{B} > \rho_{Li}$

**Reason R:** The radius $R$ of nucleus is related to its mass number $A$ as $R = R_0 A^{1/3}$, where $R_0$ is a constant.

In the light of the above statement, choose the correct answer from the options given below:

(1) Both A and R are true and R is the correct explanation of A

(2) A is false but R is true

(3) A is true but R is false

(4) Both A and R are true but R is not the correct explanation of A

**26.** A free neutron decays to a proton but a free proton does not decay to a neutron. This is because

(1) neutron is a composite particle made of a proton and an electron whereas proton is fundamental particle

(2) neutron is an uncharged particle whereas proton is a charged particle

(3) neutron has larger rest mass than the proton

(4) weak forces can operate in a neutron but not in a proton.

**27.** The mass of proton, neutron and helium nucleus are respectively 1.0073 $u$, 1.0087 $u$ and 4.0015 $u$. The binding energy of helium nucleus is

(1) 14.2 MeV (2) 28.4 MeV
(3) 56.8 MeV (4) 7.1 MeV

**28.** $^{238}_{92}A \rightarrow ^{234}_{90}B + ^{4}_{2}D + Q$

In the given nuclear reaction, the approximate amount of energy released will be:

[Given, mass of $^{238}_{92}A = 238.05079 \times 931.5\ \text{MeV}/c^2$, mass of $^{234}_{90}B = 234.04363 \times 931.5\ \text{MeV}/c^2$, mass of $^{4}_{2}D = 4.00260 \times 931.5\ \text{MeV}/c^2$

(1) 3.82 MeV (2) 5.9 MeV
(3) 2.12 MeV (4) 4.25 MeV

**29.** The stable nucleus that has a radius 1/3 that of $Os^{189}$ is -

(1) $_3Li^7$ (2) $_2He^4$
(3) $_5B^{10}$ (4) $_6C^{12}$

**30.** Find the binding energy per nucleon for $^{120}_{50}Sn$. Mass of proton $m_P$ = 1.00783 $u$, mass of neutron $m_n$ = 1.00867 $u$ and mass of tin nucleus $m_{Sn}$= 119.902199 $u$.

(Take 1 $u$ = 931 MeV)

(1) 9.0 MeV
(2) 8.5 MeV
(3) 8.0 MeV
(4) 7.5 MeV

**31.** Read the following statements:

(A) Volume of the nucleus is directly proportional to the mass number.
(B) Volume of the nucleus is independent of mass number.
(C) Density of the nucleus is directly proportional to the mass number.
(D) Density of nucleus is directly proportional to the cube root of the mass number.
(E) Density of the nucleus is independent of the mass number.

Choose the correct option from the following options.

(1) (A) and (D) only
(2) (A) and (E) only
(3) (B) and (E) only
(4) (A) and (C) only

**32.** Let $F_{pp}$, $F_{pn}$ and $F_{nn}$ denote the magnitudes of the nuclear force by a proton on a proton, by a proton on a neutron and by a neutron on a neutron respectively. When the separation is 1 $fm$,

(1) $F_{pp} > F_{pn} = F_{nn}$
(2) $F_{pp} = F_{pn} = F_{nn}$
(3) $F_{pp} > F_{pn} > F_{nn}$
(4) $F_{pp} < F_{pn} = F_{nn}$

**33.** Given the masses of various atomic particles $m_p$ = 1.0072 $u$, $m_n$ = 1.0087 $u$, $m_e$= 0.000548 $u$, $m_{\bar{\nu}} = 0$, $m_d$ = 2.0141 $u$, where $p \equiv$ proton, $n \equiv$ neutron, $e \equiv$ electron, $\bar{\nu} \equiv$ antineutrino and $d \equiv$ deuteron. Which of the following process is allowed by momentum and energy conservation?

(1) $n + n \rightarrow$ deuterium atom (electron bound to the nucleus)
(2) $n + p \rightarrow d + \gamma$
(3) $p \rightarrow n + e^+ + \bar{\nu}$
(4) $e^+ + e^- \rightarrow \gamma$

**34.** In a reactor, 2 $kg$ of $_{92}U^{235}$ fuel is fully used up in 30 days. The energy released per fission is 200 MeV. Given that the Avogadro number, $N_A$ = $6.023 \times 10^{26}$ per kilo mole and 1 $eV$ = $1.6 \times 10^{-19}$ $J$. The power output of the reactor is close to

(1) 125 MW
(2) 35 MW
(3) 60 MW
(4) 54 MW

**35.** Which of the following is a wrong description of binding energy of a nucleus ?

(1) It is the energy required to break a nucleus into its constituent nucleons.

(2) It is the energy released when free nucleons combine to from a nucleus

(3) It is the sum of the rest mass energies of its nucleons minus the rest mass energy of the nucleus

(4) It is the sum of the kinetic energy of all the nucleons in the nucleus

**36.** Consider the nuclear fission $Ne^{20} \rightarrow 2He^4 + C^{12}$. Given that the binding energy / nucleon of $Ne^{20}$, $He^4$ and $C^{12}$ are, respectively, 8.03 MeV, 7.07 MeV, and 7.86 MeV, identify the correct statement:

(1) energy of 12.4 MeV will be supplied

(2) 8.3 MeV energy will be released

(3) energy of 3.6 MeV will be released

(4) energy of 9.72 MeV will be released

**37.** Consider the following statements:

(A) Atoms of each element emit characteristics spectrum.

(B) According to Bohr's Postulate, an electron in a hydrogen atom, revolves in a certain stationary orbit.

(C) The density of nuclear matter depends on the size of the nucleus.

(D) A free neutron is stable but a free proton decay is possible.

(E) Radioactivity is an indication of the instability of nuclei

Choose the correct answer from the options given below:

(1) (B) and (D) only

(2) (A), (C) and (E) only

(3) (A), (B), (C), (D) and (E)

(4) (A), (B) and (E) only

**38.** Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

**Assertion A :** The binding energy per nucleon is practically independent of the atomic number for nuclei of mass number in the range 30 to 170 .

**Reason R :** Nuclear force is short ranged.

In the light of the above statements, choose the correct answer from the options given below

(1) Both A and R are true but R is not the correct explanation of A

(2) A is true but R is false

(3) A is false but R is true

(4) Both A and R are true and R is the correct explanation of A

**39.** A nucleus of mass $M$ emits $\gamma$ –ray photon of energy '$hv$'. The loss of internal energy by the nucleus is: [Take '$c$' as the speed of electromagnetic wave]

(1) $hv\left[1+\frac{hv}{2Mc^2}\right]$ (2) 0

(3) $hv\left[1-\frac{hv}{2Mc^2}\right]$ (4) $hv$

## *Integer Type Questions (40 to 54)*

**40.** In a fission reaction

$${}^{236}_{92}U \longrightarrow {}^{117}X + {}^{117}Y + n + n$$

the average binding energy per nucleon of $X$ and $Y$ is 8.5 MeV whereas that of ${}^{236}U$ is 7.6 MeV. The total energy liberated will be about____ MeV.

**41.** In the nuclear fusion reaction,

$${}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + n$$

given that the repulsive potential energy between the two nuclei is ~ $7.7 \times 10^{-14}$ $J$, the temperature at which the gases must be heated to initiate the reaction is nearly $3.7 \times 10^{x}$ $K$. Value of $x$ is___. (Boltzmann's constant $k = 1.38 \times 10^{-23}$ $J/K$)

**42.** The binding energy per nucleon of deuteron $\left({}_{1}^{2}H\right)$ and helium nucleus $\left({}_{2}^{4}He\right)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is___ $\times 10^{-1}$ MeV

**43.** An α-particle of energy 5 MeV is scattered through 180º by a fixed uranium nucleus. The distance of the closest approach is of the order of $10^{-x}$ cm. Value of $x$ is ___.

**44.** If radius of the ${}_{13}^{27}Al$ nucleus is estimated to be 3.6 Fermi, then the radius of ${}_{52}^{125}Te$ nucleus be nearly___ Fermi.

**45.** Nucleus $A$ is having mass number 220 and its binding energy per nucleon is 5.6 MeV. It splits in two fragments $B$ and $C$ of mass numbers 105 and 115. The binding energy of nucleons in $B$ and $C$ is 6.4 MeV per nucleon. The energy $Q$ released per fission will be ___ MeV.

**46.** An unstable heavy nucleus at rest break into two nuclei which move away with velocities in the ratio of 8 : 27. The ratio of the radii of the nuclei (assume to be spherical) is given as $\frac{a}{2}$. The value of $a$ is___.

**47.** 4 Helium nuclei combine to form an oxygen nucleus. The energy released in the reaction is, if $m_O$ = 15.9994 amu and $m_{He}$ = 4.0026 amu, ____ MeV (to the nearest integer).

**48.** From the given data, the amount of energy required to break the nucleus of aluminium ${}_{13}^{27}Al$ is ________ $x \times 10^{-3}$ $J$.

Mass of neutron = 1.00866$u$

Mass of proton = 1.00726 $u$

Mass of Aluminium nucleus = 27.18846 $u$

(Assume 1 u corresponds to $x$ $J$ of energy)

(Round off to the nearest integer)

**49.** The ratio of the density of oxygen nucleus $({}_{8}^{16}O)$ and helium nucleus $({}_{2}^{4}He)$ is $\frac{x}{2}$. The value of $x$ is___.

**50.** A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into fragment each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is ________ MeV.

**51.** A nucleus disintegrates into two smaller parts, which have their velocities in the ratio 3 : 2. The ratio of their nuclear radii will be $\left(\frac{x}{3}\right)^{\frac{1}{3}}$. The value of '$x$' is _______.

**52.** Nucleus A having $Z$ = 17 and equal number of protons and neutrons has 1.2 MeV binding energy per nucleon. Another nucleus $B$ of $Z$ = 12 has total 26 nucleons and 1.8MeV binding energy per nucleons. The difference of binding energy of $B$ and $A$ will be _____ MeV.

**53.** Assume that protons and neutrons have equal masses. Mass of a nucleon is $1.6 \times 10^{-27}$ kg and radius of nucleus is $1.5 \times 10^{-15} A^{1/3}$ $m$. The approximate ratio of the nuclear density and water density is $n \times 10^{13}$. The value of $n$ (to the nearest integer) is _________

**54.** Mass numbers of two nuclei are in the ratio of 4 : 3. Their nuclear densities will be in the ratio of $x$ : 1. Find $x$.

# CHAPTER 26

# ELECTRONIC DEVICES

## Single Option Correct Type Questions (01 to 50)

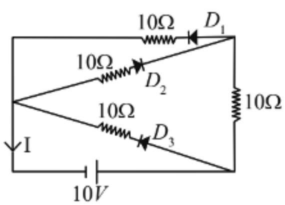
**1.** If each diode has a forward bias resistance of 25 Ω in the below circuit,

Which of the following options is correct?

(1) $\frac{I_3}{I_4} = 1$  (2) $\frac{I_2}{I_3} = 1$

(3) $\frac{I_1}{I_2} = 1$  (4) $\frac{I_1}{I_2} = 2$

**2.** In the given circuit, the current (I) through the battery will be:




(1) 1.5 A  (2) 2 A

(3) 2.5 A  (4) 2 A

**3.** Match the List-I with List-II

| | List-I | | List-II |
|---|---|---|---|
| A | Intrinsic Semiconductor | I | Fermi-level near conduction band |
| B | *n*-type semiconductor | II | Fermi-level at middle |
| C | p-type semiconductor | III | Fermi-level near valence band |
| D | Metals | IV | Fermi-level inside conduction band |

Choose the correct answer from the options given below:

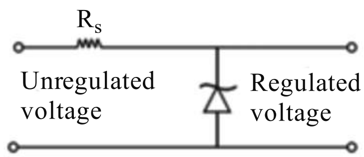
(1) A → III, B → IV, C → I, D → II

(2) A → IV, B → I, C → II, D → III

(3) A → II, B → I, C → III, D→ IV

(4) A → I, B → III, C → II, D → IV

**4.** A zener diode of power rating 1.6 W is to be used as voltage regulator. If the zener diode has a breakdown of 8 V and it has to regulate voltage fluctuating between 3 V and 10 V. The value of resistance $R_S$ for safe operation of diode will be:




(1) 13.3 Ω  (2) 12 Ω

(3) 10 Ω  (4) 13 Ω

**5.** **Statement-I:** When a Si sample is doped with Boron, it becomes P type and when doped by Arsenic it becomes N-type semi conductor such that P-type has excess of holes and N-type has excess of electrons.

**Statement-II:** When such P-type and N-type semiconductors, are fused to make a junction, a current will automatically flow which can be detected with an externally connected ammeter.

In light of the above statements, choose the most appropriate answer from the options given below:
(1) Both Statement-I and statement-II are incorrect
(2) Statement-I is incorrect but statement-II is correct
(3) Both Statement-I and statement-II are correct
(4) Statement-I is correct but statement-II is incorrect

**6.** The effect of increase in temperature on the number of electrons in conduction band ($n_e$) and resistance of a semiconductor will be as:
(1) Both $n_e$ and resistance decrease
(2) Both $n_e$ and resistance increase
(3) $n_e$ increases, resistance decreases
(4) $n_e$ decreases, resistance increases

**7.** Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R)
Assertion (A): Photodiodes are preferably operated in reverse bias condition for light intensity measurement.
Reason (R): The current in the forward bias is more than the current in the reverse bias for a p – n junction diode.
In the light of the above statement, choose the correct answer from the options given below:
(1) A is false but R is true
(2) Both A and R are true but R is NOT the correct explanation of A
(3) A is true but R is false
(4) Both A and R are true and R is the correct explanation of A

**8.** Choose the correct statement about Zener diode:
(1) It works as a voltage regulator in reverse bias and behaves like simple pn junction diode in forward bias.
(2) It works as a voltage regulator in both forward and reverse bias.
(3) It works as voltage regulator only in forward bias.
(4) It works as a voltage regulator in forward bias and behaves like simple pn junction diode in reverse bias.

**9.** Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R). Assertion (A): Diffusion current in a p-n junction is greater than the drift current in magnitude if the junction is forward biased.
Reason (R): Diffusion current in a p-n junction is from the n-side to the p-side if the junction is forward biased.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Both A and R are correct and R is the correct explanation of A
(2) Both A and R are correct but R is not the correct explanation of A
(3) A is correct but R is not correct
(4) A is not correct but R is correct

**10.** Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R)
**Assertion (A):** Photodiodes are used in forward bias usually for measuring the light intensity.
**Reason (R):** For a *p-n* junction diode, at applied voltage $V$ the current in the forward bias is more than the current in the reverse bias for $|V_z| > \pm V \geq |V_0|$ where $V_0$ is the threshold voltage and $V_z$ is the breakdown voltage.
Choose the correct answer from the options given below:
(1) Both A and R are true and R is the correct explanation of A
(2) Both A and R are true but R is NOT the correct explanation of A
(3) A is false but R is true
(4) A is true but R is false

**11.** Which of the following Statement-is not correct in the case of light emitting diodes?
A. It is a heavily doped p-n junction.
B. It emits light only when it is forward biased.
C. It emits light only when it is reverse biased.
D. The energy of the light emitted is equal to or slightly less than the energy gap of the semiconductor used. Choose the correct answer from the options given below:
(1) C and D (2) A
(3) C (4) B

**12.** The photodiode is used to detect the optical signals. These diode are preferably operated in reverse biased mode because.

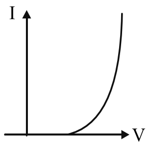
(1) Fractional change in majority carriers produce higher forward bias current

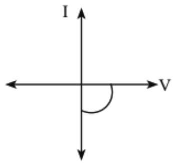
(2) Fractional change in majority carriers produce higher reverse bias current

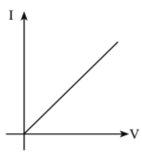
(3) Fractional change in majority carriers produce higher forward bias current

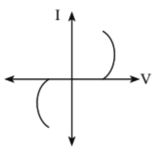
(4) Fractional change in minority carriers produce higher reverse bias current

**13.** Identify the solar cell characteristics from the following options:

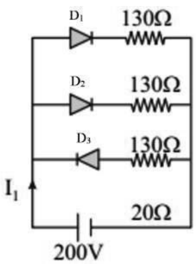
(1) 


(2) 


(3) 


(4) 


**14.** In the given figure, each diode has a forward bias resistance of 30 Ω and infinite resistance in reverse bias. The current $I_1$ will be:




(1) 3.75 A (2) 2.73 A

(3) 2.35 A (4) 2 A

**15.** Zener breakdown occurs in a *p–n* junction having *p* and *n* both:

(1) Lightly doped and have wide depletion layer.

(2) Heavily doped and have wide depletion layer.

(3) Lightly doped and have narrow depletion layer.

(4) Heavily doped and have narrow depletion layer.

**16.** For extrinsic semiconductors; when doping level is increased;

(1) Fermi-level of *p* and *n*-type semiconductors will not be affected.

(2) Fermi-level of *p*-type semiconductor will go upward and Fermi-level of *n*-type semiconductors will go downward.

(3) Fermi-level of *p*-type semiconductors will go downward and Fermi-level of *n*-type semiconductor will go upward.

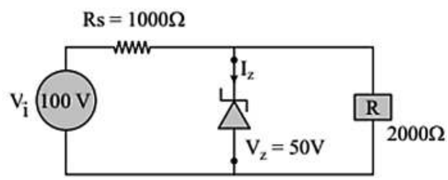
(4) Fermi-level of both *p*-type and *n*-type semiconductors will go upward for $T > T_F$ K and downward for $T < T_F$ K, where $T_F$ is Fermi temperature.

**17.** Consider a situation in which reverse biased current of a particular *P–N* junction increase when it is exposed to a light of wavelength 621 nm. During this process, enhancement in carrier concentration takes place due to generation of hole-electron pairs. The value of band gap is nearly [Take hc = 1242 eV –nm]

(1) 1 eV (2) 4 eV

(3) 0.5 eV (4) 2 eV

**18.** For the circuit shown below, calculate the value of $I_z$ :




(1) 0.15 A (2) 0.1 A

(3) 25 mA (4) 0.05 A

**19.** LED is constructed from *GaAsP* semiconducting material. The energy gap of this LED is 1.9 eV. Calculate the wavelength of light emitted and its colour. [$h = 6.63 \times 10^{-34}$ Js and $c = 3 \times 10^8$ ms$^{-1}$]

(1) 654 nm and orange colour

(2) 1046 nm and blue colour

(3) 1046 nm and red colour

(4) 654 nm and red colour

**20.** **Statement-I:** By doping silicon semiconductor with pentavalent material, the electrons density increases.

**Statement-II:** The n-type semiconductor has net negative charge.

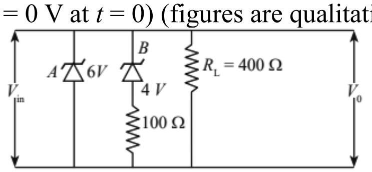
In the light of the above statements, choose the most appropriate answer from the options given below:

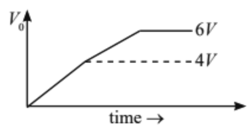
(1) Both Statement-I and Statement-II are true
(2) Statement-I is true but Statement-II is false
(3) Statement-I is false but Statement-II is true
(4) Both Statement-I and Statement-II are false

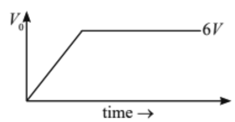
**21.** If a semiconductor photodiode can detect a photon with a maximum wavelength of 400 nm, then its band gap energy is [Planck's constant h = $6.63 \times 10^{-34}$ Js, Speed of light c = $3 \times 10^8$ m/s.]

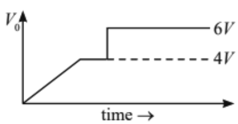
(1) 1.1 eV (2) 2.0 eV
(3) 3.1 eV (4) 1.5 eV

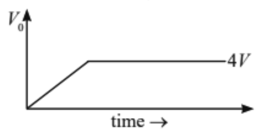
**22.** Two Zener diodes ($A$ and $B$) having breakdown voltages of 6 V and 4 V respectively, are connected as shown in the circuit below. The output voltage $V_0$ variation with input voltage linearly increasing with time, is given by: ($V_{input}$ = 0 V at $t$ = 0) (figures are qualitative)



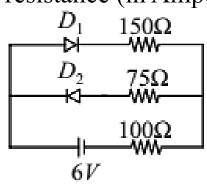

(1)



(2)



(3)


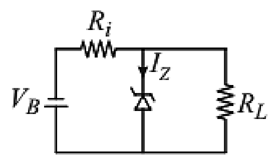

(4)



**23.** The circuit shown below contains two ideal diodes, each with a forward resistance of 50Ω. If the battery voltage is 6V, the current through the 100Ω resistance (in Amperes) is



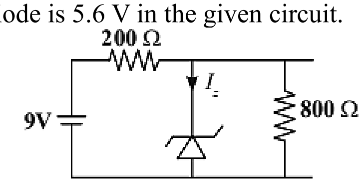

(1) 0.036 (2) 0.020
(3) 0.027 (4) 0.030

**24.** The figure represents a voltage regulator circuit using a Zener diode. The breakdown voltage of the Zener diode is 6V and the load resistance is $R_L$ = 4 kΩ. The series resistance of the circuit is $R_i$ = 1 kΩ. If the battery voltage $V_B$ varies from 8V to 16V, what are the minimum and maximum values of the current through Zener diode




(1) 0.5 mA ; 6 mA (2) 0.5 mA ; 8.5 mA
(3) 1.5 mA ; 8.5 mA (4) 1 mA : 8.5 mA

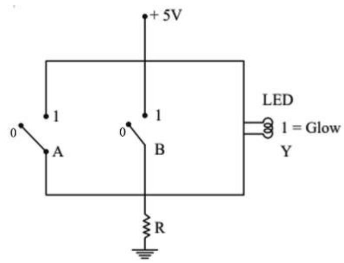
**25.** The reverse breakdown voltage of a Zener diode is 5.6 V in the given circuit.




The current $I_z$ , through the Zener is:

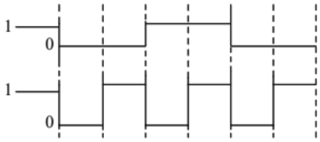
(1) 10 mA (2) 15 mA
(3) 7 mA (4) 17 mA

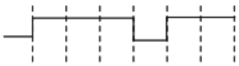
**26.** Name the logic gate equivalent to the diagram attached



(1) OR (2) NOR
(3) NAND (4) AND

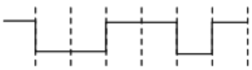
**27.** The output from a NAND gate having inputs *A* and *B* given below will be.



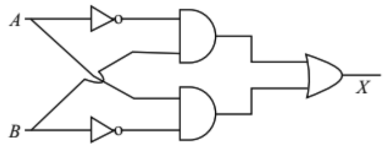

(1)


(2)


(3)


(4)


**28.** For the given logic gates combination, the correct truth table will be




(1)

| *A* | *B* | *X* |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(2)

| *A* | *B* | *X* |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

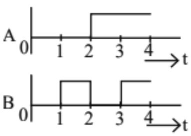
(3)

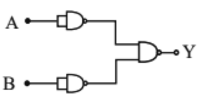
| *A* | *B* | *X* |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

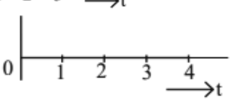
(4)

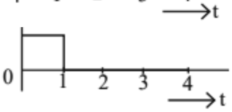
| *A* | *B* | *X* |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

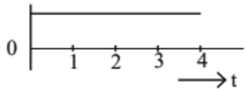
**29.** For the logic circuit shown, the output waveform at Y is:

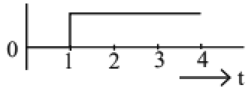


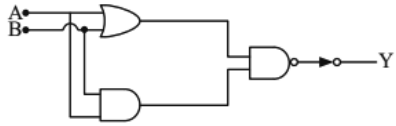

(1)


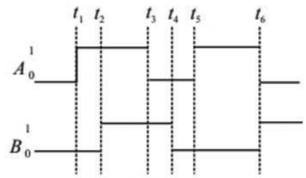
(2)


(3)


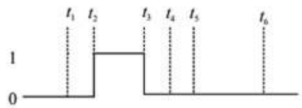
(4)


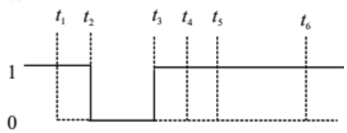
**30.** The output waveform of the given logical circuit for the following inputs *A* and *B* as shown below, is:

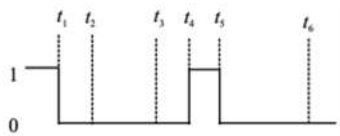


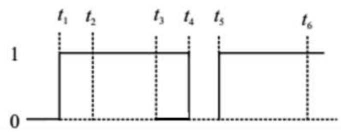



Inputs

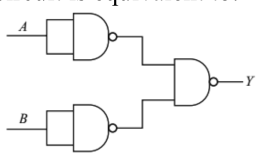
(1)


(2)


(3)


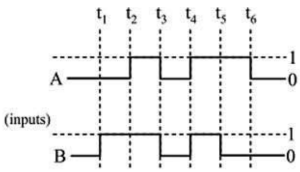
(4)


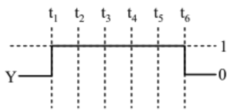
**31.** The logic operations performed by the given digital circuit is equivalent to:

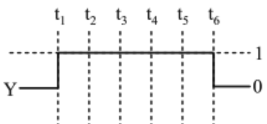


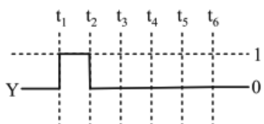

(1) AND (2) NOR
(3) OR (4) NAND

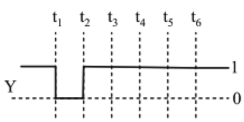
**32.** For the following circuit and given inputs $A$ and $B$, choose the correct option for output '$Y$'



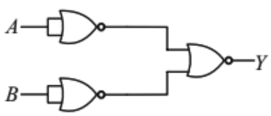
(1) 

(2) 

(3) 

(4) 

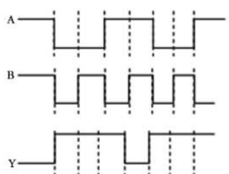
**33.** Identify the logic operation performed by the given circuit:

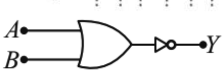


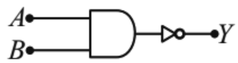
(1) AND gate (2) OR gate

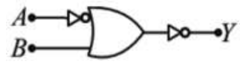
(3) NOR gate (4) NAND gate

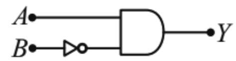
**34.** Identify the correct logic gate for the following output ($Y$) of two inputs $A$ and $B$.



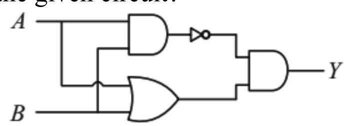
(1) 

(2) 

(3) 

(4) 

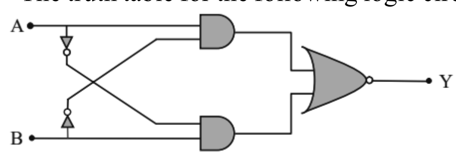
**35.** Which one of the following will be the output of the given circuit?



(1) XOR Gate (2) NOR Gate

(3) NAND Gate (4) AND Gate

**36.** The truth table for the following logic circuit is:



(1)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(2)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

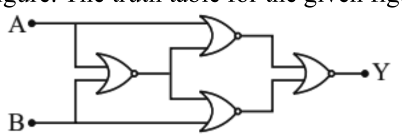
(3)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(4)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**37.** Four NOR gates are connected as shown in figure. The truth table for the given figure is:



(1)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(2)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

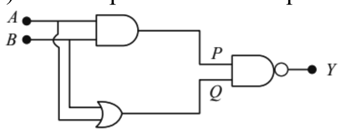
(3)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(4)

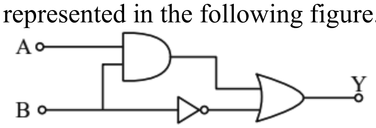
| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**38.** In the following logic circuit the sequence of the inputs A, B are (0, 0), (0,1), (1, 0) and (1, 1). The output Y for this sequence will be:




(1) 0, 1, 0, 1  (2) 1, 1, 1, 0
(3) 1, 0, 1, 0  (4) 0, 0, 1, 1

**39.** Find the truth table for the function $Y$ of $A$ and $B$ represented in the following figure.




(1)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(2)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

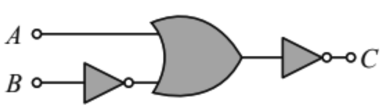
(3)

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

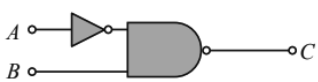
(4)

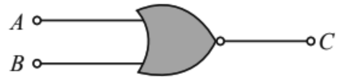
| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

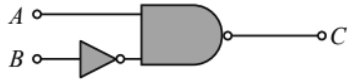
**40.**

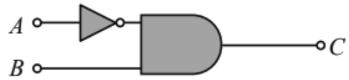



The logic circuit shown above is equivalent to:

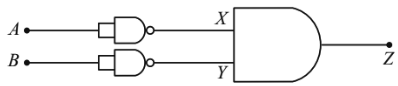
(1)



(2)



(3)


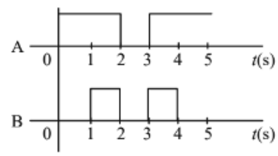

(4)


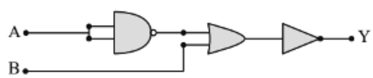

**41.** Identify the logic operation carried out by the given circuit :-

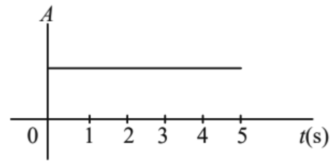


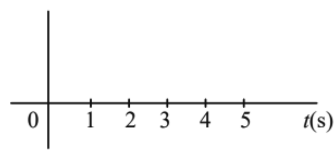

(1) NAND
(2) NOR
(3) AND
(4) OR

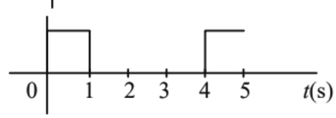
**42.** Draw the output signal $Y$ in the given combination of gates.

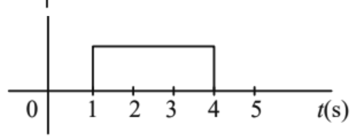


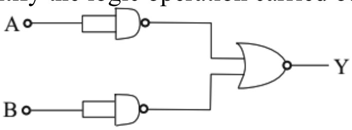

(1)



(2)



(3)


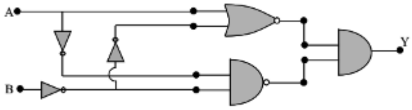

(4)


**43.** Identify the logic operation carried out.



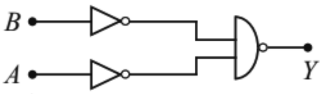

(1) OR (2) NOR
(3) AND (4) NAND

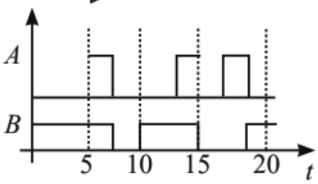
**44.** In the logic circuit shown in the figure, if input $A$ and $B$ are 0 and 1 respectively, then output at $Y$ would be '$x$'. The value of $x$ is




(1) 0 (2) 1
(3) 10 (4) 2

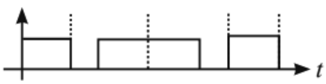
**45.** Identify the correct output signal Y in the given combination of gates (as shown) for the given inputs $A$ and $B$.



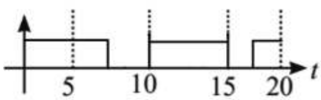




(1)

(2)

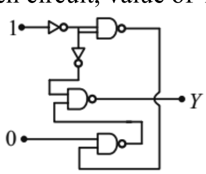


(3)



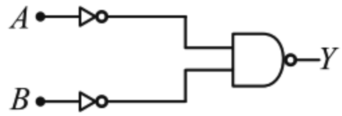

(4)

**46.** In the given circuit, value of Y is:



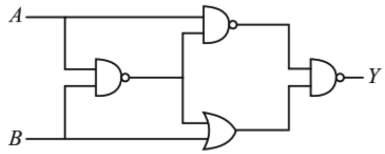

(1) 0
(2) 1
(3) toggles between 0 and 1
(4) will not execute

**47.** The logic gate equivalent to the given logic circuit is



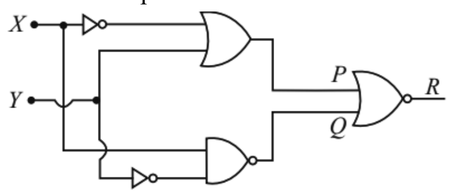

(1) OR (2) AND
(3) NOR (4) NAND

**48.** The output of the given logic circuit is:



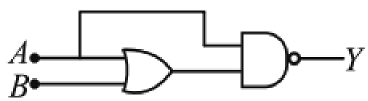

(1) $A\bar{B}+\bar{A}B$ (2) $AB+\overline{AB}$
(3) $A\bar{B}$ (4) $\bar{A}B$

**49.** To get output '1' at $R$, for the given logic gate circuit the input values must be:




(1) $X=0,\ Y=1$ (2) $X=1,\ Y=1$
(3) $X=1,\ Y=0$ (4) $X=0,\ Y=0$

**50.** The truth table for the circuit given in the figure is




(1)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(2)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(3)

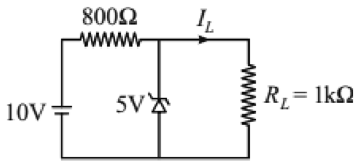
| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(4)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

## *Integer Type Questions (51 to 66)*

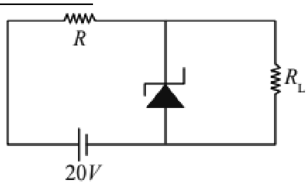
**51.** In the given circuit, the value of current $I_L$ will be ________ mA. (When $R_L = 1\ k\Omega$)




**52.** A potential barrier of 0.4 V exists across a p–n junction. An electron enters the junction from the n side with a speed of $6.0 \times 10^5\ ms^{-1}$. The speed with which electron enters the p side will be $\frac{x}{3} \times 10^5\ m/s$. The value of $x$ is _______.

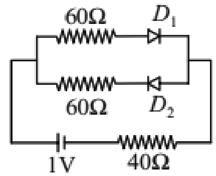
(Given mass of electron = $9 \times 10^{-31}$ kg, charge on electron = $1.6 \times 10^{-19}$ C)

**53.** A 8 V Zener diode along with a series resistance $R$ is connected across a 20 V supply (as shown in the figure). If the maximum Zener current is 25 mA, then the minimum value of $R$ will be ____________ Ω.

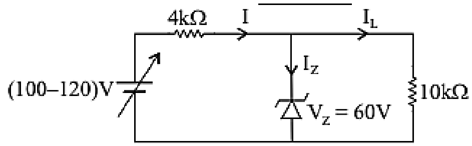



**54.** The energy band gap of semiconducting material to produce violet (wavelength = 4000Å) LED is _______ eV. (Round off to the nearest integer).

**55.** The cut off voltage of the diodes (shown in figure) in forward bias is 0.6 V. The current through the resistance of 40 Ω is _________ mA.

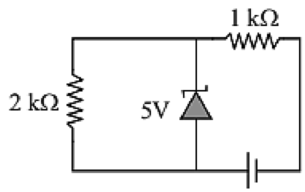



**56.** In the circuit shown below, maximum zener diode current will be _______mA.

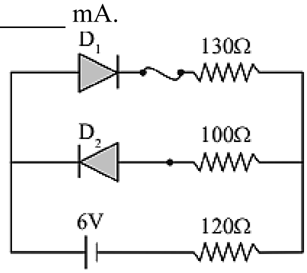



**57.** If the potential barrier across a p-n junction is 0.6 V. Then the electric field intensity, in the depletion region having the width of $6 \times 10^{-6}$ m, will be $n \times 10^5$ N/C. Find $n$.

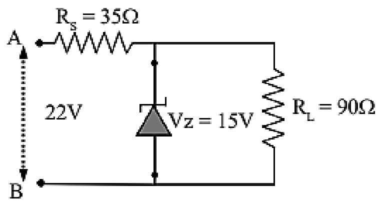
**58.** In connection with the circuit drawn below, the value of current flowing through 2 kΩ resistor is______ $\times 10^{-4}$ A.



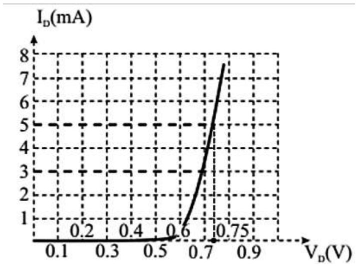

**59.** The circuit contains two diodes each with a forward resistance of 50 Ω and with infinite reverse resistance. If the battery voltage is 6 V, the current through the 120 Ω resistance is __________ mA.



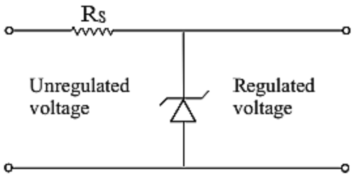

**60.** The value of power dissipated across the zener diode ($Vz$ = 15 V) connected in the circuit as shown in the figure is $x \times 10^{-1}$ watt. The value of x, to the nearest integer, is _______.



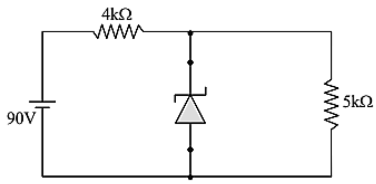

**61.** For the forward biased diode characteristics shown in the figure, the dynamic resistance at $I_D$ = 3 mA will be _________Ω.



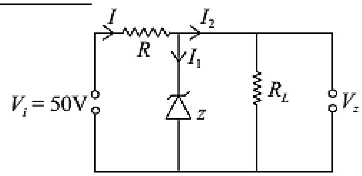

**62.** A zener diode of power rating 2W is to be used as a voltage regulator. If the zener diode has a breakdown of 10 V and it has to regulate voltage fluctuated between 6 V and 14 V, the value of Rs for safe operation should be _______ Ω.




**63.** The zener diode has a $V_Z$ = 30 V. The current passing through the diode for the following circuit is ……… mA.

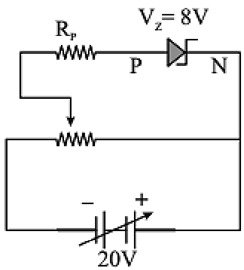



**64.** In a given circuit diagram, a 5 V zener diode along with a series resistance is connected across a 50 V power supply. The minimum value of the resistance required, if the maximum zener current is 90 mA be _________ Ω.




**65.** In a semiconductor, the number density of intrinsic charge carriers at 27°C is $1.5 \times 10^{16}/m^3$. If the semiconductor is doped with impurity atom, the hole density increases to $4.5 \times 10^{22}$ /m$^3$. The electron density in the doped semiconductor is ________ $\times 10^9/m^3$.

**66.** A zener diode having zener voltage 8 V and power dissipation rating of 0.5 W is connected across a potential divider arranged with maximum potential drop across zener diode is as shown in the diagram. The value of protective resistance $R_P$ is _________ Ω.



## 01. MATHEMATICAL TOOLS, UNITS, DIMENSIONS AND ERRORS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (2) | 9. | (2) | 17. | (2) | 25. | (1) | 33. | (2) | 41. | (3) | 49. | (2) | 57. | (3) |
| 2. | (3) | 10. | (2) | 18. | (4) | 26. | (2) | 34. | (2) | 42. | (2) | 50. | (2) | 58. | (4) |
| 3. | (1) | 11. | (4) | 19. | (3) | 27. | (3) | 35. | (1) | 43. | (1) | 51. | (1) | 59. | (3) |
| 4. | (3) | 12. | (2) | 20. | (3) | 28. | (1) | 36. | (4) | 44. | (3) | 52. | (1) | 60. | (3) |
| 5. | (3) | 13. | (4) | 21. | (1) | 29. | (3) | 37. | (3) | 45. | (3) | 53. | (2) | | |
| 6. | (2) | 14. | (4) | 22. | (3) | 30. | (1) | 38. | (4) | 46. | (2) | 54. | (1) | | |
| 7. | (1) | 15. | (1) | 23. | (3) | 31. | (4) | 39. | (3) | 47. | (2) | 55. | (4) | | |
| 8. | (2) | 16. | (2) | 24. | (2) | 32. | (1) | 40. | (4) | 48. | (4) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (1) | 63. | (1) | 65. | (1) | 67. | (8) | 69. | (120) | 71. | (15) | 73. | (2) | 75. | (45) |
| 62. | (4) | 64. | (1) | 66. | (2) | 68. | (2) | 70. | (53) | 72. | (120) | 74. | (0) | | |

## 02. KINEMATICS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 9. | (4) | 17. | (1) | 25. | (1) | 33. | (2) | 41. | (1) | 49. | (4) | 57. | (1) |
| 2. | (1) | 10. | (4) | 18. | (2) | 26. | (2) | 34. | (3) | 42. | (3) | 50. | (1) | 58. | (4) |
| 3. | (2) | 11. | (4) | 19. | (2) | 27. | (2) | 35. | (4) | 43. | (2) | 51. | (1) | 59. | (3) |
| 4. | (4) | 12. | (1) | 20. | (4) | 28. | (4) | 36. | (3) | 44. | (1) | 52. | (3) | 60. | (2) |
| 5. | (4) | 13. | (3) | 21. | (4) | 29. | (3) | 37. | (4) | 45. | (3) | 53. | (3) | | |
| 6. | (4) | 14. | (1) | 22. | (4) | 30. | (3) | 38. | (4) | 46. | (2) | 54. | (4) | | |
| 7. | (4) | 15. | (4) | 23. | (2) | 31. | (2) | 39. | (4) | 47. | (2) | 55. | (3) | | |
| 8. | (3) | 16. | (2) | 24. | (1) | 32. | (3) | 40. | (1) | 48. | (4) | 56. | (1) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (50) | 63. | (200) | 65. | (300) | 67. | (50) | 69. | (20) | 71. | (80) | 73. | (5) | 75. | (1) |
| 62. | (3) | 64. | (5) | 66. | (120) | 68. | (1) | 70. | (3) | 72. | (80) | 74. | (30) | | |

## 03. LAWS OF MOTION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (2) | 9. | (2) | 17. | (4) | 25. | (1) | 33. | (2) | 41. | (4) | 49. | (3) | 57. | (2) |
| 2. | (2) | 10. | (3) | 18. | (4) | 26. | (3) | 34. | (4) | 42. | (2) | 50. | (1) | 58. | (4) |
| 3. | (1) | 11. | (2) | 19. | (1) | 27. | (4) | 35. | (1) | 43. | (1) | 51. | (2) | 59. | (1) |
| 4. | (3) | 12. | (1) | 20. | (4) | 28. | (2) | 36. | (1) | 44. | (1) | 52. | (2) | 60. | (3) |
| 5. | (1) | 13. | (3) | 21. | (3) | 29. | (2) | 37. | (1) | 45. | (4) | 53. | (3) | | |
| 6. | (2) | 14. | (4) | 22. | (2) | 30. | (3) | 38. | (1) | 46. | (1) | 54. | (2) | | |
| 7. | (4) | 15. | (4) | 23. | (2) | 31. | (2) | 39. | (1) | 47. | (1) | 55. | (4) | | |
| 8. | (2) | 16. | (1) | 24. | (2) | 32. | (2) | 40. | (4) | 48. | (2) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (61 TO 73)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (20) | 63. | (100) | 65. | (12) | 67. | (5) | 69. | (4) | 71. | (2) | 73. | (3) |
| 62. | (9) | 64. | (3) | 66. | (32) | 68. | (346) | 70. | (2) | 72. | (21) | | |

## 04. WORK, ENERGY AND POWER

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (1) | 17. | (1) | 25. | (4) | 33. | (1) | 41. | (3) | 49. | (3) | 57. | (2) |
| 2. | (2) | 10. | (3) | 18. | (1) | 26. | (4) | 34. | (2) | 42. | (3) | 50. | (2) | 58. | (3) |
| 3. | (1) | 11. | (1) | 19. | (1) | 27. | (1) | 35. | (2) | 43. | (3) | 51. | (4) | 59. | (4) |
| 4. | (3) | 12. | (4) | 20. | (1) | 28. | (2) | 36. | (2) | 44. | (3) | 52. | (1) | 60. | (1) |
| 5. | (2) | 13. | (4) | 21. | (4) | 29. | (1) | 37. | (2) | 45. | (2) | 53. | (3) | | |
| 6. | (4) | 14. | (3) | 22. | (1) | 30. | (2) | 38. | (1) | 46. | (3) | 54. | (3) | | |
| 7. | (4) | 15. | (3) | 23. | (2) | 31. | (1) | 39. | (2) | 47. | (2) | 55. | (3) | | |
| 8. | (4) | 16. | (2) | 24. | (4) | 32. | (4) | 40. | (1) | 48. | (4) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (16) | 63. | (2) | 65. | (135) | 67. | (40) | 69. | (300) | 71. | (1) | 73. | (5) | 75. | (1) |
| 62. | (100) | 64. | (6) | 66. | (1) | 68. | (100) | 70. | (140) | 72. | (1) | 74. | (1) | | |

## 05. CIRCULAR MOTION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (3) | 17. | (3) | 25. | (1) | 33. | (2) | 41. | (2) | 49. | (1) | 57. | (3) |
| 2. | (4) | 10. | (4) | 18. | (3) | 26. | (4) | 34. | (4) | 42. | (4) | 50. | (3) | 58. | (4) |
| 3. | (1) | 11. | (3) | 19. | (2) | 27. | (2) | 35. | (2) | 43. | (2) | 51. | (1) | 59. | (1) |
| 4. | (1) | 12. | (2) | 20. | (4) | 28. | (3) | 36. | (2) | 44. | (4) | 52. | (2) | 60. | (2) |
| 5. | (3) | 13. | (4) | 21. | (3) | 29. | (3) | 37. | (1) | 45. | (3) | 53. | (4) | | |
| 6. | (4) | 14. | (1) | 22. | (1) | 30. | (1) | 38. | (2) | 46. | (2) | 54. | (2) | | |
| 7. | (1) | 15. | (4) | 23. | (2) | 31. | (3) | 39. | (1) | 47. | (3) | 55. | (3) | | |
| 8. | (3) | 16. | (1) | 24. | (3) | 32. | (2) | 40. | (1) | 48. | (1) | 56. | (3) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (200) | 63. | (1) | 65. | (50) | 67. | (1) | 69. | (10) | 71. | (14) | 73. | (10) | 75. | (200) |
| 62. | (7) | 64. | (8) | 66. | (12) | 68. | (4) | 70. | (30) | 72. | (36) | 74. | (125) | | |

## 06. SYSTEM OF PARTICLES AND CENTRE OF MASS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (4) | 9. | (1) | 17. | (1) | 25. | (1) | 33. | (1) | 41. | (1) | 49. | (1) | 57. | (1) |
| 2. | (4) | 10. | (2) | 18. | (1) | 26. | (3) | 34. | (4) | 42. | (3) | 50. | (1) | 58. | (3) |
| 3. | (4) | 11. | (1) | 19. | (1) | 27. | (3) | 35. | (2) | 43. | (2) | 51. | (2) | 59. | (2) |
| 4. | (4) | 12. | (2) | 20. | (3) | 28. | (1) | 36. | (4) | 44. | (1) | 52. | (3) | 60. | (1) |
| 5. | (3) | 13. | (1) | 21. | (1) | 29. | (4) | 37. | (4) | 45. | (2) | 53. | (2) | | |
| 6. | (1) | 14. | (3) | 22. | (3) | 30. | (3) | 38. | (2) | 46. | (2) | 54. | (1) | | |
| 7. | (3) | 15. | (3) | 23. | (2) | 31. | (3) | 39. | (2) | 47. | (2) | 55. | (2) | | |
| 8. | (3) | 16. | (2) | 24. | (2) | 32. | (3) | 40. | (4) | 48. | (3) | 56. | (2) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (2) | 63. | (3) | 65. | (3) | 67. | (10) | 69. | (1) | 71. | (25) | 73. | (30) | 75. | (12) |
| 62. | (7) | 64. | (67) | 66. | (2) | 68. | (8) | 70. | (2) | 72. | (3) | 74. | (6) | | |

## 07. RIGID BODY MOTION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 59)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (2) | 17. | (3) | 25. | (1) | 33. | (4) | 41. | (1) | 49. | (1) | 57. | (1) |
| 2. | (4) | 10. | (3) | 18. | (1) | 26. | (3) | 34. | (4) | 42. | (1) | 50. | (4) | 58. | (3) |
| 3. | (3) | 11. | (1) | 19. | (1) | 27. | (3) | 35. | (2) | 43. | (2) | 51. | (2) | 59. | (2) |
| 4. | (3) | 12. | (3) | 20. | (3) | 28. | (2) | 36. | (4) | 44. | (1) | 52. | (4) | | |
| 5. | (2) | 13. | (3) | 21. | (4) | 29. | (4) | 37. | (3) | 45. | (1) | 53. | (2) | | |
| 6. | (2) | 14. | (2) | 22. | (2) | 30. | (2) | 38. | (1) | 46. | (1) | 54. | (4) | | |
| 7. | (3) | 15. | (3) | 23. | (2) | 31. | (2) | 39. | (2) | 47. | (3) | 55. | (3) | | |
| 8. | (4) | 16. | (2) | 24. | (4) | 32. | (3) | 40. | (3) | 48. | (3) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (60 TO 74)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | (728) | 62. | (3) | 64. | (5) | 66. | (3) | 68. | (2) | 70. | (18) | 72. | (10) | 74. | (15) |
| 61. | (32) | 63. | (5) | 65. | (110) | 67. | (20) | 69. | (10) | 71. | (10) | 73. | (3) | | |

## 08. GRAVITATION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 58)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (1) | 17. | (3) | 25. | (3) | 33. | (3) | 41. | (2) | 49. | (3) | 57. | (3) |
| 2. | (3) | 10. | (3) | 18. | (4) | 26. | (4) | 34. | (3) | 42. | (4) | 50. | (1) | 58. | (1) |
| 3. | (4) | 11. | (4) | 19. | (2) | 27. | (4) | 35. | (4) | 43. | (4) | 51. | (1) | | |
| 4. | (3) | 12. | (2) | 20. | (1) | 28. | (1) | 36. | (1) | 44. | (1) | 52. | (4) | | |
| 5. | (3) | 13. | (4) | 21. | (1) | 29. | (1) | 37. | (2) | 45. | (4) | 53. | (3) | | |
| 6. | (3) | 14. | (3) | 22. | (1) | 30. | (2) | 38. | (3) | 46. | (1) | 54. | (2) | | |
| 7. | (1) | 15. | (2) | 23. | (1) | 31. | (4) | 39. | (4) | 47. | (4) | 55. | (2) | | |
| 8. | (1) | 16. | (3) | 24. | (3) | 32. | (2) | 40. | (3) | 48. | (2) | 56. | (2) | | |

*INTEGER TYPE QUESTIONS (59 TO 73)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59. | (6) | 61. | (2) | 63. | (16) | 65. | (9) | 67. | (200) | 69. | (8) | 71. | (64) | 73. | (32) |
| 60. | (64) | 62. | (3) | 64. | (10) | 66. | (3) | 68. | (198) | 70. | (2) | 72. | (48) | | |

## 09. PROPERTIES OF MATTER – SOLIDS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 45)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **(1)** | **7.** | **(4)** | **13.** | **(4)** | **19.** | **(4)** | **25.** | **(1)** | **31.** | **(2)** | **37.** | **(4)** | **43.** | **(2)** |
| **2.** | **(2)** | **8.** | **(3)** | **14.** | **(1)** | **20.** | **(2)** | **26.** | **(3)** | **32.** | **(3)** | **38.** | **(1)** | **44.** | **(1)** |
| **3.** | **(3)** | **9.** | **(4)** | **15.** | **(3)** | **21.** | **(2)** | **27.** | **(3)** | **33.** | **(4)** | **39.** | **(3)** | **45.** | **(3)** |
| **4.** | **(3)** | **10.** | **(2)** | **16.** | **(1)** | **22.** | **(3)** | **28.** | **(1)** | **34.** | **(1)** | **40.** | **(3)** | | |
| **5.** | **(3)** | **11.** | **(4)** | **17.** | **(4)** | **23.** | **(1)** | **29.** | **(2)** | **35.** | **(1)** | **41.** | **(1)** | | |
| **6.** | **(4)** | **12.** | **(2)** | **18.** | **(1)** | **24.** | **(1)** | **30.** | **(3)** | **36.** | **(4)** | **42.** | **(4)** | | |

*INTEGER TYPE QUESTIONS (46 TO 59)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **46.** | **(60)** | **48.** | **(20)** | **50.** | **(2)** | **52.** | **(2)** | **54.** | **(500)** | **56.** | **(15)** | **58.** | **(1)** |
| **47.** | **(2)** | **49.** | **(5)** | **51.** | **(25)** | **53.** | **(48)** | **55.** | **(20)** | **57.** | **(11)** | **59.** | **(4)** |

## 10. PROPERTIES OF MATTER – FLUIDS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 58)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **(2)** | **9.** | **(2)** | **17.** | **(3)** | **25.** | **(3)** | **33.** | **(3)** | **41.** | **(1)** | **49.** | **(2)** | **57.** | **(4)** |
| **2.** | **(2)** | **10.** | **(2)** | **18.** | **(1)** | **26.** | **(2)** | **34.** | **(1)** | **42.** | **(4)** | **50.** | **(3)** | **58.** | **(4)** |
| **3.** | **(4)** | **11.** | **(1)** | **19.** | **(3)** | **27.** | **(1)** | **35.** | **(4)** | **43.** | **(1)** | **51.** | **(2)** | | |
| **4.** | **(1)** | **12.** | **(3)** | **20.** | **(3)** | **28.** | **(1)** | **36.** | **(3)** | **44.** | **(2)** | **52.** | **(1)** | | |
| **5.** | **(4)** | **13.** | **(3)** | **21.** | **(1)** | **29.** | **(1)** | **37.** | **(2)** | **45.** | **(1)** | **53.** | **(3)** | | |
| **6.** | **(3)** | **14.** | **(4)** | **22.** | **(3)** | **30.** | **(1)** | **38.** | **(1)** | **46.** | **(1)** | **54.** | **(3)** | | |
| **7.** | **(3)** | **15.** | **(1)** | **23.** | **(1)** | **31.** | **(3)** | **39.** | **(4)** | **47.** | **(4)** | **55.** | **(4)** | | |
| **8.** | **(1)** | **16.** | **(1)** | **24.** | **(1)** | **32.** | **(2)** | **40.** | **(1)** | **48.** | **(4)** | **56.** | **(3)** | | |

*INTEGER TYPE QUESTIONS (59 TO 73)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **59.** | **(20)** | **61.** | **(5)** | **63.** | **(3)** | **65.** | **(20)** | **67.** | **(20)** | **69.** | **(2)** | **71.** | **(2)** | **73.** | **(2)** |
| **60.** | **(0)** | **62.** | **(1)** | **64.** | **(3)** | **66.** | **(2)** | **68.** | **(2)** | **70.** | **(2)** | **72.** | **(4)** | | |

## 11. THERMODYNAMICS & KINETIC THEORY OF GASES

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 61)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (4) | 9. | (4) | 17. | (1) | 25. | (3) | 33. | (2) | 41. | (4) | 49. | (1) | 57. | (3) |
| 2. | (2) | 10. | (2) | 18. | (1) | 26. | (1) | 34. | (3) | 42. | (2) | 50. | (2) | 58. | (1) |
| 3. | (1) | 11. | (4) | 19. | (4) | 27. | (1) | 35. | (1) | 43. | (3) | 51. | (4) | 59. | (4) |
| 4. | (3) | 12. | (3) | 20. | (4) | 28. | (3) | 36. | (4) | 44. | (3) | 52. | (4) | 60. | (4) |
| 5. | (2) | 13. | (4) | 21. | (2) | 29. | (3) | 37. | (3) | 45. | (1) | 53. | (1) | 61. | (3) |
| 6. | (4) | 14. | (2) | 22. | (1) | 30. | (4) | 38. | (1) | 46. | (1) | 54. | (4) | | |
| 7. | (1) | 15. | (2) | 23. | (3) | 31. | (1) | 39. | (2) | 47. | (1) | 55. | (1) | | |
| 8. | (2) | 16. | (3) | 24. | (2) | 32. | (4) | 40. | (3) | 48. | (2) | 56. | (3) | | |

*INTEGER TYPE QUESTIONS (62 TO 76)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62. | (90) | 64. | (21) | 66. | (28) | 68. | (3) | 70. | (14) | 72. | (255) | 74. | (25) | 76. | (2) |
| 63. | (8) | 65. | (4) | 67. | (25) | 69. | (100) | 71. | (400) | 73. | (5) | 75. | (12) | | |

## 12. OSCILLATIONS & WAVES

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 9. | (4) | 17. | (2) | 25. | (2) | 33. | (3) | 41. | (2) | 49. | (4) | 57. | (2) |
| 2. | (3) | 10. | (3) | 18. | (1) | 26. | (1) | 34. | (4) | 42. | (2) | 50. | (3) | 58. | (1) |
| 3. | (1) | 11. | (2) | 19. | (1) | 27. | (1) | 35. | (3) | 43. | (1) | 51. | (1) | 59. | (2) |
| 4. | (4) | 12. | (2) | 20. | (2) | 28. | (2) | 36. | (4) | 44. | (3) | 52. | (1) | 60. | (2) |
| 5. | (2) | 13. | (1) | 21. | (2) | 29. | (2) | 37. | (4) | 45. | (4) | 53. | (4) | | |
| 6. | (1) | 14. | (2) | 22. | (4) | 30. | (3) | 38. | (3) | 46. | (1) | 54. | (3) | | |
| 7. | (1) | 15. | (4) | 23. | (4) | 31. | (1) | 39. | (3) | 47. | (4) | 55. | (4) | | |
| 8. | (1) | 16. | (3) | 24. | (1) | 32. | (4) | 40. | (4) | 48. | (1) | 56. | (2) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (200) | 63. | (10) | 65. | (100) | 67. | (344) | 69. | (2) | 71. | (5) | 73. | (3) | 75. | (3) |
| 62. | (1) | 64. | (16) | 66. | (600) | 68. | (5) | 70. | (25) | 72. | (2) | 74. | (6) | | |

## 13. CHARGES AND ELECTROSTATIC FIELD

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 9. | (3) | 17. | (2) | 25. | (4) | 33. | (3) | 41. | (1) | 49. | (3) | 57. | (2) |
| 2. | (1) | 10. | (3) | 18. | (3) | 26. | (4) | 34. | (4) | 42. | (1) | 50. | (1) | 58. | (1) |
| 3. | (1) | 11. | (3) | 19. | (1) | 27. | (3) | 35. | (1) | 43. | (3) | 51. | (1) | 59. | (1) |
| 4. | (2) | 12. | (4) | 20. | (2) | 28. | (4) | 36. | (3) | 44. | (4) | 52. | (2) | 60. | (3) |
| 5. | (3) | 13. | (3) | 21. | (3) | 29. | (3) | 37. | (4) | 45. | (3) | 53. | (2) | | |
| 6. | (1) | 14. | (3) | 22. | (3) | 30. | (2) | 38. | (1) | 46. | (3) | 54. | (3) | | |
| 7. | (3) | 15. | (3) | 23. | (2) | 31. | (3) | 39. | (2) | 47. | (2) | 55. | (3) | | |
| 8. | (2) | 16. | (4) | 24. | (3) | 32. | (2) | 40. | (3) | 48. | (2) | 56. | (3) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (2) | 63. | (2) | 65. | (2) | 67. | (6) | 69. | (4) | 71. | (9) | 73. | (6) | 75. | (2) |
| 62. | (60) | 64. | (54) | 66. | (2) | 68. | (4) | 70. | (54) | 72. | (8) | 74. | (2) | | |

## 14. ELECTROSTATIC POTENTIAL AND CAPACITANCE

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 59)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 9. | (1) | 17. | (4) | 25. | (1) | 33. | (1) | 41. | (1) | 49. | (2) | 57. | (2) |
| 2. | (2) | 10. | (4) | 18. | (3) | 26. | (1) | 34. | (4) | 42. | (2) | 50. | (2) | 58. | (3) |
| 3. | (2) | 11. | (3) | 19. | (1) | 27. | (4) | 35. | (3) | 43. | (3) | 51. | (3) | 59. | (1) |
| 4. | (1) | 12. | (3) | 20. | (4) | 28. | (2) | 36. | (2) | 44. | (2) | 52. | (4) | | |
| 5. | (3) | 13. | (3) | 21. | (3) | 29. | (4) | 37. | (1) | 45. | (3) | 53. | (2) | | |
| 6. | (3) | 14. | (2) | 22. | (3) | 30. | (1) | 38. | (2) | 46. | (2) | 54. | (3) | | |
| 7. | (4) | 15. | (1) | 23. | (4) | 31. | (1) | 39. | (1) | 47. | (4) | 55. | (2) | | |
| 8. | (4) | 16. | (1) | 24. | (3) | 32. | (2) | 40. | (3) | 48. | (4) | 56. | (2) | | |

*INTEGER TYPE QUESTIONS (60 TO 71)*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | (4) | 62. | (0) | 64. | (6) | 66. | (18) | 68. | (6) | 70. | (161) |
| 61. | (0) | 63. | (16) | 65. | (27) | 67. | (6) | 69. | (200) | 71. | (125) |

## 15. CURRENT ELECTRICITY

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (2) | 9. | (3) | 17. | (3) | 25. | (3) | 33. | (3) | 41. | (4) | 49. | (1) | 57. | (1) |
| 2. | (1) | 10. | (1) | 18. | (4) | 26. | (2) | 34. | (2) | 42. | (3) | 50. | (2) | 58. | (1) |
| 3. | (3) | 11. | (4) | 19. | (1) | 27. | (2) | 35. | (3) | 43. | (1) | 51. | (1) | 59. | (1) |
| 4. | (3) | 12. | (2) | 20. | (2) | 28. | (1) | 36. | (2) | 44. | (2) | 52. | (1) | 60. | (1) |
| 5. | (1) | 13. | (2) | 21. | (3) | 29. | (1) | 37. | (1) | 45. | (4) | 53. | (2) | | |
| 6. | (2) | 14. | (4) | 22. | (3) | 30. | (2) | 38. | (3) | 46. | (3) | 54. | (2) | | |
| 7. | (4) | 15. | (4) | 23. | (4) | 31. | (3) | 39. | (1) | 47. | (2) | 55. | (2) | | |
| 8. | (3) | 16. | (3) | 24. | (1) | 32. | (4) | 40. | (4) | 48. | (1) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (1) | 63. | (40) | 65. | (3) | 67. | (4) | 69. | (8) | 71. | (220) | 73. | (4) | 75. | (100) |
| 62. | (3) | 64. | (4) | 66. | (2) | 68. | (4) | 70. | (2) | 72. | (5) | 74. | (2) | | |

## 16. MAGNETIC EFFECTS OF CURRENT & MAGNETISM

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 55)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (4) | 8. | (3) | 15. | (1) | 22. | (1) | 29. | (1) | 36. | (2) | 43. | (4) | 50. | (4) |
| 2. | (1) | 9. | (2) | 16. | (3) | 23. | (1) | 30. | (3) | 37. | (2) | 44. | (4) | 51. | (4) |
| 3. | (1) | 10. | (4) | 17. | (4) | 24. | (4) | 31. | (4) | 38. | (3) | 45. | (1) | 52. | (1) |
| 4. | (2) | 11. | (4) | 18. | (4) | 25. | (1) | 32. | (1) | 39. | (2) | 46. | (2) | 53. | (1) |
| 5. | (3) | 12. | (1) | 19. | (3) | 26. | (1) | 33. | (2) | 40. | (2) | 47. | (1) | 54. | (2) |
| 6. | (3) | 13. | (4) | 20. | (2) | 27. | (3) | 34. | (2) | 41. | (2) | 48. | (3) | 55. | (3) |
| 7. | (1) | 14. | (2) | 21. | (1) | 28. | (2) | 35. | (2) | 42. | (3) | 49. | (1) | | |

*INTEGER TYPE QUESTIONS (56 TO 69)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 56. | (6) | 58. | (4) | 60. | (64) | 62. | (8) | 64. | (5) | 66. | (2) | 68. | (4) |
| 57. | (2) | 59. | (8) | 61. | (19) | 63. | (1) | 65. | (2) | 67. | (2) | 69. | (0) |

## 17. MAGNETISM AND MATTER

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 20)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 4. | (2) | 7. | (1) | 10. | (4) | 13 | (4) | 16. | (1) | 19. | (2) |
| 2. | (3) | 5. | (2) | 8. | (3) | 11. | (4) | 14. | (1) | 17. | (4) | 20. | (2) |
| 3. | (3) | 6. | (4) | 9. | (1) | 12. | (1) | 15. | (4) | 18. | (2) | | |

*INTEGER TYPE QUESTIONS (21 TO 29)*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21. | (14) | 23. | (4) | 25. | (2) | 27. | (250) | 29. | (10) |
| 22. | (4) | 24. | (8) | 26. | (1) | 28. | (2) | | |

## 18. ELECTROMAGNETIC INDUCTION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (4) | 17. | (4) | 25. | (2) | 33. | (2) | 41. | (3) | 49. | (3) | 57. | (4) |
| 2. | (4) | 10. | (1) | 18. | (2) | 26. | (1) | 34. | (2) | 42. | (4) | 50. | (1) | 58. | (1) |
| 3. | (4) | 11. | (1) | 19. | (4) | 27. | (2) | 35. | (4) | 43. | (4) | 51. | (3) | 59. | (4) |
| 4. | (4) | 12. | (2) | 20. | (4) | 28. | (2) | 36. | (4) | 44. | (2) | 52. | (2) | 60. | (1) |
| 5. | (2) | 13. | (3) | 21. | (2) | 29. | (3) | 37. | (2) | 45. | (3) | 53. | (2) | | |
| 6. | (4) | 14. | (2) | 22. | (4) | 30. | (2) | 38. | (4) | 46. | (2) | 54. | (2) | | |
| 7. | (4) | 15. | (1) | 23. | (2) | 31. | (3) | 39. | (4) | 47. | (1) | 55. | (3) | | |
| 8. | (4) | 16. | (2) | 24. | (2) | 32. | (3) | 40. | (3) | 48. | (4) | 56. | (4) | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61. | (625) | 63. | (8) | 65. | (2) | 67. | (6) | 69. | (12) | 71. | (2) | 73. | (250) | 75. | (2) |
| 62. | (15) | 64. | (2) | 66. | (12) | 68. | (2) | 70. | (1) | 72. | (3) | 74. | (12) | | |

## 19. ALTERNATING CURRENT

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 56)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (2) | 8. | (4) | 15. | (1) | 22. | (2) | 29. | (2) | 36. | (3) | 43. | (2) | 50. | (2) |
| 2. | (3) | 9. | (3) | 16. | (1) | 23. | (2) | 30. | (4) | 37. | (1) | 44. | (1) | 51. | (4) |
| 3. | (1) | 10. | (1) | 17. | (1) | 24. | (4) | 31. | (1) | 38. | (4) | 45. | (2) | 52. | (1) |
| 4. | (4) | 11. | (3) | 18. | (2) | 25. | (2) | 32. | (3) | 39. | (3) | 46. | (2) | 53. | (1) |
| 5. | (1) | 12. | (4) | 19. | (3) | 26. | (2) | 33. | (1) | 40. | (1) | 47. | (4) | 54. | (4) |
| 6. | (2) | 13. | (3) | 20. | (3) | 27. | (2) | 34. | (2) | 41. | (2) | 48. | (4) | 55. | (4) |
| 7. | (2) | 14. | (3) | 21. | (1) | 28. | (3) | 35. | (2) | 42. | (1) | 49. | (3) | 56. | (4) |

*INTEGER TYPE QUESTIONS (57 TO 70)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57. | (102) | 59. | (100) | 61. | (400) | 63. | (1) | 65. | (5) | 67. | (1) | 69. | (20) |
| 58. | (8) | 60. | (20) | 62. | (2) | 64. | (65) | 66. | (2) | 68. | (11) | 70. | (4) |

## 20. ELECTROMAGNETIC WAVES

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 58)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (1) | 9. | (3) | 17. | (3) | 25. | (3) | 33. | (2) | 41. | (2) | 49. | (4) | 57. | (1) |
| 2. | (2) | 10. | (3) | 18. | (1) | 26. | (4) | 34. | (3) | 42. | (2) | 50. | (2) | 58. | (3) |
| 3. | (2) | 11. | (1) | 19. | (3) | 27. | (2) | 35. | (4) | 43. | (4) | 51. | (2) | | |
| 4. | (3) | 12. | (4) | 20. | (3) | 28. | (3) | 36. | (2) | 44. | (2) | 52. | (3) | | |
| 5. | (3) | 13. | (2) | 21. | (3) | 29. | (4) | 37. | (3) | 45. | (4) | 53. | (1) | | |
| 6. | (3) | 14. | (2) | 22. | (4) | 30. | (3) | 38. | (2) | 46. | (4) | 54. | (2) | | |
| 7. | (4) | 15. | (1) | 23. | (3) | 31. | (1) | 39. | (1) | 47. | (2) | 55. | (3) | | |
| 8. | (3) | 16. | (1) | 24. | (2) | 32. | (2) | 40. | (3) | 48. | (4) | 56. | (3) | | |

*INTEGER TYPE QUESTIONS (59 TO 71)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59. | (8) | 61. | (6) | 63. | (15) | 65. | (4) | 67. | (25) | 69. | (137) | 71. | (2) |
| 60. | (9) | 62. | (667) | 64. | (2) | 66. | (43) | 68. | (3) | 70. | (500) | | |

## 21. RAY OPTICS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 58)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **(1)** | **9.** | **(2)** | **17.** | **(3)** | **25.** | **(2)** | **33.** | **(2)** | **41.** | **(3)** | **49.** | **(3)** | **57.** | **(2)** |
| **2.** | **(4)** | **10.** | **(3)** | **18.** | **(2)** | **26.** | **(3)** | **34.** | **(3)** | **42.** | **(4)** | **50.** | **(3)** | **58.** | **(3)** |
| **3.** | **(3)** | **11.** | **(2)** | **19.** | **(2)** | **27.** | **(2)** | **35.** | **(3)** | **43.** | **(3)** | **51.** | **(3)** | | |
| **4.** | **(2)** | **12.** | **(1)** | **20.** | **(1)** | **28.** | **(4)** | **36.** | **(4)** | **44.** | **(3)** | **52.** | **(4)** | | |
| **5.** | **(2)** | **13.** | **(2)** | **21.** | **(2)** | **29.** | **(1)** | **37.** | **(2)** | **45.** | **(2)** | **53.** | **(3)** | | |
| **6.** | **(2)** | **14.** | **(2)** | **22.** | **(2)** | **30.** | **(2)** | **38.** | **(1)** | **46.** | **(2)** | **54.** | **(1)** | | |
| **7.** | **(2)** | **15.** | **(3)** | **23.** | **(3)** | **31.** | **(3)** | **39.** | **(2)** | **47.** | **(3)** | **55.** | **(2)** | | |
| **8.** | **(3)** | **16.** | **(4)** | **24.** | **(3)** | **32.** | **(2)** | **40.** | **(1)** | **48.** | **(1)** | **56.** | **(1)** | | |

*INTEGER TYPE QUESTIONS (59 TO 72)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **59.** | **(4)** | **61.** | **(90)** | **63.** | **(20)** | **65.** | **(5)** | **67.** | **(6)** | **69.** | **(1)** | **71.** | **(113)** |
| **60.** | **(90)** | **62.** | **(30)** | **64.** | **(5)** | **66.** | **(4)** | **68.** | **(12)** | **70.** | **(400)** | **72.** | **(100)** |

## 22. WAVE OPTICS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 60)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | **(1)** | **9.** | **(4)** | **17.** | **(3)** | **25.** | **(4)** | **33.** | **(2)** | **41.** | **(4)** | **49.** | **(1)** | **57.** | **(1)** |
| **2.** | **(4)** | **10.** | **(4)** | **18.** | **(2)** | **26.** | **(3)** | **34.** | **(3)** | **42.** | **(3)** | **50.** | **(2)** | **58.** | **(1)** |
| **3.** | **(3)** | **11.** | **(3)** | **19.** | **(2)** | **27.** | **(4)** | **35.** | **(3)** | **43.** | **(2)** | **51.** | **(3)** | **59.** | **(2)** |
| **4.** | **(4)** | **12.** | **(1)** | **20.** | **(1)** | **28.** | **(3)** | **36.** | **(4)** | **44.** | **(4)** | **52.** | **(2)** | **60.** | **(3)** |
| **5.** | **(1)** | **13.** | **(1)** | **21.** | **(2)** | **29.** | **(3)** | **37.** | **(4)** | **45.** | **(1)** | **53.** | **(3)** | | |
| **6.** | **(1)** | **14.** | **(1)** | **22.** | **(3)** | **30.** | **(2)** | **38.** | **(1)** | **46.** | **(2)** | **54.** | **(4)** | | |
| **7.** | **(3)** | **15.** | **(4)** | **23.** | **(1)** | **31.** | **(3)** | **39.** | **(3)** | **47.** | **(2)** | **55.** | **(2)** | | |
| **8.** | **(4)** | **16.** | **(2)** | **24.** | **(3)** | **32.** | **(2)** | **40.** | **(1)** | **48.** | **(1)** | **56.** | **(3)** | | |

*INTEGER TYPE QUESTIONS (61 TO 75)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **61.** | **(48)** | **63.** | **(10)** | **65.** | **(09)** | **67.** | **(7)** | **69.** | **(750)** | **71.** | **(2)** | **73.** | **(3)** | **75.** | **(4)** |
| **62.** | **(600)** | **64.** | **(600)** | **66.** | **(462)** | **68.** | **(1)** | **70.** | **(30)** | **72.** | **(300)** | **74.** | **(75)** | | |

## 23. DUAL NATURE OF MATTER AND RADIATION

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 54)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 8. | (1) | 15. | (2) | 22. | (4) | 29. | (4) | 36. | (2) | 43. | (2) | 50. | (4) |
| 2. | (4) | 9. | (4) | 16. | (1) | 23. | (3) | 30. | (2) | 37. | (3) | 44. | (3) | 51. | (3) |
| 3. | (3) | 10. | (2) | 17. | (1) | 24. | (4) | 31. | (3) | 38. | (4) | 45. | (4) | 52. | (3) |
| 4. | (4) | 11. | (2) | 18. | (1) | 25. | (4) | 32. | (1) | 39. | (4) | 46. | (3) | 53. | (1) |
| 5. | (4) | 12. | (2) | 19. | (1) | 26. | (1) | 33. | (2) | 40. | (4) | 47. | (2) | 54. | (2) |
| 6. | (1) | 13. | (3) | 20. | (1) | 27. | (3) | 34. | (1) | 41. | (4) | 48. | (4) | | |
| 7. | (3) | 14. | (3) | 21. | (4) | 28. | (2) | 35. | (3) | 42. | (2) | 49. | (1) | | |

*INTEGER TYPE QUESTIONS (55 TO 69)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55. | (3) | 57. | (35) | 59. | (4) | 61. | (9) | 63. | (910) | 65. | (138) | 67. | (4) | 69. | (2) |
| 56. | (2) | 58. | (4) | 60. | (2) | 62. | (11) | 64. | (1) | 66. | (382) | 68. | (4) | | |

## 24. ATOMS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 57)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (3) | 9. | (4) | 17. | (1) | 25. | (3) | 33. | (1) | 41. | (3) | 49. | (1) | 57. | (1) |
| 2. | (1) | 10. | (2) | 18. | (2) | 26. | (3) | 34. | (1) | 42. | (3) | 50. | (3) | | |
| 3. | (2) | 11. | (2) | 19. | (1) | 27. | (2) | 35. | (2) | 43. | (3) | 51. | (2) | | |
| 4. | (1) | 12. | (2) | 20. | (2) | 28. | (3) | 36. | (3) | 44. | (3) | 52. | (1) | | |
| 5. | (1) | 13. | (1) | 21. | (1) | 29. | (2) | 37. | (4) | 45. | (4) | 53. | (1) | | |
| 6. | (1) | 14. | (1) | 22. | (3) | 30. | (2) | 38. | (3) | 46. | (3) | 54. | (1) | | |
| 7. | (2) | 15. | (1) | 23. | (4) | 31. | (3) | 39. | (1) | 47. | (4) | 55. | (4) | | |
| 8. | (4) | 16. | (4) | 24. | (3) | 32. | (2) | 40. | (1) | 48. | (4) | 56. | (2) | | |

*INTEGER TYPE QUESTIONS (58 TO 71)*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58. | (3) | 60. | (5) | 62. | (114) | 64. | (15) | 66. | (136) | 68. | (2) | 70. | (3) |
| 59. | (27) | 61. | (27) | 63. | (5) | 65. | (15) | 67. | (828) | 69. | (425) | 71. | (3) |

## 25. NUCLEUS

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 39)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (4) | 6. | (3) | 11. | (4) | 16. | (1) | 21. | (2) | 26. | (3) | 31. | (2) | 36. | (4) |
| 2. | (3) | 7. | (3) | 12. | (3) | 17. | (4) | 22. | (1) | 27. | (2) | 32. | (2) | 37. | (4) |
| 3. | (2) | 8. | (4) | 13. | (2) | 18. | (1) | 23. | (1) | 28. | (4) | 33. | (2) | 38. | (4) |
| 4. | (3) | 9. | (4) | 14. | (3) | 19. | (3) | 24. | (3) | 29. | (1) | 34. | (3) | 39. | (1) |
| 5. | (4) | 10. | (2) | 15. | (4) | 20. | (4) | 25. | (2) | 30. | (2) | 35. | (4) | | |

*INTEGER TYPE QUESTIONS (40 TO 54)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40. | (195) | 42. | (236) | 44. | (6) | 46. | (3) | 48. | (27) | 50. | (121) | 52. | (6) | 54. | (1) |
| 41. | (9) | 43. | (12) | 45. | (176) | 47. | (10) | 49. | (2) | 51. | (2) | 53. | (11) | | |

## 26. ELECTRONIC DEVICES

*SINGLE OPTION CORRECT TYPE QUESTIONS (01 TO 50)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (4) | 8. | (1) | 15. | (4) | 22. | (1) | 29. | (4) | 36. | (1) | 43. | (3) | 50. | (1) |
| 2. | (1) | 9. | (3) | 16. | (3) | 23. | (2) | 30. | (1) | 37. | (1) | 44. | (1) | | |
| 3. | (3) | 10. | (3) | 17. | (4) | 24. | (2) | 31. | (3) | 38. | (2) | 45. | (3) | | |
| 4. | (3) | 11. | (3) | 18. | (3) | 25. | (1) | 32. | (4) | 39. | (2) | 46. | (1) | | |
| 5. | (4) | 12. | (4) | 19. | (4) | 26. | (2) | 33. | (1) | 40. | (4) | 47. | (1) | | |
| 6. | (3) | 13. | (2) | 20. | (2) | 27. | (1) | 34. | (2) | 41. | (2) | 48. | (3) | | |
| 7. | (2) | 14. | (4) | 21. | (3) | 28. | (2) | 35. | (1) | 42. | (3) | 49. | (3) | | |

*INTEGER TYPE QUESTIONS (51 TO 66)*

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51. | (5) | 53. | (480) | 55. | (4) | 57. | (1) | 59. | (20) | 61. | (25) | 63. | (9) | 65. | (5) |
| 52. | (14) | 54. | (3) | 56. | (9) | 58. | (25) | 60. | (5) | 62. | (20) | 64. | (500) | 66. | (192) |

# Hints & Solutions

# MATHEMATICAL TOOLS, UNITS, DIMENSIONS AND ERRORS

*Single Option Correct Type Questions (01 to 60)*

**1.** **(2)**

**Sol:** Velocity depends on length and time, so cannot be taken as base quantities. A fundamental quantity should be such that it does not depend on other fundamental quantities.

**2.** **(3)**

**Sol:** Angle is dimensionless but has unit (radian or degree)

**3.** **(1)**

**Sol:** A unitless quantity will always be dimensionless as it has to be a ratio of quantities with the same dimensions.

**4.** **(3)**

**Sol:** [moment of force] = $[F]\,[d] = ML^2T^{-2}$

[Moment of Inertia] = $[I] = ML^2$

Both are different from each other.

**5.** **(3)**

**Sol:** $d = k\ (\rho)^a\ (S)^b\ (f)^c$

$$\Rightarrow\ [L] = \left[\frac{M}{L^3}\right]^a \left[\frac{M^1L^2T^{-3}}{L^2\ \ 1}\right]^b \left[\frac{1}{T}\right]^c$$

$0 = a + b$

$1 = -3a \qquad \Rightarrow a = -\frac{1}{3} \qquad b = -a = \frac{1}{3}$

So, $n = 3$

**6.** **(2)**

**Sol:** $[v] = [k]\,[\lambda^a\,\rho^b\,g^c] \Rightarrow LT^{-1} = L^a\,M^b\,L^{-3b}\,L^c\,T^{-2c}$

$\Rightarrow LT^{-1} = M^b\,L^{a-3b+c}\,T^{-2c}$

$\Rightarrow a = 1/2,\ b = 0,\ c = 1/2$

So, $v^2 = kg\lambda$

**7.** **(1)**

**Sol:** $\tan 15 = \tan(45 - 30)$

$$= \frac{\tan 45 - \tan 30}{1 + \tan 45 \tan 30} = \frac{1 - \frac{1}{\sqrt{3}}}{1 + \frac{1}{\sqrt{3}}} = \frac{\sqrt{3}-1}{\sqrt{3}+1}$$

$$= \frac{(\sqrt{3}-1)^2}{2} = \frac{3+1-2\sqrt{3}}{2} = \frac{4-2\sqrt{3}}{2} = 2-\sqrt{3}$$

**8.** **(2)**

**Sol:** [Force] = $M^1L^1T^{-2}$ [Velocity] = $LT^{-1}$

[density] = $ML^{-3}$ [Area] = $L^2$

So, $F \propto \rho^a v^b A^c$

Solving it we get $a = 1$, $b = 2$, $c = 1$

So $F \propto \rho^1 A^1 V^2$

**9.** **(2)**

**Sol:** $\therefore\ \cos\left(\frac{\pi}{2}+\theta\right) = -\sin\theta$ [cos in II quadrant gives negative value]

$\sin(\theta-\pi) = \sin[-(\pi-\theta)] = -\sin(\pi-\theta)$

$= -\sin\theta$

$\sin(\pi+\theta) = -\sin\theta$ [sin function is –ve in III quadrant]

$\cos\left(\frac{\pi}{2}-\theta\right) = \sin\theta$

**10.** **(2)**

**Sol:** (i) $U = \sigma A T^4 \Rightarrow [\sigma] = \frac{[U]}{[A][T^4]}$

$$= \frac{ML^2T^{-3}}{L^2K^4} = MT^{-3}K^{-4}$$

(ii) $\lambda T = b \Rightarrow [b] = [\lambda][T] = LK$

(iii) $\Rightarrow [\eta]\frac{[F]}{[r][v]} = \frac{MLT^{-2}}{L.LT^{-1}} = ML^{-1}T^{-1}$

(iv) $I = \frac{P}{A} = \frac{ML^2T^{-3}}{L^2} = ML^oT^{-3}$

**11.** **(4)**

**Sol:** 2d sinθ = λ ….(1)

$$d = \frac{\lambda}{2\sin\theta} = \frac{\lambda}{2}(\text{cosec}\,\theta)$$

Differentiate

$$\Delta(d) = \frac{\lambda}{2}(-\text{cosec}\,\theta\ \cot\theta)\Delta\theta$$

$$|\Delta(d)| = \frac{\lambda\cos\theta}{2\sin^2\theta}\Delta\theta \quad ….(2)$$

As θ = increases, cos θ decreases and sin θ increases so $\frac{\lambda\cos\theta}{2\sin^2\theta}$ decreases

⇒ Absolute error in *d* (that is |Δ (d)|) decreases.

$$\frac{|\Delta(d)|}{d} = \frac{\cos\theta}{\sin\theta}(\Delta\theta) = \cot\theta\Delta\theta$$

as θ = increases, cotθ decreases so fractional error in *d* (that $\frac{|\Delta(d)|}{d}$) will also decrease

**12.** **(2)**

**Sol:** Sum of any 3 sides should be greater than fourth side.

**13.** **(4)**

**Sol:** Least count of screw gauge

$$\frac{0.5}{50}\text{ mm} = 0.01\text{ mm}$$

∴ Reading = [Main scale reading + circular scale reading × L.C.] – (zero error)

= [3 + 35 × 0.01] – (–0.03) = 3.38 MM

**14.** **(4)**

**Sol:** Slope = tan45° = $\frac{v}{u} \Rightarrow v = u$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{-v} \Rightarrow v = 2f = u \quad P \equiv (2f, 2f)$$

**15.** **(1)**

**Sol:** Rule: I. We know all non-zero digits are significant.

Rule: II. If zero is between two non-zero digits this is also significant.

Rule: III. If zero left to the non-zero digit they are non-significant.

Significant figures for number 23.023 is 5. Using I & II.

Significant figures for number 0.0003 is 1. Using I, II & III.

Significant figures for number 2.1 × $10^{-3}$ is 2. Using I.

**16.** **(2)**

**Sol:** If student measure 3.50 cm it means that there in an uncertainly of order 0.01 cm

L.C of V.C = 1 MSD – 1VSD

$$= \frac{1}{10}\left[1 - \frac{9}{10}\right] = \frac{1}{100}\text{ cm}$$

**17.** **(2)**

**Sol:** Given $\frac{\Delta L}{L} = \frac{0.1}{20}$

and $\frac{\Delta t}{t} = \frac{1}{90}$

$$g = \left(\frac{1}{4\pi^2}\right)\frac{L}{T^2} = \left(\frac{1}{4\pi^2}\right)\frac{L}{\left(\frac{t}{100}\right)^2}$$

$$\Rightarrow \frac{\Delta g}{g}\times 100\% = \frac{\Delta L}{L}\times 100 + \frac{2\Delta t}{t}\times 100$$

$$\frac{\Delta g}{g}\times 100\% = \left(\frac{0.1}{20}\right)100 + 2\left(\frac{1}{90}\right)100 = 2.72\%$$

So closest option is 3%.

**18. (4)**

**Sol:** $t_{\text{mean}} = \dfrac{90+91+95+92}{4} = 92$ sec.

Absolute error in each reading = 2, 1, 3, 0

Mean error = $\dfrac{2+1+3+0}{2} = 1.5$ sec.

put the least count of the measuring clock is 1 sec.

so it cannot measure upto 0.5 second so we have to round it off.

so mean error will be 2 second

So, $t = 92 \pm 2$ sec.

**19. (3)**

**Sol:** $[A] = [MLT^{-2}]$

$[B] = [L^{-1}]$

$[D] = [T^{-1}]$

$\left[\dfrac{AD}{B}\right] = \dfrac{[MLT^{-2}][T^{-1}]}{[L^{-1}]}$ or

$\left[\dfrac{AD}{B}\right] = [ML^2T^{-3}]$

**20. (3)**

**Sol:** $f(x) = \log x^3 = 3 \log x = 3g(x)$

**21. (1)**

**Sol:** $G = 6.67 \times 10^{-11}$ N m$^2$ (kg)$^{-2}$

$= 6.67 \times 10^{-11} \times 10^5$ dyne $\times 100^2$ cm$^2$/ $(10^3)^2$ $g^2$

$= 6.67 \times 10^{-8}$ dyne-cm$^2$-g$^{-2}$

**22. (3)**

**Sol:** Dimension of energy ($E$) $ML^2T^{-2}$ …(i)

Dimension of momentum ($P$) = $MLT^{-1}$ …(ii)

Dimension of area ($A$) = $L^2$or $A^{1/2}$ …(iii)

Substituting (ii) and (iii) in equation (i) we get

Dimensional formula for energy (e) $P^1T^{-1}A^{1/2}$

**23. (3)**

**Sol:** $\sin A \,.\, [\sin A \cos B + \cos A \,.\, \sin B]$

$\sin^2 A \,.\, \cos B + \sin A \,.\, \cos A \,.\, \sin B$

$\sin^2 A \,.\, \cos B + \dfrac{1}{2} \sin 2A \,.\, \sin B$

**24. (2)**

**Sol:** $[g] = LT^{-2}$ and numerical value $\propto \dfrac{1}{\text{units}}$

**25. (1)**

**Sol:** $\vec{F} = 2\hat{i} - 3\hat{j}$ N

**26. (2)**

**Sol:** (I) $\dfrac{GM_eM_s}{R_e^{\,2}}$ = Force

$[GM_eM_s]$ = [Force] $[R_e^2]$ = $MLT^{-2}\,L^2$

$= ML^3T^{-2}$

Hence SI unit of $GM_eM_s$, will be (kilogram) (meter$^3$)(sec$^{-2}$)

ie same as (volt) (coulomb) (metre)

(II) $\sqrt{\dfrac{3RT}{M}} = V_{\text{R.M.S.}}$

$\left[\dfrac{3RT}{M_0}\right] = [V_{\text{R.M.S.}}]^2 = L^2T^{-2}$

Hence SI unit will be (metre)$^2$ (second)$^{-2}$

ie same as (farad) (volt)$^2$ (kg)$^{-1}$

(III) $\dfrac{[F^2]}{[q^2B^2]} = \dfrac{[q^2v^2B^2]}{[q^2B^2]} = [V^2] = L^2T^{-2}$

Hence SI unit (metre)$^2$ (second)$^{-2}$

i.e. same as (farad) (volt)$^2$ (kg)$^{-1}$

(IV) $\left[\dfrac{GM_e}{R_e}\right] = \dfrac{[\text{Force}]\ [R_e]}{[\text{Mass}]}$

$= \dfrac{MLT^{-2}L}{M} = L^2T^{-2}$

Hence SI unit will be (meter)$^{-2}$ (second)$^{-2}$ i.e. same as (farad) (volt)$^2$ (kg)$^{-1}$

**27. (3)**

**Sol:** $b$ has the dimensions of volume, $[b] = [V]$

$\because \left[\dfrac{a}{V^2} = [P]\right] \Rightarrow \left[\dfrac{a}{b^2}\right] = [P]$

$\therefore \left[\dfrac{b^2}{a}\right] = \dfrac{1}{[P]} = \dfrac{1}{[B]} = [K]$

**28.** **(1)**

**29.** **(3)**

**Sol:** $R^2 = 2A^2(1+\cos\theta) = 2A^2\left(1+2\cos^2\frac{\theta}{2}-1\right)$

$= 2^2 A^2 \cos^2\frac{\theta}{2}$

$R = 2A\cos\frac{\theta}{2}$

**30.** **(1)**

**Sol:** $128[M_1L_1^{-3}] = n_2[M_2L_2^{-3}]$

$\Rightarrow n_2 = 128\left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]^{-3} = 128\left[\frac{1000}{50}\right]\left[\frac{100}{25}\right]^{-3}$

$= \frac{128\times 20}{64} = 40$

**31.** **(4)**

**Sol:** $t = \sqrt{\frac{L}{5}} + \frac{L}{300}$

$dt = \frac{1}{\sqrt{5}}\frac{1}{2}L^{-1/2}dL + \left(\frac{1}{300}dL\right)$

$dt = \frac{1}{2\sqrt{5}}\frac{1}{\sqrt{20}}dL + \frac{dL}{300} = 0.01$

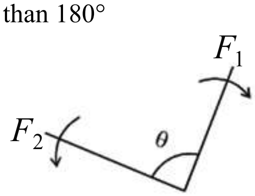
$dL\left(\frac{1}{20}+\frac{1}{300}\right) = 0.01$

$dL = \frac{3}{16}$

$\frac{dL}{L}\times 100 = \frac{3}{16}\times\frac{1}{20}\times 100 = \frac{15}{16} \simeq 1\%$

**32.** **(1)**

**Sol:** Angle between two vectors can never be greater than 180°




$F_{net} = F_1^2 + F_2^2 + 2F_1F_2\cos\theta$

From 0 to 180° the cosθ decrease

So, on increasing the θ, the magnitude of resultant vectors decreases.

**33.** **(2)**

**Sol:** Initial velocity = $\vec{u} = 50\hat{j}$

Final velocity = $\vec{v} = -50\hat{j}$

So $\vec{v}-\vec{u} = -50\hat{i} - 50\hat{j}$

$|\vec{v}-\vec{u}| = -50\sqrt{2}$

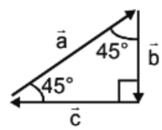
Along south west.

**34.** **(2)**

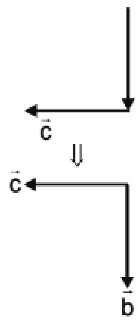
**Sol:** $a+b \geq |\vec{a}+\vec{b}| \geq a-b$

**35.** **(1)**

**Sol:**



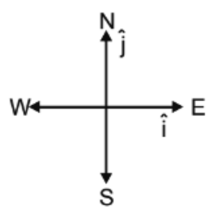

By vector translation




∴ 90°, 135°, 135°

**36.** **(4)**

**Sol:**




$\vec{A} \to -\hat{k}$

$\vec{B} \to +\hat{i}$

$\vec{A}\times\vec{B} = -\hat{k}\times\hat{i} = -\hat{j} \Rightarrow$ south

**37.** **(3)**

**Sol:** $a^2 + b^2 + 2ab\cos\theta = a^2 + 4b^2 - 4ab\cos\theta$

or $\cos\theta = \dfrac{b}{2a} \le 1 \qquad \therefore\ b \le 2a$

**38.** **(4)**

**Sol:** (I) $\int \sec x \tan x\, dx = \sec x + C$

(II) $\int \text{cosec}\, kx \cot kx\, dx = \dfrac{-\text{cosec}\, kx}{k} + C$

(III) $\int \text{cosec}^2\ kx\, dx = -\dfrac{\cot kx}{k} + C$

(IV) $\int \cos kx\, dx = \dfrac{\sin kx}{k} + C$

**39.** **(3)**

**Sol:** (I) $|\vec{A}+\vec{B}| = A^2 + B^2 + 2AB\cos\theta$

$A^2 = A^2 + A^2 + 2A^2\cos\theta \quad \cos\theta = -\dfrac{1}{2}, \theta = 120$

(II) $F_1 \sim F_2 \le R \le F_1 + F_2$

Here $F_1 \sim F_2 = 4$ and $F_1 + F_2 = 12$

(III) $\cos\theta = \dfrac{\vec{A}\ .\ \vec{B}}{|A||B|} = \dfrac{0}{2\sqrt{2}\times 3} = 0$. So, $\theta = 90^\circ$

(IV) $\vec{A}+\vec{B} = 2\hat{i} + \hat{j} + 3\hat{k}$

$|\vec{A}+\vec{B}| = \sqrt{2^2 + 1 + 3^2} = \sqrt{14}$

**40.** **(4)**

**Sol:** $\dfrac{dx}{dt} = V = 3t^2 - 6t + 12$ and $\dfrac{dv}{dt} = a = 6t - b$

$a = 0$ at $t = 1$ sec

$v = 3t^2 - 6t + 12 = 9$ m/s

**41.** **(3)**

**Sol:** $|\vec{a}| - |\vec{b}| \le |\vec{a}+\vec{b}| \le |\vec{a}| + |\vec{b}|$

**42.** **(2)**

**Sol:** $R = \sqrt{A_x^2 + B_y^2} = \sqrt{8^2 + 6^2} = 10$

**43.** **(1)**

**Sol:** Angle between two vector given by.

$\cos\theta = \dfrac{\vec{A}.\vec{B}}{AB}$

so $\cos\theta = \dfrac{(\hat{i}+\hat{j}).\hat{k}}{|(\hat{i}+\hat{j})||\hat{k}|} = \dfrac{0}{\sqrt{2}\times 1} = 0$

$\cos\theta = 0 \qquad \theta = \dfrac{\pi}{2}$

**44.** **(3)**

**Sol:** $A(1, 1, -1)\ B(2, -3, 4)$

$\overrightarrow{AB} = \vec{B} - \vec{A} = (2\hat{i} - 3\hat{j} + 4\hat{k}) - (\hat{i} + \hat{j} - \hat{k})$

$\therefore\ \overrightarrow{AB} = \hat{i} - 4\hat{j} + 5\hat{k}$

**45.** **(3)**

**Sol:** (I) $U = \dfrac{1}{2}kT$

$\Rightarrow ML^2T^{-2} = [k]\ K \Rightarrow [k] = ML^2T^{-2}K^{-1}$

(II) $F = \eta A\dfrac{dv}{dx}$

$\Rightarrow [\eta] = \dfrac{MLT^{-2}}{L^2LT^{-1}L^{-1}} = ML^{-1}\ T^{-1}$

(III) $E = h\nu$

$\Rightarrow ML^2T^2 = [h]\ T^{-1} \Rightarrow [h] = ML^2\ T^{-1}$

(IV) $\dfrac{dQ}{dt} = \dfrac{kA\Delta\theta}{\ell}$

$\Rightarrow [k] = \dfrac{ML^2T^{-3}L}{L^2K} = MLT^{-3}\ K^{-1}$

**46.** **(2)**

**Sol:** $\vec{E} = \dfrac{A}{x^2}i + \dfrac{B}{y^3}j$

$\left[\dfrac{A}{x^2}\right] = NC^{-1} \Rightarrow [A] = Nm^2C^{-1}$

$\left[\dfrac{A}{y^3}\right] = NC^{-1} \Rightarrow [A] = Nm^3C^{-1}$

**47.** **(2)**

**Sol:** $m = \dfrac{4\pi R^3}{3}\times\rho$

$\ell n(m) = \ell n\left(\dfrac{4\pi}{3}\right) + \ell n(\rho) + 3\ell n(R)$

$0 = 0 + \dfrac{1}{\rho}\dfrac{d\rho}{dt} + \dfrac{3}{R}\dfrac{dR}{dt}$

$\Rightarrow \left(\frac{dR}{dt}\right) = v \propto -R \times \frac{1}{\rho}\left(\frac{d\rho}{dt}\right)$

$v \propto R$

**48.** **(4)**

**Sol:** Energy stored in inductor

$U = \frac{1}{2}LI^2 \Rightarrow L = \frac{2U}{I^2}$

$[L] = \frac{ML^2T^{-2}}{Q^2/T^2} = \frac{ML^2}{Q^2}$

Since Henry is unit of inductance L

$\therefore$ (4) is correct.

**49.** **(2)**

**Sol:** From $F = qvB$

$\Rightarrow$ $[MLT^{-2}] = [C]\,[LT^{-1}]\,[B]$

$\Rightarrow$ $[B] = [MC^{-1}T^{-1}]$

**50.** **(2)**

**Sol:** $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{R^2}$

$\varepsilon_0 = \frac{q_1q_2}{4\pi FR^2}$

Hence $\varepsilon_0 = \frac{C^2}{N.m^2} = \frac{[AT]^2}{MLT^{-2}\,.\,L^2}$

$= [M^{-1}L^{-3}T^4A^2]$

**51.** **(1)**

**52.** **(1)**

A vector has both magnitude and direction. A vector is charged if its rotated through certain angle as its direction has been charged if vector is multiplied by scalar quantity its magnitude is changed. A vector does not change if it is displaced parallel to itself.

**53.** **(2)**

**Sol:** (I) Planck's constant

$h = \frac{E}{v} = \frac{[M^1L^2T^{-2}]}{[T^{-1}]} = [M^1L^2T^{-1}]$

(II) $E = qV$

$V = \frac{E}{q} = \frac{[M^1L^2T^{-2}]}{[A^1T^1]} = [M^1L^2T^{-3}A^{-1}]$

(III) $\phi$ (work function) = energy = $[M^1L^2T^{-2}]$

(IV) Momentum $(p)(Q) = Ft = [M^1L^1T^{-2}T^1]$

$= [M^1L^1T^{-1}]$

**54.** **(1)**

**Sol:** We know that,

Velocity gradient = $\frac{dv}{dx}$

Decay constant ($\lambda$) = $\frac{0.693}{T_{1/2}} = [T^{-1}]$

$\therefore$ Dimension of velocity gradient $\left(\frac{dv}{dx}\right) = \frac{LT^{-1}}{L} = \left[T^{-1}\right]$

**55.** **(4)**

**Sol:** $\Delta Q = ms\Delta T \Rightarrow [s] = \frac{[\Delta Q]}{[m][\Delta T]}$

$\Rightarrow [s] = \frac{[ML^2T]^{-1}}{[MT]} = \frac{[ML^2T^{-2}]}{[MT]}[L^{-2}T^{-3}]$

$\Delta Q = mL \Rightarrow [L] = \frac{ML^2T^{-2}}{M} = L^2T^{-2}$

So specific heat capacity and Latent heat have different dimension.

**56.** **(4)**

**Sol:** Dimension for permittivity $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$

Dimension for permeability $[\mu_0] = MLT^{-2}A^{-2}$

Dimension for electrical resistance $[R] = ML^2T^{-3}A^{-2}$

Using the given options

$[R] = \sqrt{\frac{\mu_0}{\varepsilon_0}}$

**57.** **(3)**

**Sol:** $120^\circ + \theta + \theta = 180^\circ$

$\Rightarrow \theta = 30^\circ$

So, $\angle A = \angle C = 30^\circ$

$\frac{\sin 120}{10} = \frac{\sin\angle A}{a} = \frac{\sin\angle C}{c}$

$\Rightarrow \frac{\sin 120}{10} = \frac{\sin 30}{a} = \frac{\sin 30}{C}$

Side $a$ = side $c = \frac{10\sqrt{3}}{3}$ m

**58.** **(4)**

**Sol:** Given, $u = \frac{\alpha}{\beta}\sin\left(\frac{\alpha x}{kt}\right)$

Dimension of Boltzmann Constant,

$[K] \rightarrow [M^1L^2T^{-2}K^{-1}]$

Dimension of energy density $[\mu] \rightarrow [ML^{-1}T^{-2}]$

Dimension of Temperature $[t] = [K]$

Since, angle has no dimension, therefore its dimensional formula is $[M^0L^0T^0]$

or $\frac{\alpha x}{kt} = [M^0L^0T^0]$

$\Rightarrow \frac{\alpha[L]}{[ML^2T^{-2}K^{-1}K]}[M^0L^0T^0]$

$\alpha = [MLT^{-2}]$

Also, dimension of $\frac{\alpha}{\beta}$ = dimension of energy density

$\frac{\alpha}{\beta} = [ML^{-1}T^{-2}]$

$\beta = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]}[M^0L^2T^0]$

**59.** **(3)**

**Sol:** $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc} = \frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{r^2} \times \frac{r^2}{\frac{hc}{\lambda}\times\lambda} = \frac{Fr \times r}{E \times \lambda}$ as

$\left(E = \frac{hc}{\lambda} \text{ and } F = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}\right)$

Dimension of '$Fr$' and '$E$' are same.

Therefore, given quantity is dimensionless

**60.** **(3)**

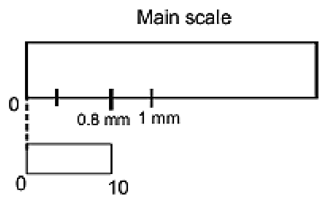
**Sol:** $\cos^2\theta = 1 - 2\sin^2\theta$

$2\sin^2\theta = 1 - \cos^2\theta \Rightarrow \sin^2\theta = \left(\frac{1-\cos^2\theta}{2}\right)$

## *Integer Type Questions (61 to 75)*

**61.** **(1)**

**Sol:**




20 VSD = 16 MCD

1 VSD = 0.8 MSD

Least count = MSD – VSD = 1 mm – 0.8 mm = 0.2 mm = $x$ mm

So $\frac{x}{0.2} = 1$

**62.** **(4)**

**Sol:** $E(t) = A^2e^{\alpha t}$ $\quad\quad$ $\alpha = 0.2\,s^{-1}$

$\frac{dA}{A} = 1.25\%$ $\quad\quad$ $\frac{dt}{t} = 1.50\%$

$\frac{dE}{E} = ?$

$\log E = 2\log A - \alpha t$

$\frac{dE}{E} = \pm 2\frac{dA}{A} \pm \alpha dt$

$= \pm 2(1.25) \pm 0.2(7.5) = \pm 2.5 \pm 1.5 = \pm 4\%$

**63.** **(1)**

**Sol:** 29 division of main scale coincides with 30 divisions of vernier scale

Hence one division of vernier scale = $\frac{29}{30}$ of main scale = $\frac{29}{30} \times 0.5^\circ$

So least count = 1 MSD – 1 VSD

$= 0.5^\circ - \frac{29}{30} \times 0.5^\circ = \frac{1}{30} \times 0.5^\circ$

$= \frac{1}{30} \times 0.5 \times 60 \text{ min} = 1 \text{ min}$

So, $n = 1$

**64. (1)**

**Sol:** $I = e^{\frac{1000V}{T}} - 1$

$I + 1 = e^{\frac{1000V}{T}}$

$\log(I+1) = \frac{1000}{T} dV$

$\frac{d(I+1)}{I+1} = \frac{1000}{T} dV$

$\frac{dI}{I+1} = \frac{1000}{T} dV$

$\frac{dI}{(5+1)mA} = \frac{1000}{300}(0.01)$

$dI = 0.2$ mA

So $n = 0.2$ and $\frac{n}{0.2} = 1$.

**65. (1)**

**Sol:** $f(\pi/2) = \cos \pi/2 + \sin \pi/2 = 1$

**66. (2)**

**Sol:** $c^2 = a^2 + b^2 - 2ab \cos\theta$

$9 = 9 + 16 - 2 \times 3 \times 4 \times \cos\theta$

$\cos\theta = \frac{16}{24} = \frac{2}{3}$

So, $n = 2$

**67. (8)**

**Sol:** $x = -t^2 + 4t + 4$ ............... (i)

For maxima

$\frac{dx}{dt} = 0$

$-2t + 4 = 0$

$t = 2$

from equation (i)

$\frac{d^2x}{dt^2} = -2 < 0$

$x$ has maximum value at $t = 2$ sec. maximum value of $x$

$t = 2$ sec.

$x_{max} = -(2)^2 + 4(2) + 4 = 8$

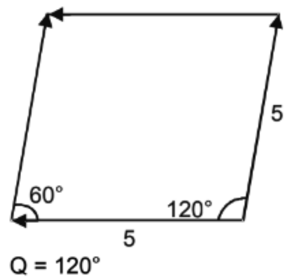
**68. (2)**

**Sol:** $\int_0^\pi y\,dx = \int_0^\pi \sin x\,dx = [-\cos x]_0^\pi$

$[-\cos\pi + \cos 0] = 2$

**69. (120)**

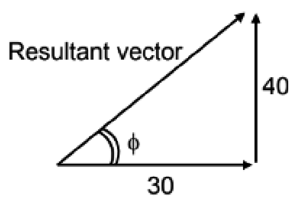
**Sol:**




**70. (53)**

**Sol:** $\vec{A} = 30\,\hat{i}$

$\vec{B} = 30\,\hat{j}$




$\hat{i} = \vec{A} + \vec{B} = 30\hat{i} + 40\hat{j}$

$\tan\phi = \frac{4}{3} = 53^\circ$

So, 53° with east

So, $y = 53$

**71. (15)**

**Sol:** $\frac{3\pi^2}{2}$

$$\left[\frac{\theta^2}{2}\right]_{\pi}^{2\pi} = \frac{4\pi^2}{2} - \frac{\pi^2}{2} = \frac{3\pi^2}{2} = 15$$

So, $n = 15$

**72.** **(120)**

**Sol:** $|\vec{A}+\vec{B}| = |\vec{A}| = |\vec{B}|$

and $|A| = |B| \neq 0$

$$|\vec{A}+\vec{B}|^2 = A^2 + B^2 + AB\cos\theta \ (|A| = |B|)$$

$= 2A^2 + 2A^2 \cos\theta$

$= 2A^2 (1 + \cos\theta)$

$= 2A^2 (2\cos^2 \frac{\theta}{2})$

$= 4A^2 (\cos^2 \frac{\theta}{2})$

Now $|\vec{A}+\vec{B}| = \vec{A}$

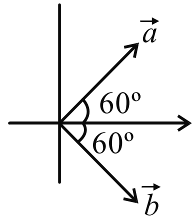
So $A^2 = 4A^2 \left(\cos^2 \frac{\theta}{2}\right)$

$\cos\left|\frac{\theta}{2}\right| = \frac{1}{2}$ $\quad\quad$ $\frac{\theta}{2} = 60^o$

$\theta = 120^o$

**73.** **(2)**

**Sol:**



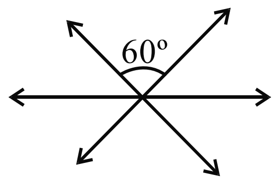

Only horizontal along + x-axis

$\Rightarrow$ 2cos 60° + 2 cos 60° = 2

**74.** **(0)**

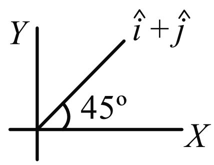
**Sol:** Opposite forces cancel each other.

So, the resultant force is zero.




**75.** **(45)**

**Sol:**



# KINEMATICS

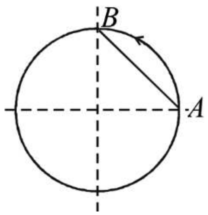
## Single Option Correct Type Questions (01 to 60)

**1.** **(1)**

**Sol:** Displacement = $d_1 = \sqrt{2}r$

Distance from $A$ to $B = d_2 = \left(\frac{\pi r}{2}\right)$

$$\frac{d_2}{d_1} = \frac{\frac{\pi r}{2}}{\sqrt{2}\ r} = \left(\frac{\pi}{2\sqrt{2}}\right)$$




**2.** **(1)**

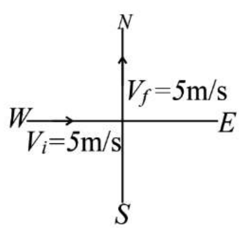
**Sol:** $$< v >= \left(\frac{x}{\frac{x}{30}+\frac{x}{60}+\frac{x}{180}}\right) = \left(\frac{1}{\frac{1}{30}+\frac{1}{60}+\frac{1}{180}}\right)$$

$$= \frac{180}{6+3+1}$$

$< v > = 18$ km/h

**3.** **(2)**

**Sol:**

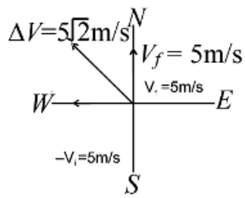



$$\vec{a} = \frac{\vec{V}_f - \vec{V}_i}{\Delta_t}$$

$$\vec{a} = \frac{5\hat{j} - 5\hat{i}}{10}$$

$$|\ \vec{a}\ | = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\ \text{m/s}^2$$

Direction north west




**4.** **(4)**

**Sol:** $x = a_0 + a_1 t + a_2 t^2$

$$\frac{dx}{dt} = 0 + a_1 + 2a_2 t$$

$$a = \frac{d^2x}{dt^2} = 0 + 2a_2$$

**5.** **(4)**

**Sol:** $s = t^3 - 6t^2 + 3t + 4$

$$v = \frac{ds}{dt} = 3t^2 - 12t + 3$$

$$a = \frac{dv}{dt} = 6t - 12 = 0 \ \therefore\ t = 2 \text{ sec}$$

$v = 3(2)^2 - 12 \times 2 + 3$

$= 12 - 24 + 3 = -9$m/s

**6.** **(4)**

**Sol:** $\sqrt{x} = t + 7$

$x = (t + 7)^2 = t^2 + 49 + 14t$

$v = \frac{dx}{dt} = 2t + 14$

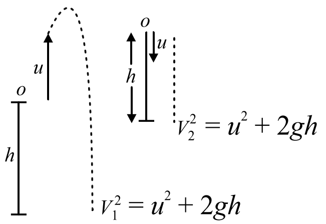
$a = 2$

**7.** **(4)**

**Sol:** At maximum height velocity is zero and acceleration is $g$.

**8.** **(3)**

**Sol:**




$V_1 = V_2$ so $\frac{V_1}{V_2} = 1 : 1$

**9.** **(4)**

**Sol:** $V_A = \tan 30^\circ$

$V_B = \tan 60^\circ$

$\frac{V_A}{V_B} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{1}{\sqrt{3}.\sqrt{3}} = 1 : 3$

**10.** **(4)**

**Sol:** Distance travelled by the body in 4 sec.

= area under $v$–$t$ graph

$= \frac{1}{2} \times 1 \times 20 + 1 \times 20 + 2 \times 10 + \frac{1}{2} \times 1 \times 10 = 10 + 20 + 20 + 5 = 55$ m

**11.** **(4)**

**Sol:** Maximum height $= \frac{1}{2} \times 120 \times 1000 = 60$ km

**12.** **(1)**

**Sol:** As the slope of tangent decreases, velocity also decreases with time.

after time distance becomes constant i.e particle stops.

**13.** **(3)**

**Sol:** Slope is –ve at $E$.

**14.** **(1)**

**Sol:** $v = u - gt$

$v = -gt + u$

**15.** **(4)**

**Sol:** $h_1 = \frac{1}{2} g (3)^2$

$h_2 = \frac{1}{2} g (3 - 2)^2$

$h_1 - h_2 = \frac{1}{2} g (9 - 1) = 4 \times 9.8 = 39.2$ m

**16.** **(2)**

**Sol:** $T = \frac{2u}{g}$

maximum height $H = \frac{u^2}{2g} = 20$m

$u = 20$ m/s, $T = 4$ sec

Time gap between each ball = 1 sec

$h_1 = ut_1 - \frac{1}{2} g{t_1}^2 = 20 \times 1 - \frac{1}{2} \times 10 (1)^2$

$= 20 - 5 = 15$m

$h_2 = ut_2 - \frac{1}{2} gt^2$

$= 20 \times 2 - \frac{1}{2} \times 10(2)^2 = 40 - 20 = 20$m

$h_3 = ut_3 - \frac{1}{2} g{t_3}^2$

$= 20 \times 3 - \frac{1}{2} \times 10(3)^2 = 60 - 45 = 15$ m

**17.** **(1)**

**Sol:** Average velocity $= \frac{\text{Displacement}}{\text{Time taken}}$ & Average speed $= \frac{\text{Distance}}{\text{Time taken}}$

Distance can be equal to or greater than displacement magnitude.

When speed is zero throughout an interval, particle does not move at all.

So, average speed is also zero in that interval.

Hence, (3) is incorrect.

When speed is not zero in an interval, particle covers some distance, but displacement can be zero.

So, average velocity can be zero in that interval but average speed will never be zero.

Hence, (4) is incorrect

**18.** **(2)**

**Sol:** Let $a$ be the retardation produced by resistive force, $t_a$ and $t_d$ be the time of ascent and time of descent respectively. If the particle rises upto a height 'h'.

Then $h = \frac{1}{2}(g + a)\,t_a^2$ and $h = \frac{1}{2}(g - a)\,t_d^2$

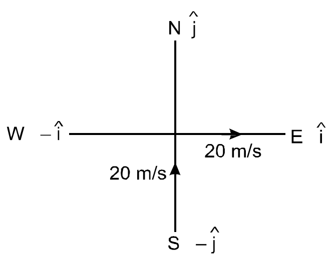
$$\therefore \quad \frac{t_a}{t_d} = \sqrt{\frac{g-a}{g+a}} = \sqrt{\frac{10-2}{10+2}} = \sqrt{\frac{2}{3}}$$

**19.** **(2)**

**Sol:** $\vec{V_1} = 20\hat{j}$

$\vec{V_2} = 20\hat{i}$

Change in velocity




$\Delta\vec{V} = \vec{V_2} - \vec{V_1}$

$\Delta\vec{V} = +20\hat{i} - 20\hat{j}$

$\left|\Delta\vec{V}\right| = 20\sqrt{2}$

Direction *S-E*

**20.** **(4)**

**21.** **(4)**

**Sol:** Magnitude of average velocity

$$= \left|<\vec{V}>\right| = \frac{|\text{ displacement}|}{\text{time}}$$

Average speed, $<V> = \frac{\text{distance travelled}}{\text{time taken}}$

Since magnitude of displacement is not necessarily equal to distance travelled; hence $|<\vec{V}>|$ is not always equal to $< V >$.

So, Statement 1. is false.

But,| instantaneous vel.| = instantaneous speed.

**22.** **(4)**

**Sol:** A particle is projected vertically upwards. In duration of time from projection till *T* reaches back to point of projection, average velocity is zero. Hence statement I is false.

**23.** **(2)**

**Sol:** The expression for velocity and time can be expressed as $v = (t - 2)(t - 4)$

The speed is therefore zero at $t = 2$ and $t = 4$. Hence speed is minimum at $t = 2$.

But $\frac{dv}{dt} = 2t - 6$ is zero at $t = 3$ seconds.

Hence statement I is true also we know statement II is true but II is not a correct explanation of I.

**24.** **(1)**

**Sol:** $a = k,\ x = \frac{kt^2}{2}$

**25.** **(1)**

**Sol:** $\Delta\vec{v} = -20 - 20 = -40$ m/s

$$<\vec{a}> = \frac{\Delta\vec{v}}{\Delta t} = \frac{-40}{15} = \frac{-8}{3}\ \text{m/s}^2$$

Displacement $= \frac{1}{2} \times 5 \times 20 + \frac{1}{2} \times 10 \times (-20)$

$= -50$ m

Acceleration $= -\frac{20}{5} = -4$ m/s$^2$

**26.** **(2)**

**Sol:** $u$ and $4u$ are speeds of two cars at a specific instant. Both cars are stopped from the specific instant therefore,

For I[st] car:

$v = 0, \quad a = a_1$

From equation of motion,

$v = u - at$

$0 = u - a_1 t$

$a_1 t = u \quad .....(i)$

From equation of motion,

$v^2 = u^2 - 2as$

Here, $s = s_1, v = v_1 = 0$

($s_1$ is the distance covered by I[st] car before coming to rest.)

$\therefore \quad 0 = u^2 - 2a_1 s_1$

$2a_1 s_1 = u^2 \quad .....(ii)$

Putting the value of $a_1$ in equation (ii), we get

$$2.\frac{u}{t}.s_1 = u^2$$

$$s_1 = \frac{ut}{2}$$

For 2[nd] car:

Similarly, $a_2 t = 4u$

$$\Rightarrow a_2 = \frac{4u}{t} \quad .....(iii)$$

and $0 = (4u)^2 - 2a_2 s_2 \quad .....(iv)$

From equation (iii) and (iv), we get

$$2.\frac{4u}{t}.s_2 = 16u^2 \quad \text{or } s_2 = 2ut$$

$$\text{so, } \frac{s_1}{s_2} = \frac{ut}{2.2ut}$$

$$\Rightarrow \frac{s_1}{s_2} = \frac{1}{4} = 1:4$$

Hence, the ratio of respective distance is 1 : 4

**27.** **(2)**

**Sol:** $x = \alpha t^3, y = \beta t^3$

$$v_x = \frac{dx}{dt} = 3\alpha t^2$$

$$v_y = \frac{dy}{dt} = 3\beta t^2$$

Resultant velocity

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{9\alpha^2 t^4 + 9\beta^2 t^4}$$

$$= 3t^2\sqrt{\alpha^2 + \beta^2}$$

**28.** **(4)**

**Sol:** The braking retardation will remain same and assumed to be constant, let it be $a$ from 3[rd] equation of motion,

$v^2 = u^2 + 2as$

**I[st] case** $\Rightarrow \left(60 \times \frac{5}{18}\right)^2 - 2a \times s_1 = 0$

$$\Rightarrow s_1 = \frac{(60 \times 5/18)^2}{2a}$$

**2nd case** $\Rightarrow 0 = \left(120 \times \frac{5}{18}\right)^2 - 2a \times s_2$

$$\Rightarrow s_2 = \frac{(120 \times 5/18)^2}{2a}$$

$$\therefore \frac{s_1}{s_2} = \frac{1}{4}$$

$\Rightarrow s_2 = 4s_1 = 4 \times 20 = 80$ m.

**29.** **(3)**

**Sol:** Given $t = ax^2 + bx$

Differentiating w.r.t. '$t$'

$$\frac{dt}{dt} = 2ax\frac{dx}{dt} + \frac{dx}{dt}$$

$$v = \frac{dx}{dt} = \frac{1}{(2ax + b)}$$

Again differentiating. w.r.t. '$t$'

$$\frac{dv}{dt} = \frac{-2a}{(2ax+b)^2}\frac{dx}{dt} = -2av^3$$

**30. (3)**

**Sol:** $v = \alpha\sqrt{x} \Rightarrow \frac{dx}{dt} = \alpha \cdot \sqrt{x}$

or $\frac{dx}{\sqrt{x}} = \alpha.\, dt$

Perform integration

$$\int_0^x \frac{dx}{\sqrt{x}} = \int_0^t \alpha \cdot dt$$

[ $\because$ at $t = 0$, $x = 0$ and let at any time $t$, particle is at $x$]

[ $\because$ $t = 0, x = 0$]

$\Rightarrow \left.\frac{x^{1/2}}{1/2}\right|_0^x = \alpha t$

or $x^{1/2} = \frac{\alpha}{2} t$

or $x = \frac{\alpha^2}{4} \times t^2$ or $x \propto t^2$

**31. (2)**

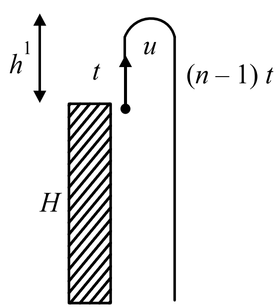
**Sol:** $\int_{6.25}^{0} \frac{dv}{\sqrt{v}} = -2.5 \int_0^t dt$

$\left|2\sqrt{v}\right|_{6.25}^{0} = -2.5$ t

$2.\sqrt{6.25} = 2.5$ t $\Rightarrow$ $t = 2$ sec.

**32. (3)**

**Sol:**




$t = u/g$ .....(1)

$h^1 = \frac{u^2}{2g}$ .....(2)

$h^1 + H = \frac{1}{2} g\,(n-1)^2\, t^2 \Rightarrow \frac{u^2}{2g} + H$

$= \frac{1}{2} g\,(n-1)^2 \frac{u^2}{g^2}$

$H = \frac{(n-1)^2 u^2}{2g} - \frac{u^2}{2g} \Rightarrow H = \frac{u^2}{2g}\,[n^2 - 2n]$

**33. (2)**

**Sol:** Distance travelled in $t^{th}$ second is,

$s_t = u + at - \frac{1}{2} a$

Given : $u = 0$

$\therefore \frac{s_n}{s_{n+1}} = \frac{an - \frac{1}{2}a}{a(n+1) - \frac{1}{2}a} = \frac{2n-1}{2n+1}$

**34. (3)**

**Sol:** Area under acceleration-time graph gives the change in velocity.

Hence, $v_{max} = \frac{1}{2} \times 10 \times 11 = 55$ m/s

**35. (4)**

**Sol:** $r_{t=5}$ = area (initially particle is at origin)

$= \left(\frac{1}{2} \times 2 \times 2 + 2 \times 2 + 3 \times 1\right) m$

$= (2 + 4 + 3) = 9$ m.

**36. (3)**

**Sol:** Given $AB = x$ and $BC = x$

$\because AB + BC + CD = 3x$

$\Rightarrow 2x + CD = 3x$

$\therefore CD = x$

Average speed $< v > =$

$$\frac{3x}{\frac{x}{v_1} + \frac{x}{v_2} + \frac{x}{v_3}} = \frac{3v_1v_2v_3}{v_2v_3 + v_1v_3 + v_1v_2}$$

**37. (4)**

**Sol:** $x = at + bt^2 - ct^3$

$$v = \frac{dx}{dt} = a + 2bt - 3ct^2$$

$$a = \frac{dv}{dt} = 2b - 6ct = 0 \Rightarrow t = \frac{b}{3c}$$

$$v_{\left(at\,t=\frac{b}{3c}\right)} = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b}{3c}\right)^2 = a + \frac{b^2}{3c}$$

**38. (4)**

**Sol:** Using law of motion's equation, $v = u + at$

$60 = 10 + 2t \Rightarrow 2t = 50$

$t = 25$ sec.

**39. (4)**

**Sol:** Displacement of the body = 16 – 8 + 16 – 8

= 16 m

Distance travelled by the body = Σ |area|

= 48 m

$$\Rightarrow \frac{\text{Displacement}}{\text{Distance}} = \frac{1}{3}$$

**40. (1)**

**Sol:** As, slope of $B$ > Slope of $A$

∴ Speed of $B$ > Speed of $A$

$\Rightarrow t_B < t_A$

**41. (1)**

**Sol:** The slope of the given $v$ versus $x$ graph is

$m = -\frac{v_0}{x_0}$ and intercept is $c = +v_0$.

Hence, varies with $x$ as

$$v = -\left(\frac{v_0}{x_0}\right)x + v_0 \qquad \ldots\text{(i)}$$

Using equation (i) in equation (ii), we get

$$a = v\frac{dv}{dx} = -\left(\frac{v_0}{x_0}\right)\left(-\frac{v_0}{x_0}x + v_0\right)$$

$$\Rightarrow \quad a = \left(\frac{v_0}{x_0}\right)^2 x - \frac{v_0^2}{x_0}$$

Thus the graph of $a$ versus $x$ is a straight line having a positive slope = $\left(\frac{v_0}{x_0}\right)^2$ and negative intercept = $\frac{v_0^2}{x_0}$.

**42. (3)**

**Sol:** We have, $u = 0$ and $a$ = constant

At time $t$,

$v = 0 + at \Rightarrow v = at$

Also $x = 0(t) + \frac{1}{2}at^2 \Rightarrow x = \frac{1}{2}at^2$

Graph (A), (B) and (D) are correct

**43. (2)**

**Sol:** $v = \alpha t + \beta t^2$

$$\frac{ds}{dt} = \alpha t + \beta t \Rightarrow ds = \left(\alpha t + \beta t^2\right)dt$$

Applying integration both side.

**44. (1)**

**Sol:** $\vec{r} = \cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}$

$$\vec{v} = \frac{d\,\vec{r}}{dt} = \omega(-\sin\omega t\,\hat{i} + \cos\omega t\,\hat{j})$$

$$\vec{a} = \frac{d\,\vec{v}}{dt} = -\omega^2(\cos\omega t\,\hat{i} + \sin\omega t\,\hat{j})$$

$$\vec{a} = -\omega^2\,\vec{r}$$

∴ $\vec{a}$ is antiparallel to $\vec{r}$

$\vec{v}\,.\,\vec{r} = \omega(-\sin\omega t\,\cos\omega t + \cos\omega t\,\sin\omega t = 0)$

so $\vec{v} \perp \vec{r}$

**45. (3)**

**Sol:** Range, $R = \frac{u^2\sin 2\theta}{g} \Rightarrow R \propto \sin(2\theta)$

$$\frac{R_1}{R_2} = \frac{\sin(2\theta_1)}{\sin(2\theta_2)} = \frac{\sin(2\times 15^\circ)}{\sin(2\times 45^\circ)} = \frac{\sin 30^\circ}{\sin 90^\circ} = \frac{1}{2}$$

**46. (2)**

**Sol:** Velocity of the projectile at the highest point

$= u\cos\theta$

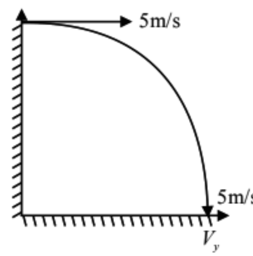
$u\cos\theta = \frac{\sqrt{3}u}{2}$

$\Rightarrow \theta = 30^\circ$

Time of flight $T = \frac{2u\sin 30^\circ}{g} = \frac{u}{g}$

**47.** **(2)**

**Sol:**




$v_x = u_x = 5$ m/s

$v_y = \sqrt{2gh} = \sqrt{200}$

$v_{net} = \sqrt{v_x^2 + v_y^2}$

$\Rightarrow v_{net} = \sqrt{25+200} = 15$ m/s

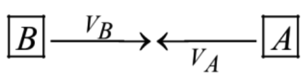
**48.** **(4)**

**Sol:** At the maximum height velocity = $u\cos\theta = u\cos 30^\circ$

$$\frac{KE_{initial}}{KE_{top}} = \frac{\frac{1}{2}M(u)^2}{\frac{1}{2}M(u\cos 30^\circ)^2} = \frac{4}{3}$$

**49.** **(4)**

**Sol:**




Velocity of train $A$, $V_A = -90$ km/h = $-25$ m/s

$\because 1$ km/h $= \frac{5}{18}$ m/s

Velocity of train $B$, $V_B = 54$ km/h = 15 m/s

Velocity of train $B$ w.r.t. train $A$

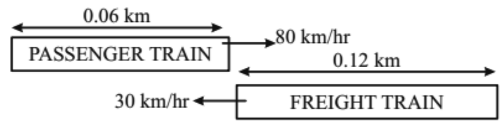
$\vec{V} = \vec{V}_B - \vec{V}_A = 15 - (-25) = 40$ m/s

Time of crossing $(t) = \frac{\text{length of train } (l)}{\text{relative velocity } (v)}$

$(8) = \frac{\ell}{40} \Rightarrow \ell = 8 \times 40 = 320$ m

**50.** **(1)**

**Sol:**




Time taken if both moving in same direction.

$t_1 = \frac{\text{distance}}{\text{speed}} = \frac{0.12+0.06}{80-30} = \frac{0.18}{50}$

Time taken if both moving in opposite direction.

$t_2 = \frac{\text{distance}}{\text{speed}} = \frac{0.12+0.06}{80+30} = \frac{0.18}{110}$

$\frac{t_1}{t_2} = \frac{11}{5}$

**51.** **(1)**

**Sol:** $\vec{v}_{BW} = 4\sqrt{2}(\cos 45^\circ \hat{i} + \sin 45^\circ \hat{j}) = 4\hat{i} + 4\hat{j}$, and

$\vec{v}_{Wg} = 0\hat{i} - \hat{j}$

Resultant velocity of butterfly,

$\vec{v}_{Bg} = \vec{v}_{BW} + \vec{v}_{Wg} = (4\hat{i} + 4\hat{j}) + (0\hat{i} - \hat{j}) = 4\hat{i} + 3\hat{j}$

$\therefore$ Speed of butterfly = $|\vec{v}_{Bg}| = 5$ m/s

Magnitude of displacement of Butterfly = $|\vec{v}_{Bg}| \times t = 5 \times 3 = 15$ m

**52.** **(3)**

**Sol:** $\frac{dx}{dt} = ky; \frac{dy}{dt} = kx$

$\frac{dx}{dy} = \frac{y}{x} \Rightarrow y^2 = x^2 + c$

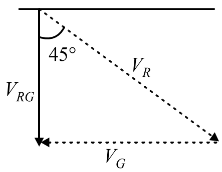
**53.** **(3)**

**Sol:** Let $V_{RG}$ be velocity of rain w.r.t. ground therefore,

$$\theta = \tan^{-1}\left(\frac{V_G}{V_{RG}}\right)$$

$$45^\circ \tan^{-1}\left(\frac{15\sqrt{2}}{V_{RG}}\right)$$

$$\tan 45^\circ = \frac{15\sqrt{2}}{V_{RG}}$$




$$V_{RG} = 15\sqrt{2} = 15 \times \frac{\sqrt{2}}{\sqrt{2}} \times \sqrt{2} = \frac{30}{\sqrt{2}} \text{ km h}^{-1}$$

**54.** **(4)**

**Sol:** $R_1 = \dfrac{u_1^2 \sin 2\theta_1}{g}$; $R_2 = \dfrac{u_2^2 \sin 2\theta_2}{g}$

$$\frac{R_1}{R_2} = \frac{40^2 \sin(2\times 30^\circ)}{60^2 \sin(2\times 60^\circ)} = \frac{4\sin 60^\circ}{9\cos 30^\circ} = \frac{4}{9}$$

**55.** **(3)**

**Sol:** Time taken to reach maximum height

$$t = \frac{u\sin\theta}{g} \therefore \frac{u_1 \sin\theta_1}{g} = \frac{u_2 \sin\theta_2}{g}$$

**56.** **(1)**

**Sol:** $R_{\max} = \dfrac{u^2 \sin 2(45^\circ)}{g} = \dfrac{u^2}{g}$

$$\frac{R}{2} = \frac{u^2}{2g} = \frac{u^2 \sin 2\theta}{g}$$

$$\sin 2\theta = \frac{1}{2}$$

$$\theta = 15^\circ, 75^\circ$$

**57.** **(1)**

**Sol.** Velocity will be zero at maximum height

**58.** **(4)**

**Sol.** $\vec{r} = 15t^2\hat{i} + \left(4 - 20t^2\right)\hat{j}$

$$\vec{v} = \frac{d\vec{r}}{dt} = 30t\vec{i} + (-40t)\vec{j}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 30\hat{i} - 40\hat{j}$$

$$|\vec{a}| = 50 \text{ m/s}^2$$

**59.** **(3)**

**Sol.** a $t_1 = \dfrac{2u\sin\theta}{g}, t_2 = \dfrac{2u\sin(90^\circ - \theta)}{g}$

and $R = \dfrac{u^2 \sin 2\theta}{g}$

$$t_1 t_2 = \frac{4u^2 \sin\theta\cos\theta}{g^2}$$

$$= \frac{2}{g}\left[\frac{2u^2\sin\theta\cos\theta}{g}\right] = \frac{2R}{g}$$

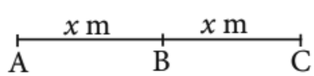
**60.** **(2)**

**Sol.** Conceptual

## *Integer Type Questions (61 to 75)*

**61.** **(50)**

**Sol:**




$$t_{AB} = \frac{x}{5 \text{ m/s}}$$

In motion $BC$

$x = d_1 + d_2$

Where $d_1$ and $d_2$ we the distance travelled with 10 m/s and 15 m/s respectively in equal time intervals $\frac{'t'}{2}$ each

$$d_1 = \frac{10t}{2},\ d_2 = \frac{15t}{2}$$

$$d_1 + d_2 = x = \frac{t}{2}(10+15) = \frac{25t}{2}$$

$$< v >= \frac{2x}{\frac{x}{5}+\frac{2x}{25}} = \frac{2\times 25}{5+2} = \frac{50}{7} \text{ m/s}$$

**62. (3)**

**Sol:** From Kinematic equation,

$$v^2 = u^2 - 2aS$$

$$0 = u^2 - 2aS$$

$$S = \frac{u^2}{2a}$$

$$S \propto u^2$$

$$\therefore \frac{S_2}{S_1} = \left(\frac{u_2}{u_1}\right)^2$$

$$S_2 = 27\times\left(\frac{1}{3}\right)^2 = 3$$

**63. (200)**

**Sol:** $u = 20$ m/s, $S_1 = 500$ m, $v = 0$

Using third equation of motion

$0 = (20)^2 - 2a.500$

$$\Rightarrow a = \frac{4}{10} \text{ m/s}^2$$

After brakes are applied

$u = 20$ m/s, $S_2 = 250$ m, $v = ?$

$$v^2 = (20)^2 - 2a.250$$

$$= v = \sqrt{200} \text{ m/s}$$

$$\therefore x = 200$$

**64. (5)**

**Sol:** Given, $u = 150$ m/s

From kinematic equations, $\vec{v} = \vec{u} + \vec{a}t$

$v = 150 - 10t$

At, $t = 3$ seconds

$v_1 = 150 - 30 = 120$

At, $t = 5$ seconds

$v_2 = 150 - 50 = 100$

$$\frac{120}{100} = \frac{x+1}{x} \Rightarrow x = 5$$

**65. (300)**

**Sol:** Displacement in n^th^ sec is given by.

$$S_{nth} = u + \frac{a}{2}(2n-1)$$

$$S_8 = 0 + \frac{1}{2}\times 10\times(2\times 8-1)$$

$$S_8 = 75 \text{ m}$$

$$\Delta U = 0.4\times 10\times 75$$

$$\Delta U = 300\text{J}$$

**66. (120)**

**Sol:** Velocity of the ball just before reaching the ground,

$$v_i = \sqrt{2gh_i} = 14 \text{ m/s}$$

Velocity of the ball just after the rebound,

$$v_f = \sqrt{2gh_f} = 10 \text{ m/s}$$

$$\because \vec{a}_{avg} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{10-(-14)}{0.2}$$

$$\Rightarrow \left|\vec{a}_{avg}\right| = \left|\frac{\Delta\vec{v}}{\Delta t}\right| = 120 \text{ m/s}^2$$

**67. (50)**

**Sol:** $h_1 = h_2$

$$35t - \frac{1}{2}gt^2 = 35(t-3) - \frac{1}{2}g(t-3)^2$$

$$35\times 3 = \frac{1}{2}g(t+t-3)\times 3$$

$$105 = \frac{10}{2}\times 3\times(2t-3) \Rightarrow t = 5 \text{ sec}$$

$$h_1 = 35\times 5 - \frac{1}{2}\times 10\times 5^2 = 50 \text{ m}$$

**68.** **(1)**

**Sol:** As, $y = mx + c$

$v^2 = 2x + 20$

$v^2 = 2x + 20$

$$\Rightarrow 2v\frac{dv}{dt} = 2$$

$$\Rightarrow a = 1 \text{ m/s}^2$$

**69.** **(20)**

**Sol:** Distance travelled = Area under the $v$-$t$ graph

$$\therefore \Delta S = \frac{1}{2}\times 5\times 8 = 20$$

so $\vec{v} \perp \vec{r}$

**70.** **(3)**

**Sol:** We have given, the distance covered by particle varies with time $t$, $x^2 = at^2 + 2bt + c$

Let acceleration be a

$2xv = 2at + 2b$

$v^2 + ax = a$

$$ax = a - \left(\frac{at+b}{x}\right)^2$$

$$a = \frac{a(at^2+2bt+c)-(at+b)^2}{x^3}$$

$$a = \frac{ac-b^2}{x^3};\ a \propto x^{-3}$$

Hence, value of $n$ is 3.

**71.** **(80)**

**Sol:** Time of flight, $T = 3 + 5 = 8$ sec

Formula of Time of flight,

$$\therefore T = \frac{2u\sin 30^\circ}{g}$$

$$u = \frac{Tg}{2\sin 30^\circ}$$

$$u = \frac{8\times 10}{2\times\left(\frac{1}{2}\right)}$$

$u = 80$ m/s

**72.** **(80)**

**Sol:** For the same horizontal range if angle of projection for projectile 1 is 60º then angle of projectile 2 is 30º for same range

$$H_1 = \frac{u^2\sin^2 60^\circ}{2g},\ H_2 = \frac{u^2\sin^2 30^\circ}{2g}$$

$$H_1 + H_2 = \frac{u^2\sin^2 60^\circ}{2g} + \frac{u^2\sin^2 30^\circ}{2g}$$

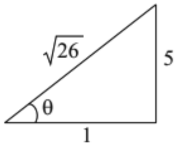
$$= \frac{u^2}{2g} = \frac{40^2}{2\times 10} = 80 \text{ m}$$

Hence, the sum of the maximum heights attained by the two projectile is 80 m.

**73.** **(5)**

**Sol:** Given, $u_x = \hat{i},\ |u_x| = 1$

$$y = x5(1-x) = x\tan\theta\left(1-\frac{x}{R}\right)$$




$\tan\theta = 5,\ R = 1$

$$\tan\theta = \frac{u_y}{u_x} \Rightarrow u_y = \tan\theta u_x$$

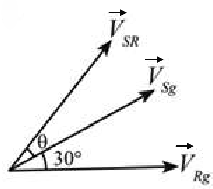
$= 5\times 1 = 5$ m/s

**74.** **(30)**

**Sol:** Both velocity vector are of same magnitude. Therefore resultant would pass exactly midway through them.

So, θ = 30º

Hence, angle θ with the line $AB$ is 30º




$$\Rightarrow u_1 \sin 30^\circ = u_2\sin 45^\circ \Rightarrow \frac{u_1}{u_2} = \frac{1/\sqrt{2}}{1/2} = \frac{\sqrt{2}}{1}$$

**75.** **(1)**

**Sol:** Time of flight is same

$\Rightarrow$ Vertical component of velocity is same

$\Rightarrow H_{max}$ is same. So, $\frac{1}{x} = 1 \Rightarrow x = 1$

# LAWS OF MOTION

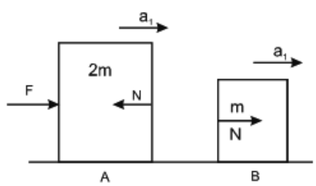
## Single Option Correct Type Questions (01 to 60)

**1.** **(2)**

**Sol:**


**2.** **(2)**

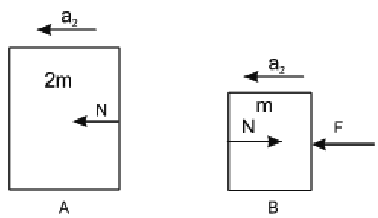
**Sol:**




$F - N = 2\ ma_1$ [Newton`s II law for block $A$]

$N = ma_1$ [Newton`s II law for block $B$]

$\Rightarrow N = \frac{F}{3}$




$N = 2\ ma_2$ [Newtons II law for block $A$]

$F - N = m \times a_2$ [Newtons II law for block $B$]

$\Rightarrow$ $N = 2F/3$ so the ratio is 1 : 2

**3.** **(1)**

**Sol:** mass $m = \frac{|\vec{F}|}{|\vec{a}|} = \frac{\sqrt{200}}{1} = 10\sqrt{2}$

**4.** **(3)**

**Sol:** In 1st case $F = m \times 4$

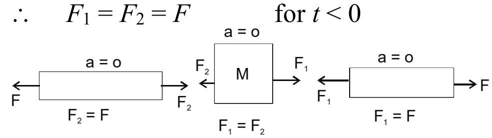
In 2nd case $F = 2\ m \times a$

so $a = 2\text{m/s}^2$

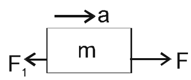
**5.** **(1)**

**Sol:** For $t < 0$ As net force on system is zero, therefore acceleration of the system is zero

$\therefore$ $F_1 = F_2 = F$ for $t < 0$

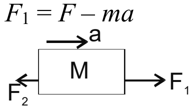



For $t > 0$ system is accelerated given by $a = \frac{F}{2m + M}$




$F - F_1 = ma$

$F_1 = F - ma$ .... (1)



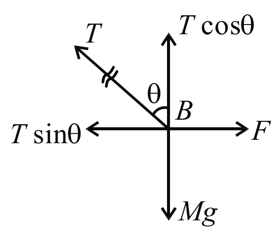

$F_1 - F_2 = Ma$

$F_1 = F_2 + Ma$ ... (2)

$F > F_1 > F_2$

**6.** **(2)**

**Sol:**




Point $B$ is massless so net force on it most be zero otherwise it will have $\infty$ acceleration

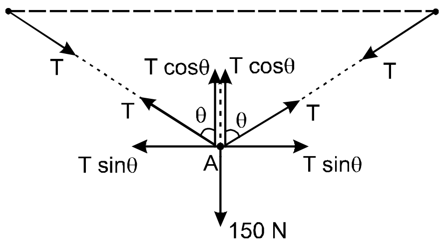
$\Rightarrow$ $F - T\sin\theta = 0$

[Equilibrium of $B$ in horizontal direction]

$\Rightarrow$ $T = \frac{F}{\sin\theta}$

**7.** **(4)**

**Sol:**




$T\cos\theta + T\cos\theta - 150 = 0$

[Equilibrium of point *A*]

$2\,T\cos\theta = 150$ $T = \dfrac{75}{\cos\theta}$

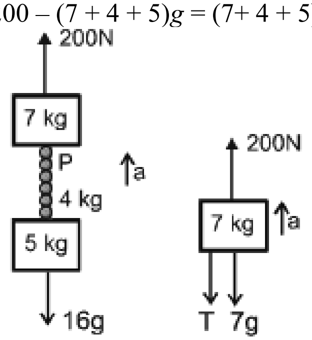
When string become straight θ becomes 90º

$\Rightarrow \quad T = \infty$

**8.** **(2)**

**Sol:** Equation of motion of system

$200 - (7 + 4 + 5)g = (7 + 4 + 5)a$




$\Rightarrow \quad a = 40/16 \text{ m/s}^2$

Equation of motion of 7 kg block;

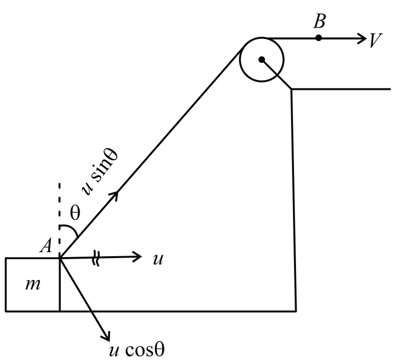
$200 - T - 7 \times g = 7 \times a = 7 \times (40/16) = 35/2$

$\Rightarrow \; 200 - 35/2 - 70 = T$

$\Rightarrow \; T = 112.5$ N

**9.** **(2)**

**Sol:**




The length of string *AB* is constant.

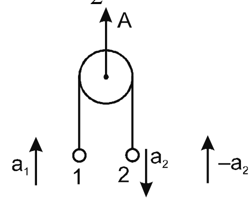
$\Rightarrow$ speed of *A* and *B* along the string are same

$u\sin\theta = V$

$u = \dfrac{V}{\sin\theta}$

**10.** **(3)**

**Sol:** $A = \dfrac{a_1 - a_2}{2}$




**11.** **(2)**

**Sol:** $\vec{F} = \dfrac{d\vec{P}}{dt}$

**12.** **(1)**

**Sol:** $\vec{F} = m\vec{a}$

**13.** **(3)**

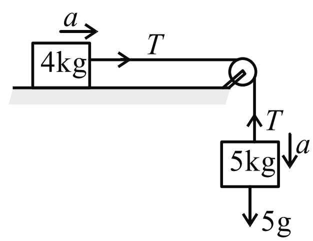
**Sol:** For at wood machine

acceleration $= a = \dfrac{(m_2 - m_1)g}{m_1 + m_2}$

$= \dfrac{(10-5)g}{5+10} = \dfrac{g}{3}$

**14.** **(4)**

**Sol:**




$a = \dfrac{\text{net driving force}}{\text{total mass in motion}} = \dfrac{5g}{5+4} = \dfrac{5g}{9}$

**15.** **(4)**

**Sol:** Acceleration of the system

$a = \dfrac{20-10}{6+4} = 1 \text{ m/s}^2$

20 ← M → T

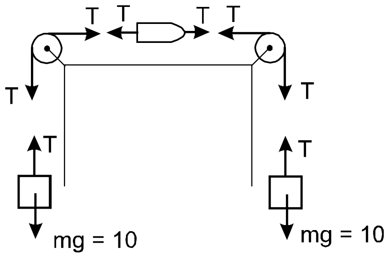
$F - T = m.a$

$20 - T = 6\,(1)$

$T = 14$ N

**16.** **(1)**

**Sol:**




$T - mg = 0$

[Equilibrium of block]

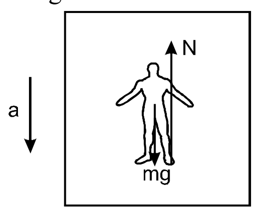
$T - 10 = 0$

$T = 10$

Reading of spring balance is same as tension in spring balance.

**17.** **(4)**

**Sol:** Weight of man in stationary lift is mg.




$mg - N = ma$

[Newton's II law for man]

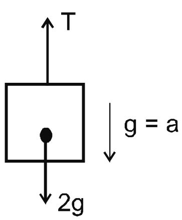
$\Rightarrow \quad N = m(g - a)$

Weight of man in moving lift is equal to $N$.

$$\Rightarrow \quad \frac{mg}{m(g-a)} = \frac{3}{2} \Rightarrow a = \frac{g}{3}$$

**18.** **(4)**

**Sol:**




Reading of spring balance is tension

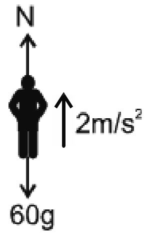
$2g - T = 2a$

$2g - 2a = T \; (a = g)$

$0 = T$

**19.** **(1)**

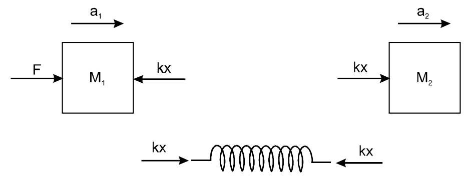
**Sol:**




$N - 60g = 60 \times 2 \Rightarrow N = 720$ Newton

**20.** **(4)**

**Sol:**




$F - kx = M_1 a_1$

[Newton's II law for $M_1$]

$kx = M_2 a_2$

[Newton's II law for $M_2$]

By adding both equations.

$$F = M_1 a_1 + M_2 a_2 \Rightarrow a_2 = \frac{F - M_1 a_1}{M_2}$$

**21.** **(3)**

**Sol:** $a = \dfrac{32 - 20}{3} = 4 \text{ m/s}^2$

**22.** **(2)**

**Sol:** $\Delta P = 2mv$

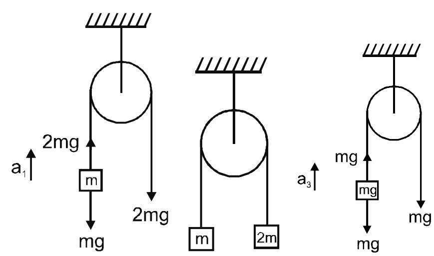
$= \quad 2 \times 10 \times 10^{-3} \times 5 = 10^{-1}$

$\Delta t = 10^{-2}$

$$F = \frac{\Delta P}{\Delta t} = \frac{10^{-1}}{10^{-2}} = 10 \text{ N}$$

**23.** **(2)**

**Sol:**



$a_1 = \dfrac{2mg - mg}{m}$

$a_2 = \dfrac{(2m - m)g}{2m + m}$

$a_3 = 0 \qquad a_1 = g \qquad a_2 = \dfrac{g}{3}$

So, $a_1 > a_2 > a_3$

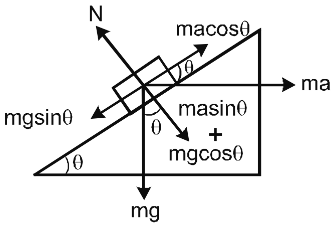
**24. (2)**

**Sol:** $ma \cos\theta = mg \sin\theta$

$a = g \tan\theta$

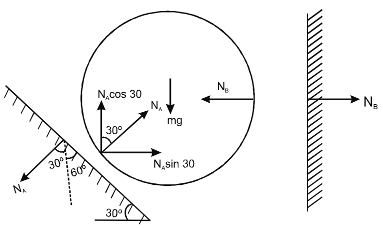
$N = mg \cos\theta + ma \sin\theta$

$= mg \cos\theta + \dfrac{mg \sin^2\theta}{\cos\theta} = \dfrac{mg}{\cos\theta}$




**25. (1)**

**Sol:**




$mg - N_A \cos30° = 0$

[Equilibrium in vertical direction]

$\Rightarrow N_A = \dfrac{mg}{\cos 30°}$

$\Rightarrow N_A = \dfrac{1000}{\sqrt{3}}$ N

$N_B - N_A \sin30° = 0$

[Equilibrium in horizontal]

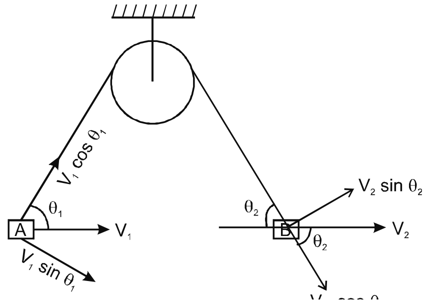
$\Rightarrow N_B = N_A \sin30°$

$\Rightarrow N_B = \dfrac{1000}{\sqrt{3}} \times \dfrac{1}{2}$

$\Rightarrow N_B = \dfrac{500}{\sqrt{3}}$ N

**26. (3)**

**Sol:**




Since string is inextensible length of string can't change

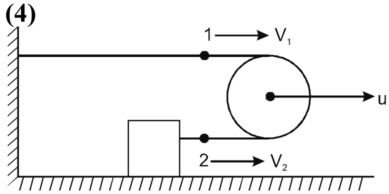
$\therefore$ rate of decreases of length of left string = rate of increase of length of right string

$\Rightarrow \quad V_1 \cos \theta_1 = V_2 \cos \theta_2$

$\Rightarrow \quad \dfrac{V_1}{V_2} = \dfrac{\cos\theta_2}{\cos\theta_1}$

**27. (4)**

**Sol:**




Velocity of point 1 is $V_1$ which is 0 because string is fixed.

Velocity of point 2 is $V_2$

$\dfrac{V_1 + V_2}{2} = u, \qquad \dfrac{0 + V_2}{2} = u$

$V_2 = 2u$

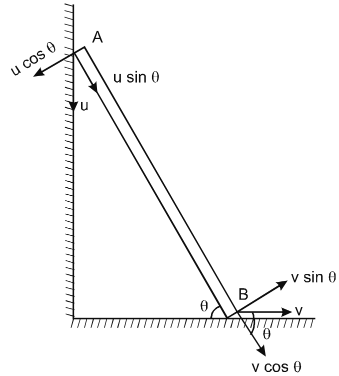
**28. (2)**

**Sol:** Since rod is rigid, its length can't increase.

$\therefore$ Velocity of $A$ and $B$ along the rod are same.

$\Rightarrow \quad u \sin \theta - v \cos \theta = 0$

$\Rightarrow \quad v = u \tan \theta$



**29.** **(2)**

**Sol:** Let $AB = \ell$, $B = (x, y)$

$\vec{v}_B = v_x\hat{i} + v_y\hat{j}$

$\vec{v}_B = \sqrt{3}\hat{i} + v_y\hat{j} \rightarrow$ (i)

$x^2 + y^2 = \ell^2$

$2xv_x + 2yv_y = 0$

$\Rightarrow \sqrt{3} + \frac{y}{x} v_y = 0$

$\Rightarrow \sqrt{3} + (\tan 60^0)\, v_y = 0$

$\Rightarrow v_y = -1$

Hence from (i)

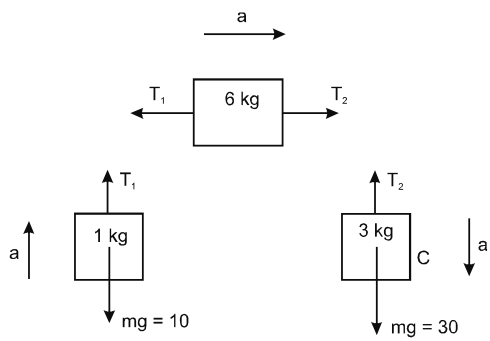
$\vec{v}_B = \sqrt{3}\hat{i} - \hat{j}$

Hence

$v_B = 2$ m/s

**30.** **(3)**

**Sol:**




$30 - T_2 = 3a$ [Newton's II law for 3 kg block]

$T_2 - T_1 = 6a$ [Newton's II law for 6 kg block]

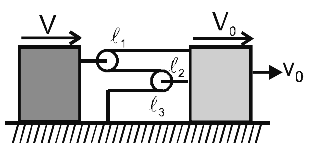
$T_1 - 10 = 1a$ [Newton's II law for 1 kg block]

By adding three equations

$30 - 10 = 10a \quad \Rightarrow \quad a = 2$ m/s$^2$.

**31.** **(2)**

**Sol:**




$\ell'_1 + \ell'_2 + \ell'_3 = 0$

$(-v + v_0) + (-v + v_0) + (0 + v_0) = 0$

$3v_0 = 2v \Rightarrow v = \frac{3v_0}{2}$

$\Rightarrow V_{AB} = V_A - V_B = V - V_0$

$= \frac{3V_0}{2} - V_0 = \frac{V_0}{2}$

**32.** **(2)**

**Sol:** $12g - 2T = 12a$

$T - 4g \sin 30° = 4b$

$T - 4g \sin 30° = 4(2a)$

$a = \frac{2g}{7}$

Tension in the string connecting by 12 kg

$= T' = 2T = \frac{60g}{7}$

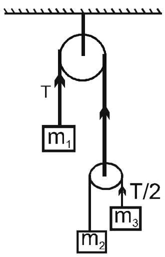
**33.** **(2)**

**Sol:** $\frac{T}{2} = \frac{2m_2m_3}{m_2 + m_3}g$

$\frac{m_1 g}{2} = \frac{2m_2m_3}{m_2 + m_3}g$

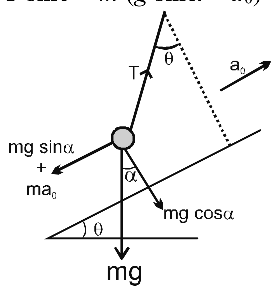
$m_1 = \frac{4m_2m_3}{m_2 + m_3}$

$\frac{1}{m_2} + \frac{1}{m_3} = \frac{4}{m_1}$




**34.** **(4)**

**Sol:** $T\sin\theta = m(g\sin\alpha + a_0)$



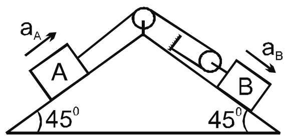

$T\cos\theta = mg\cos\alpha$

$\Rightarrow \quad \tan\theta = \left(\frac{g\sin\alpha + a_0}{g\cos\alpha}\right)$

$$\theta = \tan^{-1}\left(\frac{g\sin\alpha + a_0}{g\cos\alpha}\right)$$

**35.** **(1)**

**Sol:**




By string constraint

$a_A = 2a_B$ ................................(1)

equation for block $A$.

$$T - 10 \times 10 \times \frac{1}{\sqrt{2}} = 10\, a_A \text{ ......(2)}$$

equation for block $B$.

$$\frac{400}{\sqrt{2}} - 2T = 40\, a_B \text{ .........................(3)}$$

Solving equation (1) , (2) & (3) we get

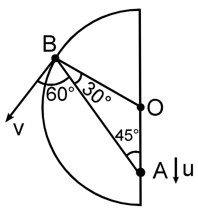
$$a_A = \frac{5}{\sqrt{2}} \text{ m/s}^2$$

$$a_B = \frac{5}{2\sqrt{2}} \text{ m/s}^2$$

$$T = \frac{150}{\sqrt{2}} \text{ N}$$

**36.** **(1)**

**Sol:** $u \cos 45° = v \cos 60°$ or $v = \sqrt{2}\,u$




**37.** **(1)**

**Sol:**

$m_2g - 2T = m_2 b$ for $m_2$

$T = m_1(2b)$ for $m_1$

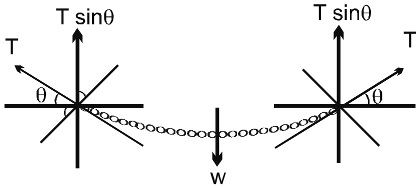
$m_2g = m_2 b + 2\,(m_1 2b)$

$m_2g = b\,[m_2 + 4m_1]$

$$b = \frac{m_2}{(m_2 + 4m_1)}\, g = \frac{m_2 g}{(4m_1 + m_2)}$$

**38.** **(1)**

**Sol:**

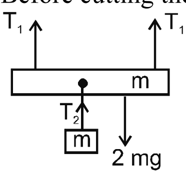



$2T \sin\theta = W$

$$T = \frac{W}{2} \text{ cosec } \theta$$

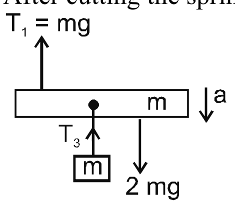
**39.** **(1)**

**Sol:** Before cutting the spring




$T_2 = mg$

After cutting the spring




$2mg - mg = 2\, ma$

$a = g/2,\ T_3 = mg/2$

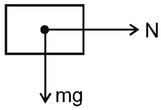
$$T_2 - T_3 = mg - \frac{mg}{2} = \frac{mg}{2}$$

**40.** **(4)**

**Sol:** The FBD of block $B$ is

The force exerted by $A$ on $B$ is $N$ (normal reaction). The forces acting on $B$ are $N$ (horizontal) and $mg$ (weight downwards).

Hence statement I is false.




**41.** **(4)**

**Sol:** Newton's third law of motion is valid in all reference frames. Hence statement-1 is incorrect.

**42.** **(2)**

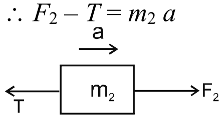
**Sol:** **(A) q ; (B) r ; (C) q ; (D) r**

Let a be acceleration of two block system towards right

$$\therefore\ a = \frac{F_2 - F_1}{m_1 + m_2}$$

The F.B.D. of $m_2$ is

$\therefore\ F_2 - T = m_2\, a$




Solving $T = \dfrac{m_1 m_2}{m_1 + m_2}\left(\dfrac{F_2}{m_2} + \dfrac{F_1}{m_1}\right)$

(B) Replace $F_1$ by $-F_1$ in result of $A$

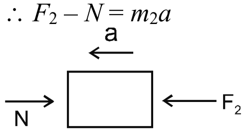
$$\therefore\ T = \frac{m_1 m_2}{m_1 + m_2}\left(\frac{F_2}{m_2} - \frac{F_1}{m_1}\right)$$

(C) Let a be acceleration of two block system towards left

$$\therefore\ a = \frac{F_2 - F_1}{m_1 + m_2}$$

The FBD of $m_2$ is:

$\therefore\ F_2 - N = m_2 a$



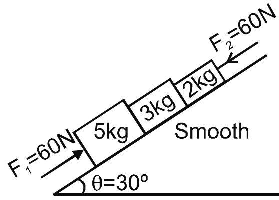

Solving $N = \dfrac{m_1 m_2}{m_1 + m_2}\left(\dfrac{F_1}{m_1} + \dfrac{F_2}{m_2}\right)$

(D) Replace $F_1$ by $-F_1$ in result of $C$

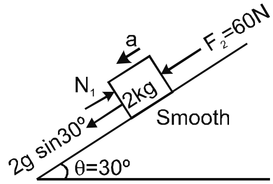
$$N = \frac{m_1 m_2}{m_1 + m_2}\left(\frac{F_2}{m_2} - \frac{F_1}{m_1}\right)$$

**43.** **(1)**

**Sol:**

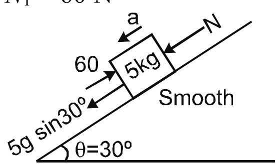



$$a_{\text{system}} = \frac{(5+3+2)g\sin 30^\circ}{10} = 5\ \text{m/s}^2$$




$60 + 10 - N_1 = 2 \times 5$

$N_1 = 60$ N

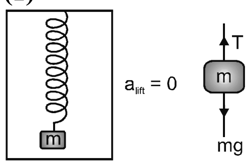



$N_2 + 25 - 60 = 5 \times 5$

$N_2 = 60$ N.

**44.** **(1)**

**Sol:**

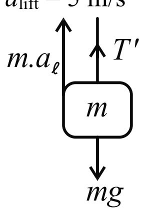



$T = mg = 49$ N

$$\Rightarrow m = \frac{49}{9.8} = 5\ \text{kg}$$

When accelerating

$a_{\text{lift}} = 5\ \text{m/s}^2 \downarrow$

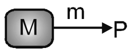



$T' + ma_\ell = mg$

$T' = m(g - a_\ell) = 49 - 5 \times 5 = 24$ N

**45.** **(4)**

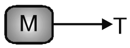
**Sol:**




acceleration of system

$$a_{\text{system}} = \frac{P}{M+m}$$

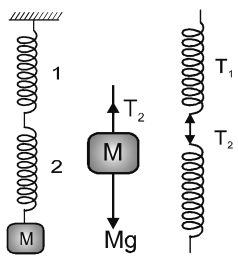
FBD




$$T = Ma_{\text{system}} = \frac{MP}{M+m}$$

**46.** **(1)**

**Sol:**



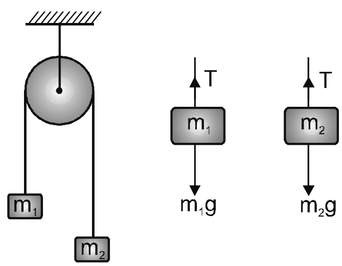

$T_1 = T_2$

Since springs are massless.

$T_1 = T_2 = Mg$

**47.** **(1)**

**Sol:** *FBD* of $m_1$ and $m_2$




$m_1g - T = m_1a$ ..........(i)

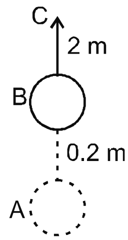
$T - m_2g = m_2a$ ..........(ii)

$$a = \frac{(m_1 - m_2)}{m_1 + m_2} g = \frac{(5-4.8)}{(5+4.8)} g$$

$$= \frac{0.2 \times 9.8}{9.8} = 0.2 \text{ m/s}^2$$

**48.** **(2)**

**Sol:**




At position $B$ & $C$

$V^2 = u^2 - 2gs$

$0 = u^2 - 2 \times 10 \times 2$

$u^2 = 40$

$$\text{acceleration} = \frac{F - mg}{m} = \left(\frac{F-2}{0.2}\right)$$

and $V_B^2 = u_A^2 + 2as$

$$40 = 0 + 2 \times \frac{(F-2)}{0.2} \times 0.2$$

$F = 20 + 2 = 22$ N.

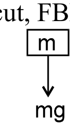
**49.** **(3)**

**Sol:** $2mg\cos\theta = \sqrt{2}\,\text{mg}$

$$\cos\theta = \frac{1}{\sqrt{2}} = \cos 45° \Rightarrow \theta = 45°$$

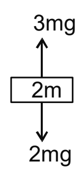
**50.** **(1)**

**Sol:** After string is cut, FBD of $m$




$$a = \frac{mg}{m} = g \downarrow$$

FBD of 2m (when string is cut tension in the spring takes finite time to become zero. How ever tension in the string immediately become zero.)



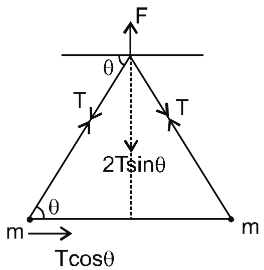

$$a = \frac{3mg - 2mg}{2m} = \frac{g}{2} \uparrow$$

**51.** **(2)**

**Sol:** $F = 2T\sin\theta$

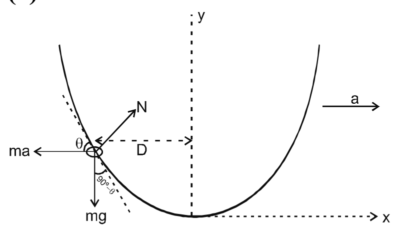
$$a = \frac{T\cos\theta}{m}$$

$$a = \frac{F\cos\theta}{2m\sin\theta} = \frac{F}{2m}\frac{x}{\sqrt{a^2 - x^2}}$$




**52.** **(2)**

**Sol:**




$ma\cos\theta = mg\cos(90 - \theta)$

$$\Rightarrow \frac{a}{g} = \tan\theta$$

$$\Rightarrow \frac{a}{g} = \frac{dy}{dx}$$

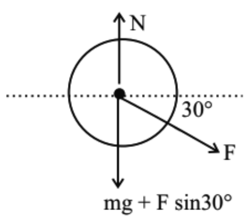
$$\Rightarrow \frac{d}{dx}(kx^2) = \frac{a}{g}$$

$$\Rightarrow x = \frac{a}{2gk}$$

**53.** **(3)**

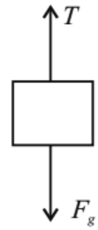
Equating the vertical force $N = mg + F\sin 30^\circ$

$$= 700 + 200 \times \frac{1}{2} = 800N$$




**54.** **(2)**

**Statement-I**




When the elevator is moving with uniform speed, $T = Fg$

**Statement-II**

When the elevator is going down with increasing speed, its acceleration is in the downward direction.

$$W - N = \frac{W}{g} \times a$$

$$N = W\left(1 - \frac{a}{g}\right) \text{ i.e. less than weight}$$

Force exerted by the floor is less than the weight $w$.

**55.** **(4)**

It is given that, $F = -\alpha x^2$

$$\Rightarrow \frac{mvdv}{dx} = -\alpha x^2$$

$$\Rightarrow \int_{v_0}^{0} vdv = -\frac{\alpha}{m}\int_0^x x^2 dx \Rightarrow \frac{0^2}{2} - \frac{v_0^2}{2} = \frac{-\alpha}{3m}x^3$$

$$\Rightarrow \frac{-v_0^2}{2} = -\frac{\alpha}{3m}x^3 \Rightarrow x = \left(\frac{3v_0^2 m}{2\alpha}\right)^{1/3}$$

**56.** **(4)**

For a perfectly smooth inclined plane

$a_1 = g\sin\theta = g/\sqrt{2}$

For the rough inclined plane

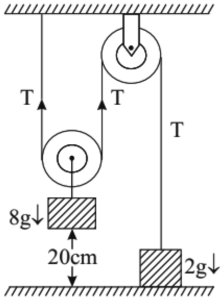
$$a_2 = g\sin\theta - Kg\cos\theta = \frac{g}{\sqrt{2}} - \frac{Kg}{\sqrt{2}}$$

Given $t_2 = nt_1$ and $a_1 t_1^2 = a_2 t_2^2$

$$\Rightarrow \frac{g}{\sqrt{2}}t_1^2 = \left(\frac{g}{\sqrt{2}} - \frac{kg}{\sqrt{2}}\right)n^2 t_1^2 \Rightarrow K = 1 - \frac{1}{n^2}$$

**57. (2)**

From the free body diagram




For 8 kg block,

$8g - 2T = 8a$ ........(i)

For 2 kg block,

$T - 2g = 2 \times 2a$ ......(ii)

Solving equations (i) and (ii)

$$a = \frac{g}{4} = 2.5 m/s^2$$

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 0.2}{2.5}} = 0.4s$$

**58. (4)**

Using formula, $v = u + at$

$\Rightarrow 0 = 20 + (-\mu g)(5)$

$[\because\ v = 0, a = -\mu g]$

$\Rightarrow \mu = 0.4$

**59. (1)**

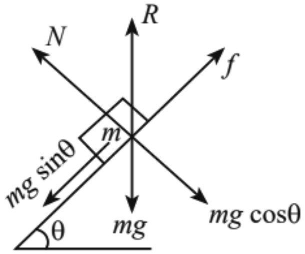
From F. B. D

$N = Mg\cos\theta$

$f = Mg\sin\theta$

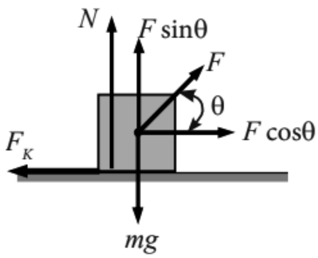
$\therefore R = \sqrt{N^2 + f^2}$

$= \sqrt{(Mg\cos\theta)^2 + (Mg\sin\theta)^2} = Mg$




**60. (3)**

From the free body diagram given below,




$N = mg - F\sin\theta$ ......(i)

$ma = F\cos\theta - \mu_k N$ .......(ii)

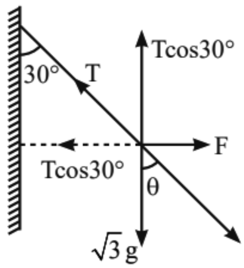
On solving (i) and (ii) we get

$ma = F\cos\theta - \mu_k(mg - F\sin\theta)$

$$\Rightarrow a = \frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right)$$

## Integer Type Questions (61 to 73)

**61. (20)**




$T\cos 30° = mg$

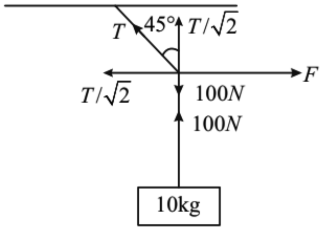
$$\cos 30° = \frac{\sqrt{3}g}{T} \Rightarrow \frac{\sqrt{3}}{2} = \frac{\sqrt{3}g}{T} \Rightarrow T = 20N$$

**62. (9)**

$$\vec{F} = \frac{d\vec{P}}{dt} = \frac{d(m\vec{v})}{dt} = \frac{dm}{dt} \times \vec{v}$$

$$\therefore |\vec{F}| = \left|\frac{10}{5} \times 4.5\right| = 9 \text{ dyne}$$

**63. (100)**




$$\frac{T}{\sqrt{2}}=100,\ \frac{T}{\sqrt{2}}=F$$

$F = 100\ N$

**64. (3)**

For Ascent:

$$t_a=\sqrt{\frac{2\ell}{a_{ascent}}}=\sqrt{\frac{2\ell}{g(\sin\theta+\mu\cos\theta)}}\quad \text{.......(i)}$$

For Descent:

$$t_d=\sqrt{\frac{2\ell}{a_{ascent}}}=\sqrt{\frac{2\ell}{g(\sin\theta-\mu\cos\theta)}}\quad \text{.......(ii)}$$

According to question, we can write

$$t_a=\frac{1}{2}t_d$$

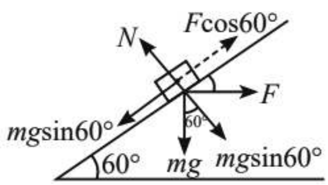
$$\Rightarrow \frac{1}{\sin\theta+\mu\cos\theta}=\left(\frac{1}{4}\right)\left(\frac{1}{\sin\theta-\mu\cos\theta}\right)$$

[From (i) and (ii)]

$$\Rightarrow \mu=\frac{3}{5}\tan\theta=\frac{3}{5}\tan 30^\circ=\frac{\sqrt{3}}{5}$$

**65. (12)**

For equilibrium of block along the inclined plane




$$F\cos 60^\circ = mg\sin 60^\circ$$

$$F=0.2\times 10\times\frac{\sqrt{3}}{2}\times\frac{2}{1}\Rightarrow F=\sqrt{12}N$$

$$\Rightarrow x=12$$

**66. (32)**

For equilibrium of the block net force should be zero. Hence we can write

$$mg\sin\theta+3=P+\text{ friction}$$

$$mg\sin\theta+3=P+\mu mg\cos\theta$$

After solving, we get, P = 32 N

**67. (5)**

In frame of belt

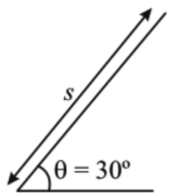
$$a=\mu g=4m/s^2,\ v=2m/s,\ u=0\ m/s$$

$$v^2=u^2+2as$$

$$\Rightarrow s=0.5m=\frac{x}{10}\Rightarrow x=5$$

**68. [346]**

For upward motion




$$\frac{1}{2}mv_0^2=\left(mg\frac{S}{2}+\mu mg\frac{\sqrt{3}}{2}S\right)$$

For downward motion

$$\frac{1}{2}\frac{mv_0^2}{4}=\left(mg\frac{S}{2}-\mu mg\frac{\sqrt{3}}{2}S\right)$$

$$4=\frac{(1+\mu\sqrt{3})}{(1-\mu\sqrt{3})}\Rightarrow 4-4\mu\sqrt{3}=1+\mu\sqrt{3}$$

$$\Rightarrow\quad 3=5\mu\sqrt{3}$$

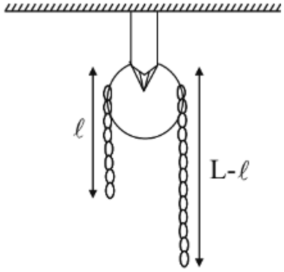
$$\therefore\quad \mu=\frac{\sqrt{3}}{5}\approx\frac{346.41}{1000}$$

$$\Rightarrow\quad 0-(10)^2=2\mu g\times 20\Rightarrow 40\mu g=100$$

$$\Rightarrow\quad \mu=\frac{1}{4}$$

**69.** **(4)**

Mass = $m$, Length = $L$,




$$\frac{m}{L} = \lambda$$

$$a = \frac{F_{\text{Pulling}}}{mass} = \frac{(L-\ell)\lambda g - \lambda \ell g}{\lambda L}$$

$$= \frac{(L-2\ell)\lambda g}{\lambda L} = \frac{g}{2}$$

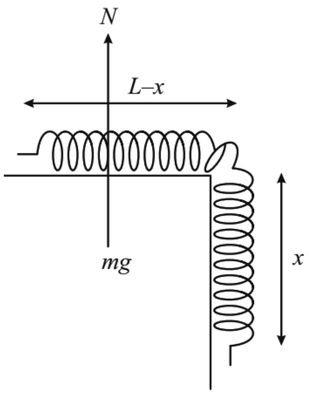
$$\Rightarrow L - 2\ell = \frac{L}{2}; \ell = \frac{L}{4} \Rightarrow x = 4$$

**70.** **(2)**

Mass per unit length = $\lambda$

$$N = mg = \lambda(L-x)g$$

$$f_{s,\max} = \mu_s N$$




$$f_{s,\max} = (0.5)(\lambda)(L-x)g$$

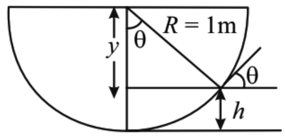
And also $f_{s,\max} = m_x g$

$$0.5\lambda(L-x)g = \lambda x g$$

$$\frac{L-x}{2} = x$$

$$\frac{L}{2} = \frac{3x}{2} \Rightarrow x = \frac{L}{3} = \frac{6}{3} = 2m$$

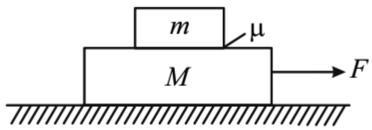
**71.** **(2)**




$$\mu = \tan\theta \Rightarrow \frac{3}{4}\tan\theta \Rightarrow \theta = 37^{o}$$

$$\therefore h = R \_ R\cos\theta = 1 - 1 \times \frac{4}{5} = 0.2m$$

**72.** **(21)**




$$a = \frac{F}{M+m}$$

$$f = ma = m\frac{F}{M+m}$$

$$m\frac{F}{M+m} \le \mu mg \text{ (for no slipping)}$$

$$\Rightarrow F \le \mu(m+M)g$$

$$\therefore F_{\max} = \frac{3}{7}(0.5+4.5)\times 9.8 = 21N$$

**73.** **(3)**

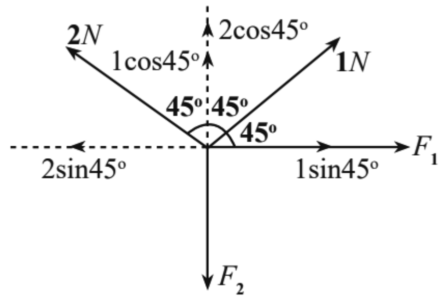
$$F_2 = 1\cos 45^\circ + 2\cos 45^\circ = 3\cos 45^\circ = \frac{3}{\sqrt{2}} N$$

$$F_1 + 1\sin 45^\circ = 2\sin 45^\circ$$

$$F_1 = 1\sin 45^\circ = \frac{1}{\sqrt{2}} N$$

$$\frac{F_1}{F_2} = 1:3$$

$$x = 3$$



# WORK, ENERGY AND POWER

*Single Option Correct Type Questions (01 to 60)*

**1.** **(3)**

**Sol:** $W$ = (force) (displacement) = (force) (zero) = 0

**2.** **(2)**

**Sol:** work done by first man + work done by gravity = 0 ...(i)

work done by second man + work done by gravity = 0 ...(ii)

Ratio of work done by them = 1 : 1

**3.** **(1)**

**Sol:** $T = mg + ma, \ S = \frac{1}{2}at^2$

$W_T = T \times S$

**4.** **(3)**

**Sol:** $F = k_1x_1, x_1 = \frac{F}{k_1}, W_1 = \frac{1}{2}k_1x_1^2 = \frac{F^2}{2k_1}$

Similarly $W_2 = \frac{F^2}{2k_2}$ since $k_1 > k_2$, $W_1 < W_2$

**5.** **(2)**

**Sol:** $a = \frac{F}{m}, \ S = \frac{1}{2}\left(\frac{F}{m}\right)t^2,$

$W_F = FS = \text{F}\left(\frac{Ft^2}{2m}\right)$

**6.** **(4)**

**Sol:** Area under curve = $\frac{1}{2}$ (4) (20) = 40 J

$W$ = work done by resistive force $F$ = – 40 J

$-40 = K_f - K_i$, $K_i = 50$ J,

so $K_f = 50 - 40 = 10$ J

**7.** **(4)**

**Sol:** $W_G = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2, \quad mgh$

$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv^2,$

So $v_f$ is free from direction of $v$.

**8.** **(4)**

**Sol:** $v = 0 + aT,$

$a = \frac{v}{T}$, velocity = $0 + at = \frac{vt}{T}$

K.E = $\frac{1}{2}(m)\left(\frac{vt}{T}\right)^2$

**9.** **(1)**

**Sol:** $E = \frac{1}{2}mv^2, \ \frac{dE}{dV} = mv = p$

**10.** **(3)**

**Sol:** Follows from definition [$W_{\text{cons.force}} = -\Delta U$]

**11.** **(1)**

**Sol:** $U_i + 0 = U_f + \frac{1}{2}mv^2$

$U_i - U_f = \frac{1}{2}mv^2$

$U = \frac{1}{2}mv^2$

$m = \frac{2U}{v^2}$

**12.** **(4)**

**Sol:** Average power = $\frac{100 \times 9.8 \times 50}{50}$ = 980 J/s

**13.** **(4)**

**Sol:** $V = 0 + at, F - \mu mg = ma, F = \mu mg + ma,$

$P = (\mu mg + ma)\, at$

**14.** **(3)**

**Sol:** We know $F = \frac{-dU}{dr}$

$\frac{dU}{dr} = 0, -\frac{2a}{r^3} + \frac{b}{r^2} = 0, r = \frac{2a}{b}$

**15.** **(3)**

**Sol:** $\frac{dU}{dx} = 0$ at $B$ and $C$

**16.** **(2)**

**Sol:** $\left.\frac{dU}{dx}\right|_{x=A} = -ve, \left.\frac{dU}{dx}\right|_{x=B} = +ve \quad F = \frac{-dU}{dr}$

So, $F_A$ = positive, $F_B$ = negative

**17.** **(1)**

**Sol:** $W_{C(P\to R)} = W_{C(P\to Q)} + W_{C(Q\to R)} = 5 + 2 = 7$

**18.** **(1)**

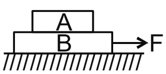
**Sol:** $W_{NC} + W_C = \Delta K$

$W_{NC} - \Delta U = \Delta K$

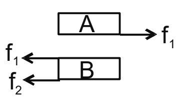
$W_{NC} = \Delta U + \Delta K$ = change in total energy

**19.** **(1)**

**Sol:**




Consider the blocks shown in the figure to be moving together due to friction between them. The free body diagrams of both the blocks is shown below.




Work done by static friction on $A$ is positive and on $B$ is negative.

**20.** **(1)**

**Sol:** As ΔKE is same in both the cases, work done will be same.

**21.** **(4)**

**Sol:** Work done by kinetic friction on a body may increase its kinetic energy.

As for (2), it is true for conservative forces.

For (3), internal forces must be conservative and work of external forces on the system must be zero.

**22.** **(1)**

**Sol:** $U(x) = x^2 - 4x$

$F = 0$

$\frac{dU(x)}{dx} = 0$

$2x - 4 = 0 \qquad x = 2$

$\Rightarrow \frac{d^2U}{dx^2} = 2 > 0$ i.e. $U$ is minimum hence $x = 2$ is a point of stable equilibrium.

**23.** **(2)**

**Sol:** Force is perpendicular to displacement hence work done is zero

**24.** **(4)**

**Sol:** $dW_F = \bar{F}.d\bar{s} = dk > 0 \Rightarrow |\bar{F}||d\bar{s}|\cos\theta > 0 \Rightarrow \quad 0 < \theta < 90^\circ$

$p = \sqrt{2m(K.E.)}$, K.E. ↑ so $p$ ↑ .

**25.** **(4)**

**Sol:** $W = \Delta K > 0 \Rightarrow K$ (= kinetic energy) increases.

$p = \sqrt{2mk}$, $p$ ↑ as $k$↑.

**26.** **(4)**

**Sol:** Only the 4th statements is true from definition of a conservative force.

"Its work is zero when the particle moves exactly once around any closed path".

"Its work depends on the end points of the motion, not on the path between".

**27.** **(1)**

**Sol:** $mg\frac{\ell}{2} = \frac{1}{2}mv^2$

$v = \sqrt{g\ell}$

**28.** **(2)**

**Sol:** $W_F + W_S = 0, \quad W_F - \Delta U = 0, \quad W_F = \Delta U = E$

$E = \frac{1}{2}k_A x_A^2$ and $Fx_A = \frac{1}{2}k_A x_A^2$

$\frac{2F}{k_A} = x_A, \quad \frac{2F}{k_A} = \sqrt{\frac{2E}{k_A}}$,

$k_A = \frac{2F^2}{E}$ ...(i)

Similarly $k_B = \frac{2F^2}{E_B}$ ,

$\because k_A = 2k_B$

$\therefore \frac{2F^2}{E} = 2\left(\frac{2F^2}{E_B}\right)$

$\therefore E_B = 2E$

**29.** **(1)**

**30.** **(2)**

**31.** **(1)**

**32.** **(4)**

**Sol:** $U \propto x^2$ graph is parabola.

**33.** **(1)**

**Sol:** **I–P; II-P; III-S; IV-Q**

**34.** **(2)**

**Sol:** $W_C = -\Delta U$

$= -(U_{\text{final}} - U_{\text{initial}})$

$= -\left(\frac{1}{2}\times k\times 15^2 - \frac{1}{2}\times k\times 5^2\right) = -8.$

Now $W_{\text{external}} = -WC$

$W_{\text{external}} = -(-8) = 8$ J

**35.** **(2)**

**Sol:** $K = 5 \times 10^3$ N/m

$x = 5$ cm

$W_1 = \frac{1}{2}k \times x_1^2 = \frac{1}{2}5 \times 10^3 \times (5 \times 10^{-2})^2$

$= 6.25$ J

$W_2 = \frac{1}{2}k(x_1 + x_2)^2$

$= \frac{1}{2} \times 5 \times 10^3 (5 + 10^{-2} + 5 \times 10^{-2})^2 = 25$ J

Net work done = $W_2 - W_1$

$= 25 - 6.25 = 18.75$ J $= 18.75$ N-m

**36.** **(2)**

**Sol:** Mass per unit length = $\frac{M}{L} = \frac{4}{2} = 2$ kg/m

The mass of 0.6 m of chain is

$= 0.6 \times 2 = 1.2$ kg

The centre of mass of hanging part

$= \frac{0.6+0}{2} = 0.3$ m

Hence, work done in pulling the chain on the table

$W = mgh$

$= 1.2 \times 10 \times 0.3$

$= 1.2 \times 10 \times 0.3 = 3.6$ J

**37.** **(2)**

**Sol:** Work done is displacing the particle

$W = \vec{F} \cdot \vec{r}$

$= (5\hat{i} + 3\hat{j} + 2\hat{k}).(2\hat{i} - \hat{j})$

$= 5 \times 2 + 3 \times (-1) + 2 \times 0$

$= 10 - 3$

$= 7$ J

**38.** **(1)**

**Sol:** $F = ma = \frac{mv}{T}\left(\therefore a = \frac{v-0}{T}\right)$

Instantaneous power = $Fv$

$= mav$

$= \frac{mv}{T}.at = \frac{mv}{T}.\frac{v}{T}.t$

$= \frac{mv^2}{T^2}.t$

**39.** **(2)**

**Sol:** Maximum height attained by the particle

$H = \frac{u^2}{2g} = \frac{5^2}{2\times 10} = \frac{5}{4}m$

$W_g = -MgH = -0.1 \times 10 \times (5/4) = -1.25$ J

**40.** **(1)**

**Sol:** Velocity of ball just after throwing

$v = \sqrt{2gh} = \sqrt{2\times 10\times 2} = \sqrt{2\times 10\times 2}$ m/s

Let a be the acceleration of ball during throwing, then

$v^2 = u^2 + 2as = 0^2 + 2as$

$\Rightarrow a = \frac{v^2}{2s} = \frac{40}{2\times 0.2} = 100$ m/s$^2$

$F - mg = ma$

$\Rightarrow F = m(g + a) = 0.2(10 + 100) = 22$ N

**41.** **(3)**

**Sol:** $\frac{1}{2}mv^2 = K$

$\Rightarrow \frac{1}{2}m(v\cos 60)^2 = \frac{1}{2}m\left(\frac{v^2}{4}\right) \Rightarrow \frac{1}{4}\left(\frac{1}{2}mv^2\right) = \frac{K}{4}\ J$

**42.** **(3)**

**Sol:** Assuming mass of athlete is between 40 kg to 100 kg

Lets consider mass of athlete $m$ = 50 kg

$V = S/t = \frac{100}{10}$ = 10 m/sec

So, $K = 1/2\ mv^2\ \ 1/2 \times (50 \times 10^2) = 2500$ J

So, range of K.E. is (3000 J – 5000 J)

**43.** **(3)**

**Sol:** K.E. = $ct$

$\frac{1}{2}mv^2 = ct$

$\frac{P^2}{2m} = ct$

$P = \sqrt{2ctm}$

$F = \frac{dP}{dt} = \sqrt{2cm}\ \frac{1}{2} \times \frac{1}{\sqrt{t}}$

$F \propto \frac{1}{\sqrt{t}}$

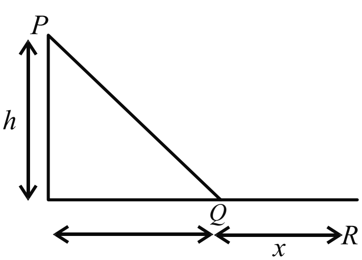
**44.** **(3)**

**Sol:** Work done is stretching the rubber band

$W = \int_0^L (ax + bx^2)dx = \frac{aL^2}{2} + \frac{bL^3}{3}$

**45.** **(2)**

**Sol:**




Using $\sin 30^\circ = \frac{h}{pQ}$ we get $PQ$ = 4 m. As work done by friction is equal over the parts $PQ$ and $QR$ of the track $\mu mg \cos 30^\circ \times 4 = \mu\, mgx$

Solving we get $x = 2\sqrt{3}$ = 3.5 m

Now applying Work Energy Theorem

$\mu gh = \mu mg \cos 30^\circ + \mu mg\ 2\sqrt{3}$

$\Rightarrow \frac{1}{2\sqrt{3}} = 0.29$

**46.** **(3)**

**Sol:** Given P.E. burnt by lifting weight

$= mgh = 10 \times 9.8 \times 1 \times 1000 = 9.8 \times 10^4$

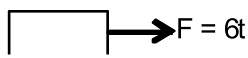
If mass lost by a person be $m$, then energy dissipated = $m \times \frac{2}{10} \times 3.8 \times 10^7$ J

$9.8 \times 10^4 = \frac{1}{5} \times 3.8 \times 10^7$

So, $m = 12.89 \times 10^{-3}$ kg

**47.** **(2)**

**Sol:**




$a = \frac{F}{m} = \frac{6t}{1} = 6t$

$\frac{dv}{dt} = 6t$

$dv = 6tdt$

$\int_0^v dv = 6\int_0^1 tdt$

$v = 6\left[\frac{t^2}{2}\right]_0^1 = 3$

$W = \Delta KE = K_F - K_i$

$= \frac{1}{2}(1)(3)^2 = 4.5$ J

**48.** **(4)**

**Sol:** $F = -Kv^2$

$m\frac{dv}{dt} = -kv^2$

$$\int_{v_0}^{v} v^{-2} dv = \int_0^t -\frac{k}{m} dt$$

After 10$s$, KE = $\frac{1}{2}mv^2 = \frac{1}{8}mv_0^2$

So, $v = \frac{v_0}{2}$

$$\left[-\frac{1}{v}\right]_{v_0}^{v_0/2} = -\frac{k}{m}t$$

$$\left(\frac{2}{v_0} - \frac{1}{v_0}\right) = \frac{k}{m}t$$

$$\Rightarrow k = \frac{m}{v_0 t} = \frac{10^{-2}}{10\times10}$$

$k = 10^{-4}$ kg m$^{-1}$

**49.** **(3)**

**Sol:** $dW = \vec{F}\cdot\vec{ds}$ where $\vec{ds} = dx\hat{i} + dy\hat{j}$

And $\vec{F} = -K(y\hat{i} + x\hat{j})$

$\therefore dW = -K(ydx + xdy) = -Kd(xy)$

$$\therefore W = \int_{(0,\,0)}^{(a,\,a)} dW$$

$$= -K\int_{(0,\,0)}^{(a,\,a)} d(xy)$$

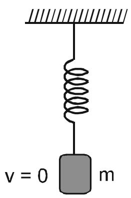
$$= -K[xy]_{(0,\,0)}^{(a,\,a)}$$

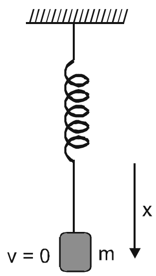
$W = -Ka^2$

**50.** **(2)**

**Sol:** Let $x$ be the maximum extension of the spring. From conservation of mechanical energy: decrease in gravitational potential energy = increase in elastic potential energy

$\therefore Mgx = \frac{1}{2}kx^2$ $\qquad x = \frac{2Mg}{k}$




**51.** **(4)**

**Sol:** $F = -\frac{dU}{dx}$

$\therefore dU = -F.\,dx$

Or $U(x) = -\int_0^x (-kx + ax^3)\,dx$

$$U(x) = \frac{kx^2}{2} - \frac{ax^4}{4}$$

$U(x) = 0$ at $x = 0$ and $x = \sqrt{\frac{2k}{a}}$

$U(x)$ = negative for $x > \sqrt{\frac{2k}{a}}$

From the given function we can see that $F = 0$ at $x = 0$ i.e. slope of $U$-$x$ graph is zero at $x = 0$. Therefore, the most appropriate option is (4).

**52.** **(1)**

**Sol:** From $F = -\frac{dU}{dx}$

$$\int_0^{U(x)} dU = -\int_0^x F dx = -\int_0^x (kx)\,dx$$

$$\therefore U(x) = -\frac{kx^2}{2}$$

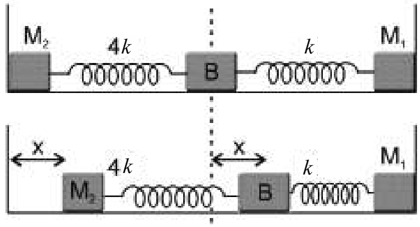
as $U(0) = 0$

**53.** **(3)**

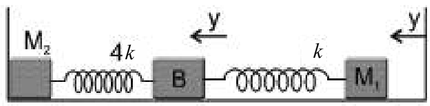
**Sol:** In horizontal plane Kinetic Energy of the block is completely converted into heat due to Friction but in the case of inclined plane some part of this Kinetic Energy is also convert into gravitational Potential Energy. So decrease in the mechanical energy in second situation is smaller than that in the first situation. So statement-1 is correct. Coefficient of Friction does not depends on normal reaction, In II case normal reaction changes with inclination but not coefficient of friction so this statement is wrong.

**54.** **(3)**

**Sol:**




As springs and supports ($M_1$ and $M_2$) are having negligible mass. Whenever springs pull the massless supports, springs will be in natural length. At maximum compression, velocity of $B$ will be zero.




And by energy conservation.

$\frac{1}{2}(4k)y^2 = \frac{1}{2}kx^2 \quad \frac{y}{x} = \frac{1}{2}$

**55.** **(3)**

**Sol:** $\int F dt = \Delta p$

$\Rightarrow \quad \frac{1}{2} \times 4 \times 3 - \frac{1}{2} \times 1.5 \times 2 = p_f - 0$

$\Rightarrow \quad p_f = 6 - 1.5 = \frac{9}{2}$

K.E. $= \frac{p^2}{2m} = \frac{81}{4\times2\times2}$ ; K.E. = 5.06 J

**56.** **(4)**

**Sol:** Suppose $x = r\cos\theta$ and $y = r\sin\theta$

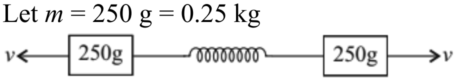
$y = r\sin\theta$

force on particle is $\frac{K}{r^3}\left(r\cos\theta\hat{i} + r\sin\theta\hat{j}\right)$

force is in radial direction so work done by this force along given path (circle) is zero as force is always perpendicular to displacement.

**57.** **(2)**

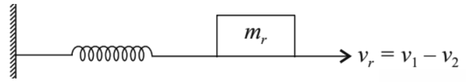
**Sol:** Let $m$ = 250 g = 0.25 kg




Reduced mass of the system

$$m_r = \frac{m_1 m_2}{m_1 + m_2} = \frac{mm}{m+m} = \frac{m}{2}$$

From conservation of energy,




$= 2v$ (relative velocity)

$K.E_i + P.E_i = K.E_f + P.E_f$

$\frac{1}{2}m_r v_r^2 + 0 = 0 + \frac{1}{2}kx^2$

$= \frac{1}{2} \times \frac{m}{2} \times 4v^2 = \frac{1}{2}kx^2$

$\frac{kx^2}{2} = mv^2$

$\frac{2}{2}x^2 = 0.25v^2$

$x = 0.5v$

$x = \frac{v}{2}$

**58.** **(3)**

**Sol:** $\frac{\Delta K}{K_i} \times 100 = \frac{\frac{P_f^2}{2m} - \frac{P_i^2}{2m}}{\frac{P_i^2}{m}} \times 100 \left[\because P = \sqrt{2M(KE)}\right]$

$$= \frac{(1.2P_i)^2 - (P_i)^2}{P_i^2} \times 100 = 44\%$$

**59.** **(4)**

**Sol:** Since, $P = \frac{mgh}{t}$

$$\frac{P_1}{P_2} = \frac{\frac{m_1 gh}{t_1}}{\frac{m_2 gh}{t_2}} = \frac{m_1}{t_1}\frac{t_2}{m_2}$$

$$\frac{3\sqrt{x}}{\sqrt{x}+1} = \frac{300\times2}{5\times50} = \frac{12}{5}$$

$12\sqrt{x} + 12 = 15\sqrt{x} \Rightarrow x = 16$

**60.** **(1)**

**Sol:** Power, $P$ = constant

$$P = Fv = mv\frac{dv}{dx}v$$

$$\frac{P}{m}\int dx = \int v^2 dv$$

$$\frac{Px}{m} = \frac{v^3}{3}$$

$$\left(\frac{3P}{m}x\right)^{1/3} = v = \frac{dx}{dt}$$

$$\left(\frac{3P}{m}\right)^{1/3}\int_0^t dt = \int_0^x x^{-1/3}dx \Rightarrow x = \left(\frac{8P}{9m}\right)^{1/2} t^{3/2}$$

## Integer Type Questions (61 to 75)

**61.** **(16)**

**Sol:** $F_1 = F$ N, $E = w = Fd$(Nm)

$F_2 = 4F$ N, E′

$= W' = 4F4\ell(\text{Nm}) = F\ell(16\text{Nm})$

$L_1 = \ell m$

$L_1 = 4\ell m$, $E' = 16E$

**62.** **(100)**

**Sol:** $W = \vec{F}.(\vec{r}_2 - \vec{r}_1) = 100$ J

**63.** **(2)**

**Sol:** $W = \int_o^{x_1} Cxdx = C\frac{x_1^2}{2}$

**64.** **(6)**

**Sol:** $W = \int_0^1 F\,dx = \frac{1}{6}$ J

**65.** **(135)**

**Sol:** $W = \int_0^5 F\,dx = 7x - \frac{2x^2}{2} + \frac{3x^3}{3}$

$= 7 \times 5 - 25 \times \frac{2}{2} + 125 \times \frac{3}{3} = 135$ J

**66.** **(1)**

**Sol:** $\text{KE} = \frac{P^2}{2m} = 1$

**67.** **(40)**

**Sol:** $W$ = area under curve = 8J. Now $W = \Delta$KE

$80 = \frac{1}{2}(0.1)\,u^2 - 0,$

So, $u = 40$ m/s

**68.** **(100)**

**Sol:** $\left(U = \frac{1}{2}Kx^2\right) \Rightarrow U \propto x^2$

**69.** **(300)**

**Sol:** $100 = \frac{1}{2}K(2\text{ cm})^2$, $E = \frac{1}{2}\text{K}(4\text{ cm})^2$

So, $\frac{E}{100} = 4$, $E = 400$ J

So final energy = 400 J

Initial energy = 100 J

Charge = 400 – 100 = 300 J

**70.** **(140)**

**Sol:** $P = \bar{F}.\bar{v} = 50 - 30 + 120 = 140$ J

**71.** **(1)**

**Sol:** $\frac{\partial U}{\partial x} = \cos(x + y),$

$\frac{\partial U}{\partial y} = \cos(x + y)$

$F = \frac{-dU}{dx}\hat{i} - \frac{dU}{dy}\hat{j}$

$\bar{F} = -\cos(x + y)\hat{i} - \cos(x + y)\hat{j}$

$= -\cos\left(0 + \frac{\pi}{4}\right)\hat{i} - \cos\left(0 + \frac{\pi}{4}\right)\hat{j}$

$= \left(\frac{1}{\sqrt{2}}\hat{i} - \frac{1}{\sqrt{2}}\hat{j}\right)$

So, $|\bar{F}| = 1$

**72.** **(1)**

**Sol:** $W_S + W_f = \Delta K$

$-\Delta U + W_f = -K_i$

$-U_f - \mu mgx = -K_i$

$\frac{1}{2}Kx^2 + \mu\, mgx = \frac{1}{2}mu^2$

$100\,x^2 + 2(0.1)(50)(10)x = 50 \times 4$

$x^2 + x - 2 = 0$

$x = 1$ m

**73. (5)**

**Sol:** $W_G + W_f = 0 - 0$

$10 \times 1 + W_f = 0$

$10 - \mu mg\, x = 0 \quad (m = 1 \text{ kg})$

$10 = (.2)(10)\, x,\ x = 5 \text{ m}$

**74. (1)**

**Sol:** (A) $mg1 - mg/2 = mv^2/2, \qquad v = \sqrt{g}$

$$d = v\sqrt{2h/g} = \sqrt{g}\sqrt{\frac{2(0.5)}{g}} = 1 \text{ m}$$

**75. (1)**

**Sol:** Let initial velocity is $u$ and retardation is a

So, $\frac{u^2}{4} = u^2 - 2a \times (0.03)$ ...(i)

$0 = \frac{u^2}{4} - 2a \times S$ ...(ii)

here S is required distance

from equation (i) & (ii)

$S = 0.01 \text{ m} = 1 \text{ cm}$

# CIRCULAR MOTION

## Single Option Correct Type Questions (01 to 60)

**1.** **(3)**

**Sol:** Speed $v_1 = \frac{2\pi r_1}{t}$

$v_2 = \frac{2\pi r_2}{t}$

$\omega_1 = \frac{v_1}{r_1} = \frac{2\pi}{t} \Rightarrow \omega_2 = \frac{v_2}{r_2} = \frac{2\pi}{t}$

$\omega_1 = \omega_2 \quad \Rightarrow \frac{\omega_1}{\omega_2} = \frac{1}{1}$

**2.** **(4)**

**Sol:** Speed = constant

In uniform circular motion, velocity and acceleration are constant in magnitude but direction is change. Therefore velocity and acceleration both change.

**3.** **(1)**

**4.** **(1)**

**Sol:** $V = \omega.r \Rightarrow V = 30 \times 2\pi \times \frac{1}{2} = 30\pi$ m/s

**5.** **(3)**

**Sol:** $r = \frac{20}{\pi} m,\ a_t$ = constant

$n = 2$

$v = 80$ m/s

$\omega_0 = 0,\ \omega_f = \frac{v}{r} = \frac{80}{20/\pi} = 4\pi$ rad/sec

$\theta = 2\pi \times 2 = 4\pi$

from 3rd equation

$\omega^2 = \omega_0^2 + 2\alpha\theta \Rightarrow (4\pi)^2 = 0^2 + 2 \times \alpha \times (4\pi)$

$\alpha = 2\pi$ rad/s$^2$

$a_t = \alpha r = 2\pi \times \frac{20}{\pi} = 40$ m/s$^2$

**6.** **(4)**

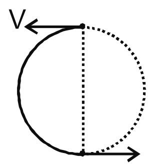
**Sol:** $\omega_{second} = \frac{2\pi}{T} = \frac{2\pi}{60}$ rad/sec.

$v = \omega.r = \frac{2\pi}{60} \times 0.06$ m/s $= 2\pi$ mm/s

$\Delta\vec{v} = \vec{v}_f - \vec{v}_i \Rightarrow |\Delta\vec{v}| = \sqrt{2}\,v = 2\sqrt{2}\,\pi$ mm/s

**7.** **(1)**

**Sol:** $\Delta\vec{V} = \vec{V}_1 - \vec{V}_2$




$= \vec{V} - (-\vec{V}) = 2\vec{V}$

$|\Delta\vec{V}| = 2V = 2 \times 100$ km/hr $= 200$ km/hr.

**8.** **(3)**

**Sol:** Angular velocity of every particle of disc is same

$a_P = \omega^2 r_p,\ a_Q = \omega^2 r_Q$

$\because r_P > r_Q \Rightarrow a_P > a_Q$

**9.** **(3)**

**Sol:** For circular motion of particle $a_r$ not equal to zero, $a_t$ may or may not be zero.

**10. (4)**

**Sol:** $p = mv$, & $F = mv^2/r \Rightarrow F = p^2/mr$

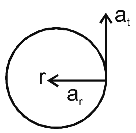
**11. (3)**

**Sol:** $a_c = \frac{v^2}{r}$, Radius is constant in case (*a*) and increase in case (*b*). So that magnitude of acceleration is constant in case (*a*) and decrease in case (*b*).

**12. (2)**

**Sol:** $a_t = a$

$a_r = \frac{v^2}{r}$




$\vec{a} = \vec{a}_r + \vec{a}_t$

$|\vec{a}| = \sqrt{\left(\frac{v^2}{r}\right)^2 + a^2}$

**13. (4)**

**Sol:** Centripetal force is constant in magnitude that means speed is constant and due to change in direction velocity is variable.

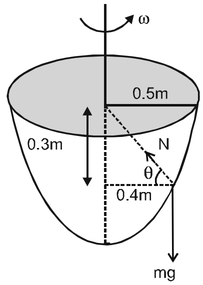
**14. (1)**

**Sol:** $N\cos\theta = m\omega^2 . r$ ....(i)

$N\sin\theta = mg$ ....(ii)

$\tan\theta = \frac{0.3}{0.4} = \frac{3}{4}$

from (i) & (ii)




$\tan\theta = \frac{mg}{m\omega^2 r}$

$\omega^2 = \frac{g}{r.\tan\theta} = \frac{10\times 4}{0.4\times 3} = \frac{100}{3}$

$\omega = \frac{10}{\sqrt{3}}$ rad/sec.

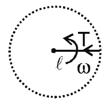
**15. (4)**

**Sol:** $T_0 = m\omega_0^2.\ell_0$

$T_1 = m\,(2\omega_0)^2.(2\ell_0)$

$= 8\,m\,\omega_0^2\ell_0$

$T_1 = 8T_0$




**16. (1)**

**Sol:** Force is perpendicular to $\vec{v}$

$R = \frac{v^2}{a_\perp} \Rightarrow R = \frac{mv^2}{F}$

**17. (3)**

**Sol:** $F_{C1} = F_{C2} \Rightarrow \frac{mv_1^2}{r_1} = \frac{mv_2^2}{r_2}$

$\frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \frac{1}{\sqrt{2}}$

**18. (3)**

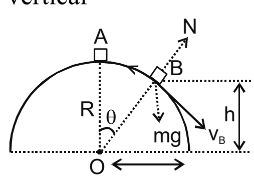
**Sol:** At $t = 0$, $t = 0$ $ij$

$a_\perp = g\cos\theta$,

$R = \frac{v^2}{a_\perp} = \frac{u^2}{g\cos\theta}$

**19. (2)**

**Sol:** Let the car looses the contact at angle θ with vertical




$mg\cos\theta - N = \frac{mv_B^2}{R}$

$\Rightarrow N = mg\cos\theta - \frac{mv_B^2}{R}$

**20. (4)**

**Sol:** For circular motion in vertical plane normal reaction is minimum at highest point and it is zero, minimum speed of motorbike is -

$$mg = \frac{mv^2}{R} \qquad \Rightarrow v = \sqrt{gR}$$

**21. (3)**

**Sol:** $T - mg\cos\theta = \dfrac{mv^2}{r}$ ....(1)

(from centripetal force)

from energy conservation.

$$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mgr(1 - \cos\theta)$$

(here $u$ is speed at lowest point)

from (1) and (2)

$$T = \frac{mu^2}{r} + 3mg\cos\theta - 2mg$$

for $\theta = 30^\circ$ & $60^\circ$ $\Rightarrow$ $T_1 > T_2$

**22. (1)**

**Sol:** $T - mg = \dfrac{mv^2}{r}$ (centripetal force at lowest point)

$$T = \frac{mv^2}{r} + \text{mg}$$

**23. (2)**

**Sol:** Normal reaction at highest point.

$$mg - N = \frac{mv^2}{r}$$

$$N = mg - \frac{mv^2}{r}$$

$R_A > R_B$ $\Rightarrow N_A > N_B$

**24. (3)**

**Sol:** Clearly, tension at lowest point = 6 $mg$ and top most point = 0

Hence, $\Delta T = 6\ mg$

**25. (1)**

**Sol:** When a string fixed with a nail, moves along a vertical circle, then the minimum horizontal velocity at the lowest point of circle is given by

$$v = \sqrt{5rg}$$

$$= \sqrt{5\times 0.25\times 10} = \sqrt{12.25}\ \text{m/s}$$

**26. (4)**

**27. (2)**

**Sol:** Here required centripetal force provide by friction force. Due to lack of sufficient centripetal force car thrown out of the road in taking a turn.

**28. (3)**

**Sol:** Conceptual

**29. (3)**

**Sol:** For water does not fall at topmost point of path that means at topmost point $N$ should be greater than or equal to zero.

for $N = 0$, $mg = \dfrac{mv^2}{r}$

and for $N > 0$, $mg < \dfrac{mv^2}{r}$

so, $mg$ is not greater than $\dfrac{mv^2}{r}$

**30. (1)**

**Sol:** When train A moves form east to west

$$mg - N_1 = \frac{m(v - \omega R)^2}{R}$$

$$\Rightarrow N_1 = mg - \frac{m(v-\omega R)^2}{R}$$

$N_1 = F_1$

When train $B$ moves from west to east

$$mg - N_2 = \frac{m(v+\omega R)^2}{R}$$

$$\Rightarrow N_2 = mg - \frac{m(v+\omega R)^2}{R}$$

$N_2 = F_2$

$F_1 > \text{F}_2$

**31. (3)**

**Sol:** $v = 72$ km/h

$= 72 \times \frac{5}{18} = 20$ m/s

$a_r = \frac{v^2}{r} = \frac{400}{80} = 5$

$\tan\theta = \frac{v^2/r}{g} = \frac{5}{10} = \frac{1}{2}$

$\theta = \tan^{-1}\left(\frac{1}{2}\right)$

**32. (2)**

**Sol:** Centripetal force provided by friction

$\mu mg \le \frac{mv^2}{r}$

**33. (2)**

**Sol:** $F_C = mk^2 rt^2$

$a_C = k^2rt^2 = \frac{v^2}{r} \Rightarrow v = krt$

$a_t = \frac{dv}{dt} = kr$

$F_t = mkr$

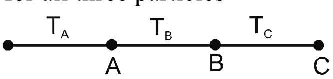
$\Rightarrow P = \vec{F} \cdot \vec{v}$ $\quad (\because \vec{F}_C \cdot \vec{v} = 0)$

$P = \vec{F}_t \cdot \vec{v} = mkr \times krt$

$= mk^2r^2t$

**34. (4)**

**Sol:** $\omega$ = const., for all three particles




$\omega = \frac{v}{3\ell}$

$T_C = m\omega^2\, 3\ell$

$T_B - T_C = m\omega^2 2\ell$

$T_B = 5\, m\omega^2\ell$

$T_A - T_B = m\omega^2\ell$

$T_A = 6\, m\omega^2\ell$

$T_C : T_B : T_A :: 3 : 5 : 6$

**35. (2)**

**Sol:** $T_1 = ka = m\omega^2\, 2a$

$\Rightarrow \omega = \sqrt{\frac{k}{2m}}$

Time period $= \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{2m}{k}} = T$

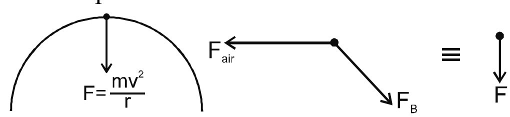
$T_2 = 2ka = m\omega^2 3a \Rightarrow \omega = \sqrt{\frac{2k}{3m}}$

Time period $= 2\pi\sqrt{\frac{3m}{2k}} = T'$

$T' = \left(\frac{\sqrt{3}}{2}\right)T$

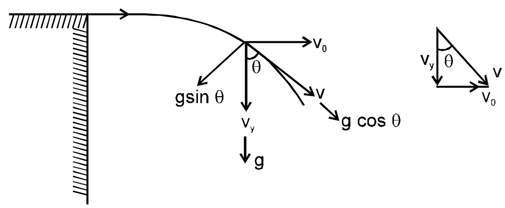
**36. (2)**

**Sol:** In uniform circular motion resultant horizontal force on the car must be towards the centre of circular path.




**37. (1)**

**Sol:**




As we know :

$a_C = \frac{v^2}{R}$ (centripetal acceleration)

From figure ; $g \sin\theta = \frac{v^2}{R}$

$\Rightarrow g.\frac{v_0}{v} = \frac{v^2}{R}$ (Since; $\sin\theta = \frac{v_0}{v}$)

$\Rightarrow R \propto v^3$

**38.** **(2)**

**Sol:** Given $v_B = 0.5\sqrt{gr}$

Assume block leave the contact at $C$, $N = 0$

$$\frac{mv_C^2}{r} = mg\cos\theta \quad \text{.... (1)}$$

from energy conservation

$$\frac{1}{2}mv_B^2 + mgr(1-\cos\theta) = \frac{1}{2}mv_C^2 \quad \text{..... (2)}$$

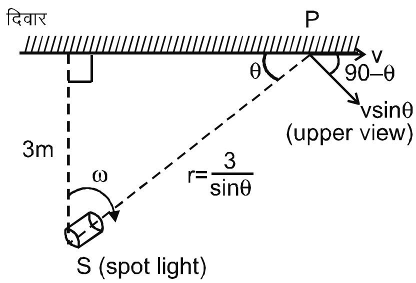
from equation (1) and (2)

$$\cos\theta = \frac{3}{4}$$

$$\Rightarrow \theta = \cos^{-1}\frac{3}{4}$$

**39.** **(1)**

**Sol:**




$$\omega = \frac{v_\perp}{r} = \frac{v\sin\theta}{r}$$

$$\Rightarrow v = \frac{\omega r}{\sin\theta} = \frac{3\omega}{\sin^2\theta}$$

$$\Rightarrow v = \frac{0.1\times 3}{(1/\sqrt{2})^2} = 0.6 \text{ m/s}$$

**40.** **(1)**

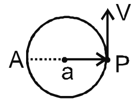
**Sol:** $\theta = \frac{1}{2}\alpha t^2$ as $\omega_0 = 0$

$$= \frac{1}{2}\times 4\times 4^2 = 32 \text{ rad}$$

$$\omega = \alpha.t = 4\times 4 = 16 \text{ rad/sec}$$

**41.** **(2)**

**Sol:** $\omega_{PA} = \frac{v}{2a} = \frac{v}{2a}$, $\omega_{PC} = \frac{v}{a}$




$$\frac{\omega_{PA}}{\omega_{PC}} = \frac{1}{2} = 1:2$$

**42.** **(4)**

**Sol:** $\omega_{PQ} = \dfrac{(V_{PQ})\text{ Perpendicular to } PQ}{PQ}$

$$= \frac{8\sin 30^\circ + 6\sin 30^\circ}{10} = \frac{4+3}{10}$$

$\omega_{PQ} = 0.7$ rad/sec.

**43.** **(2)**

**Sol:** Use WET from top to point $Q$ and centripetal at $Q$ putting normal is equal to 0

**44.** **(4)**

**Sol:** $\mu mg \geq m\omega^2 r$

$$r \leq \frac{\mu g}{\omega^2}$$

**45.** **(3)**

**Sol:** Let tension = $T'$

$T'\cos\theta = mg$ &

$$T'\sin\theta = \frac{mv^2}{\ell\sin\theta}.\frac{\ell\sin\theta}{\ell\sin\theta} = m\omega^2\ell\sin\theta$$

**46.** **(2)**

**Sol:** Range $(AC) = \sqrt{g\ell}\times\sqrt{\frac{2\times 2\ell}{g}} = 2\ell$

**47.** **(3)**

**Sol:** Let $v$ be the speed of $B$ at lowermost position, the speed of $A$ at lowermost position is $2v$.

From conservation of energy

$$\frac{1}{2}m(2v)^2 + \frac{1}{2}mv^2 = mg(2\ell) + mg\ell.$$

Solving we get, $v = \sqrt{\frac{6}{5}g\ell}$.

**48. (1)**

**Sol:** For conical pendulum of length $\ell$, mass m moving
along horizontal circle as shown.

$T\cos\theta = mg$ .... (1)

$T\sin\theta = m\omega^2\ell\sin\theta$ .... (2)

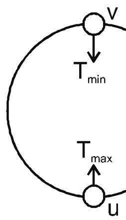
From equation 1 and equation 2, $\ell\cos\theta = \dfrac{g}{\omega^2}$

$\ell\cos\theta$ is the vertical distance of sphere below $O$ point of suspension. Hence if $\omega$ of both pendulums are same, they shall move in same horizontal plane.

Hence statement-2 is correct explanation of statement-1.

**49. (1)**

**Sol:** Let the minimum and maximum tensions be $T_{max}$ and $T_{min}$ and the minimum and maximum speed be $u$ and $v$.




$\therefore\ T_{max} = \dfrac{mu^2}{R} + mg$

$T_{min} = \dfrac{mv^2}{R} - mg$

$\therefore\ \Delta T = m\left(\dfrac{u^2}{R} - \dfrac{v^2}{R}\right) + 2\,mg.$

From conservation of energy

$\dfrac{u^2}{R} - \dfrac{v^2}{R} = 4g$

$\Rightarrow$ is independent of u.

and $\Delta T = 6\,mg$.

$\therefore$ Statement-2 is correct explanation of statement-1.

**50. (3)**

**Sol:** As the particle goes up, curve becomes sharper and sharper, and radius of curvature decreases

Statement-2 is wrong. $R = \dfrac{v^2}{a_\perp}$, where $a_\perp$ is acceleration component perpendicular to velocity.

**51. (1)**

**Sol:** $a_t = \dfrac{dv}{dt} = 1\ \text{m/s}^2$

$a_c = \dfrac{v^2}{r} = t^2$

$\theta = \dfrac{\pi}{4}\quad a_t = a_c$

$t^2 = 1 \qquad t = 1$ sec.

(II) $\tan\theta = \dfrac{a_c}{a_t} = \dfrac{t^2}{1}$

$\sec^2\theta \cdot \dfrac{d\theta}{dt} = 2t$

$\dfrac{d\theta}{dt} = \dfrac{2t}{1+\tan^2\theta}$

$= \dfrac{2\times1}{1+1} = 1$ rad/sec

(III) Friction

$= ma_{net} = \sqrt{2}\times\sqrt{1^2+\left(t^2\right)^2}$

$= \sqrt{2}\times\sqrt{2}$

$= 2$ N

(IV) $f_{\left(t=\sqrt{3}\right)} = ma = \mu\, mg$

$\mu = \dfrac{a}{g} = \dfrac{\sqrt{1+t^4}}{10} = \dfrac{\sqrt{10}}{10} = \dfrac{1}{\sqrt{10}}$

**52.** **(2)**

**Sol:** In curved path, may be circular or parabolic.

In circular path speed and magnitude of acceleration are constant.

In parabolic path acceleration is constant.

**53.** **(4)**

**Sol:**
(1) During a period of 1 year displacement is equal to zero, so that average velocity is equal to zero.
(2) During a period of one year distance travel is not equal to zero. So that average speed is not equal to zero.
(3) During a period of first 6 month of the year change in velocity not equal to zero. So that average acceleration is not equal to zero.
(4) In uniform circular motion instantaneous acceleration is act towards centre of circular path.

**54.** **(2)**

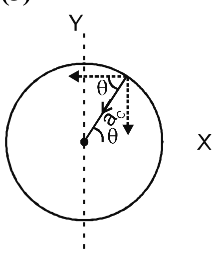
**Sol:** For a particle moving in a circle with constant angular speed, velocity vector is always tangent to the circle and the acceleration vector always points towards the centre of circle or is always point towards the centre of circle or is always along radius of the circle. Since, tangential vector is perpendicular to radial vector, therefore, velocity vector will be perpendicular to the acceleration vector. But in no case acceleration vector is tangent to the circle

**55.** **(3)**

**Sol:** When a force of constant magnitude acts on velocity of particle perpendicularly, then there is no change in the kinetic energy of particle. Hence, kinetic energy remains constant.

**56.** **(3)**

**Sol:**




$$a_C = -\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$$

**57.** **(3)**

**Sol:** They have same ω.

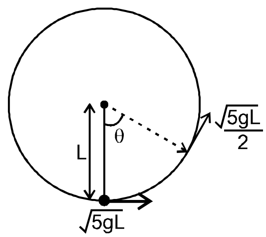
centripetal acceleration = $\omega^2 r$

$$\frac{a_1}{a_2} = \frac{\omega^2 r_1}{\omega^2 r_2} = \frac{r_1}{r_2}$$

**58.** **(4)**

**Sol:** By energy conservation,

$$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mg\ell(1-\cos\theta)$$




$$v^2 = u^2 - 2g\,(L - L\cos\theta)$$

$$\frac{5gL}{4} = 5gL - 2gL\,(1-\cos\theta)$$

$$5 = 20 - 8 + 8\cos\theta$$

$$\cos\theta = -\frac{7}{8}$$

$$\frac{3\pi}{4} < \theta < \pi$$

**59.** **(1)**

**Sol:** Centripetal force, $F_c = m\omega^2 r = 200 \times (0.2)^2 \times 70$ = 560 N

**60.** **(2)**

**Sol:** $\alpha = \frac{d\omega}{dt}$

$$\Rightarrow \int_{10}^{\omega} d\omega = \int_0^t \alpha dt$$

$$\Rightarrow [\omega]_{10}^{\omega} = \int_0^t \alpha dt$$

$$\Rightarrow \omega - 10 = \int_0^t \left(6t^2 - 2t\right)dt$$

$\omega = 10 + 2t^3 - t^2$

$\omega = 2t^3 - t^2 + 10$

$$\frac{d\theta}{dt} = 2t^3 - t^2 + 10$$

$$\Rightarrow \int_4^\theta d\theta = \int_0^t \left(2t^3 - t^2 + 10\right) dt$$

$$\Rightarrow \theta - 4 = \frac{t^4}{2} - \frac{t^3}{3} + 10t$$

$$\therefore \theta = \frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$$

## Integer Type Questions (61 to 75)

**61.** **(200)**

**Sol:** $\omega = 80$ rad/sec, $t = 5$ sec, $\omega_0 = 0$

$\alpha = 16$ rad/s$^2$

So if $\alpha$ is constant, then

$$\theta = \left(\frac{\omega + \omega_0}{2}\right) t = \left(\frac{80 + 0}{2}\right) 5 = 200 \text{ rad}$$

**62.** **(7)**

**Sol:** $\omega^2 . r = a_r \Rightarrow \omega^2 = 9.8/20 \times 10^2$ , $\omega = 7$ rad/s

**63.** **(1)**

**Sol:** For just slip $\Rightarrow \mu mg = m\omega^2 r$

here $\omega$ is double then radius is 1/4$^{th}$

$\Rightarrow \mu mg = m\omega^2 r$

$r' = 1$ cm

**64.** **(8)**

**Sol:** $$T = \frac{mv^2}{r} = \frac{0.5 \times (4)^2}{1} = 8\text{N}$$

**65.** **(50)**

**Sol:** $$T = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{Tr}{m}} = \sqrt{\frac{10 \times 0.5}{0.1}} = \sqrt{50} \text{ m/sec}$$

**66.** **(12)**

**Sol:** $r = 144\ m$, $m = 16$ kg, $T_{\max} = 16\ N$

$$T = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{Tr}{m}} = \sqrt{\frac{16 \times 144}{16}} = 12 \text{ m/s}$$

**67.** **(1)**

**Sol:** It can be observed that component of acceleration perpendicular to velocity is

$a_c = 4$ m/s$^2$

$$\therefore \quad \text{radius} = \frac{v^2}{a_c} = \frac{(2)^2}{4} = 1 \text{ metre}$$

**68.** **(4)**

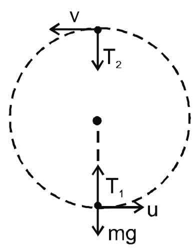
**Sol:** $$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

**69.** **(10)**

**Sol:** $$\frac{T_1}{T_2} = \frac{\frac{mu^2}{\ell} + mg}{\frac{mv^2}{\ell} - mg} = 4$$

By energy conservation

$$\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = 2\ mg\ell$$




$\Rightarrow u^2 - v^2 = 4g\ell$

$u^2 = 4g\ell + v^2$

$$3v^2 = 9\ g\ell \quad v = \sqrt{3g\ell} = \sqrt{3 \times 10 \times \frac{10}{3}} = 10 \text{ m/s}$$

**70. (30)**

**Sol:** Using the relation

$$\frac{mv^2}{r} = \mu R,\ R = mg,\ \frac{mv^2}{r} = \mu mg$$

or $v^2 = \mu rg$

or $v^2 = 0.6 \times 150 \times 10$

$\Rightarrow v = 30\ \text{m / s}$

**71. (14)**

**Sol:** $s = t^3 + 5$

Linear speed of the particle

$$v = \frac{ds}{dt} = 3t^2$$

at $t = 2s$, $v = (3 \times 2^2)$ m/s = 12 m/s

Linear acceleration

$$a_t = \frac{dv}{dt} = 6t$$

at $t = 2\ s$, $a_1 = 12\ \text{m/s}^2$

The centripetal acceleration

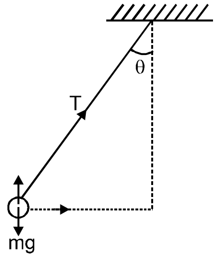
$$a_c = \frac{v^2}{R} = \frac{12^2}{20}\ \text{m/s}^2$$

$= 7.2\ \text{m/s}^2$

$$\therefore\ a_{net} = \sqrt{a_t^2 + a_c^2} = \sqrt{12^2 + 7.2^2} = 14\ \text{m/s}^2$$

**72. (36)**

**Sol:** $T \sin\theta = m L \sin\theta\ \omega^2$




$324 = 0.5 \times 0.5 \times \omega^2$

$$\omega^2 = \frac{324}{0.5 \times 0.5}$$

$$\omega = \sqrt{\frac{324}{0.5 \times 0.5}}$$

$$\omega = \frac{18}{0.5} = 36\ \text{rad/sec.}$$

**73. (10)**

**Sol:** $mg \times \frac{R}{2} - 150 = \frac{1}{2} mv^2$

$$1 \times 10 \times 20 - 150 = \frac{1}{2} v^2$$

$\Rightarrow v = 10$ m/s

**74. (125)**

**Sol:** As the stone is moving in a circular path, so the acceleration is

$$a = \omega^2 R = \left(\frac{28 \times 2\pi}{60}\right)^2 \times 1.8 = \frac{1936}{125}$$

**75. (200)**

**Sol:** $\omega^2 = \omega_0^2 + 2\alpha\theta$

$$\Rightarrow \left(\frac{2\pi}{60} \times 1800\right)^2$$

$$= \left(\frac{2\pi}{60} \times 600\right)^2 + 2\left(\frac{2\pi}{60} \times \frac{1200}{10}\right)\theta$$

On solving, $\theta = 400\pi$ rad

Number of rotation $= \frac{\theta}{2\pi} = \frac{400\pi}{2\pi} = 200$

# SYSTEM OF PARTICLES AND CENTRE OF MASS

*Single Option Correct Type Questions (01 to 60)*

**1.** **(4)**

**Sol:** Centre of mass is a point which can lie within or outside the body.

**2.** **(4)**

**Sol:** Centre of mass is at, $r_{cm} = \frac{h}{4} = \frac{40}{4} = 10\ cm$

**3.** **(4)**

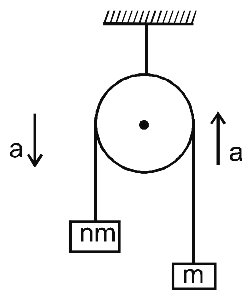
**Sol:** In absence of external force both move away from each other to keep the centre of mass at rest.

**4.** **(4)**

**Sol:** $a_{cm} = \frac{m_1 g + m_2 g}{m_1 + m_2} = g$

**5.** **(3)**

**Sol:** $a = \frac{(nm - m)}{nm + m} g = \frac{(n-1)}{(n+1)} g$




$a_1 = a_2 = a$

$$a_{cm} = \frac{nma_1 - ma_2}{(nm+m)} = \frac{(n-1)}{(n+1)} \times a$$

$$a_{cm} = \frac{(n-1)^2}{(n+1)^2} g\ .$$

**6.** **(1)**

**Sol:** we have $V_m + V_b = V_{rel} \Rightarrow V_m = V_{rel} - V_b$

by conservation of linear momentum

$mV_m - MV_b = 0$

So $m(V_{rel} - V_b) - MV_b = 0$

$\Rightarrow V_b = \frac{mv_{rel}}{m+M}$

**7.** **(3)**

**Sol:** by energy conservation $\frac{1}{2}mv^2$

$$= \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}mv^2 = \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 + \frac{1}{2}kx^2$$

$\Rightarrow \quad x = \sqrt{2mK}$

**8.** **(3)**

**Sol:** Impulse $= \int F dt$

= Area under curve

$= \frac{1}{2}(2)(2) = 2\ kg\text{-}m/sec$

**9.** **(1)**

**Sol:** Internal force can not change the total momentum of system.

**10.** **(2)**

**Sol:** by conservation of linear momentum $P_i = P_f$

$\Rightarrow mv = (100\ m)\ u \qquad \Rightarrow u = v/100$

**11.** **(1)**

**Sol:** $\Delta U = \dfrac{1}{2}\dfrac{m_1 m_2}{(m_1+m_2)}\ (V_1 - V_2)^2 = \dfrac{100}{3}$

$(V_1 - V_2)^2 \times \dfrac{2m.m}{2(m+2m)} = \dfrac{100}{3}$

[Put $V_1$ and $V_2$ with sign]

putting $m = 1$ kg

$(V_1 - V_2) = 10\ m/sec.$

**AlternateSolution:** When deformation is maximum both the particles are moving with same velocity. So applying momentum conservation.

$m_1v_1 + m_2v_2 = m_1v_1{'} + m_2v_1{'}$

$v_1{'} = \dfrac{m_1v_1 + m_2v_2}{m_1 + m_2}$

Applying energy conservation:

$\dfrac{1}{2}m_1v_1^2 + \dfrac{1}{2}m_2v_2^2$

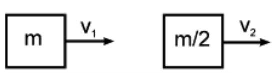
$= \dfrac{1}{2}\ (m_1 + m_2)\ (v_1{'})^2 + \Delta U_{\text{deformation}}$

$\Rightarrow \quad \Delta U_{\text{deformation}} = \dfrac{1}{2}\dfrac{m_1m_2}{(m_1+m_2)} \times (v_1 - v_2)^2$

$= \dfrac{100}{3} \Rightarrow v_1 - v_2 = 10\ m/sec.$

**12.** **(2)**

**Sol:** Let the velocities of block $A$ and body of mass $\dfrac{m}{2}$




Block $A$ Block $B$

be $v_1$ and $v_2$ after collision as shown.

From conservation of momentum,

$mv - \dfrac{m}{2}2v = mv_1 + \dfrac{m}{2}v_2$

or $\quad 2v_1 + v_2 = 0 \qquad$ ......(1)

From equation of coefficient of restitution.

$e = 1 = \dfrac{v_2 - v_1}{v + 2v} \quad \Rightarrow \quad v_2 - v_1 = 3v \qquad$ ......(2)

Solving 1 and 2 we get

$v_1 = -v$

**13.** **(1)**

**Sol:** $mu = mv_1 + mv_2$

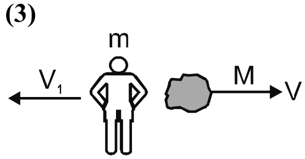
$u = v_1 + v_2 \qquad$ .......(i)

$\dfrac{v_2 - v_1}{u} = e \qquad$ ......(ii)

on solving, $\dfrac{v_1}{v_2} = \left(\dfrac{1-e}{1+e}\right).$

**14.** **(3)**

**Sol:**




$P_i = 0 \qquad$ ....(i)

$P_f = MV - mV_1 \qquad$ ....(ii)

$MV - mV_1 = 0$

$\Rightarrow v_1 = \dfrac{M}{m}V.$

using $\qquad 0^2 = v_1^2 - 2ax$

$\Rightarrow \quad v_1^2 = 2\mu gx$

$\Rightarrow \quad \left(\dfrac{MV}{m}\right)^2 = 2\mu g\,x.$

$\therefore \quad x = \dfrac{M^2V^2}{2m^2\mu g}$

**15.** **(3)**

**Sol:** use $\quad m_1v_1 = m_2v_2 = P$

$K.E. = \dfrac{1}{2}mv_1^2 + \dfrac{1}{2}m_2v_2^2$

$= \dfrac{1}{2}m_1\left(\dfrac{P}{m_1}\right)^2 + \dfrac{1}{2}m_2\left(\dfrac{P}{m_2}\right)^2$

$= \dfrac{1}{2}\dfrac{P^2(m_2+m_1)}{m_1m_2}.$

**16.** **(2)**

**Sol:** If we treat the train as a ring of mass '*M*' then its *COM* will be at a distance $\frac{2R}{\pi}$ from the centre of the circle. Velocity of centre of mass is

$V_{CM} = R_{CM}.\omega$

$= \frac{2R}{\pi}.\omega = \frac{2R}{\pi}.\left(\frac{V}{R}\right)$ $\quad (\because \omega = \frac{V}{R})$

$\Rightarrow V_{CM} = \frac{2V}{\pi}$ $\quad \Rightarrow MV_{CM} = \frac{2MV}{\pi}$

As the linear momentum of any system = $MV_{CM}$

$\therefore$ The linear momentum of the train

$= \frac{2MV}{\pi}$

**17.** **(1)**

**Sol:** When velocity of both frames are same then momentum will be same else it will be different according to different observers

**18.** **(1)**

**Sol:** $P_1 = P_f$

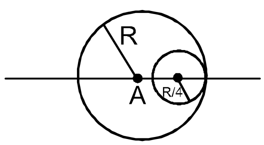
$mV\cos\theta = \frac{m}{2}(-V\cos\theta + \frac{m}{2}V')$

$V' = 3V\cos\theta$

**19.** **(1)**

**Sol:** $A_1 = \pi R^2$ $\quad A_2 = \frac{\pi R^2}{16}$

$x_1 = 0$ $\quad x_2 = \frac{3R}{4}$




$$x_{cm} = \frac{0 - \frac{\pi R^2}{16} \times \frac{3R}{4}}{\pi R^2 - \frac{\pi R^2}{16}} = -\frac{R}{20}$$

**20.** **(3)**

**Sol:** Statement-2 contradicts Newton's third law and hence is false.

**21.** **(1)**

**Sol:** From statement-2, if the component of relative velocity normal to line of impact is non-zero, they shall not have same velocity after collision. Hence statement-2 is correct explanation of statement-1.

**22.** **(3)**

**Sol:** If kinetic energy of system is zero, then momentum of system is necessarily zero.

**23.** **(2)**

**Sol:** Let Initial thrust of the blast be $F$ then $F - mg = ma$

$F = m(g + a) = 3.5 \times 10^4 \times (10 + 10)$

$= 7 \times 10^5\ N$

**24.** **(2)**

**Sol:** Before breaking, the centre of mass of system is moving under gravity. Thus, acceleration of the centre of mass is gravitational acceleration. During breaking, internal forces come into play which are not responsible for the acceleration of the centre of mass.

This indicates that, the acceleration of centre of mass remains the same (equal to gravitational acceleration).

Thus, the centre of mass of system continues its original path.

**25.** **(1)**

**Sol:** According to conservation of energy

$\frac{1}{2}kL^2 = \frac{1}{2}M\upsilon^2$

$\Rightarrow \quad kL^2 = \frac{(M\upsilon)^2}{M}$

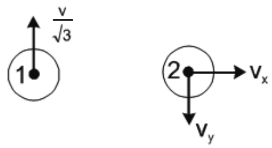
$MkL^2 = p^2 \quad (p = m\upsilon)$

$\therefore \quad p = L\sqrt{Mk}$

**26.** **(3)**

**Sol:** 

before collision




after collision

In $x$-direction

$mv + 0 = 0 + m\upsilon_x$

$\Rightarrow \upsilon_x = \upsilon$

In $y$-direction

$$0 + 0 = m\left(\frac{\upsilon}{\sqrt{3}}\right) - m\upsilon_y$$

$$\upsilon_y = \frac{\upsilon}{\sqrt{3}}$$

$\therefore$ Velocity of second mass after collision

$$\upsilon^1 = \sqrt{\left(\frac{\upsilon}{\sqrt{3}}\right)^2 + \upsilon^2} = \sqrt{\frac{4}{3}\upsilon^2}$$

$$\upsilon^1 = \frac{2V}{\sqrt{3}}$$

**27.** **(3)**

**Sol:** By conservation of linear momentum

$P_i = P_f \qquad \Rightarrow 0 = 12 \times 4 + 4 \times v$

$\Rightarrow \quad v = 12\ m/s$

So, kinetic energy of other mass is $\frac{1}{2}mv^2$

$$= \frac{1}{2} \times 4(12)^2 = 288\ J$$

**28.** **(1)**

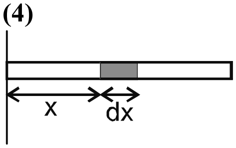
**Sol:** If mass of bigger disc is $M$ then mass of removed disc is $\frac{M}{4}$

$$r_{CM} = \frac{M \times 0 - \frac{M}{4}R}{M - \frac{M}{4}} = \frac{R}{3} = \alpha R$$

$$\Rightarrow \quad \alpha = \frac{-1}{3} \qquad \Rightarrow |\alpha| = \frac{1}{3}$$

**29.** **(4)**

**Sol:**




mass of small element is

$dm = \lambda dx = K(x/L)^n\ dx$

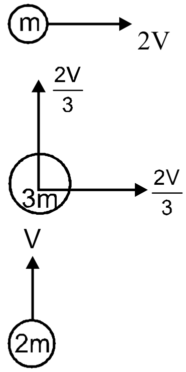
$$x_{CM} = \frac{\int dm.x}{\int dm} = \frac{\int_0^L K.\left(\frac{x}{L}\right)^n dx.x}{\int_0^L K.\left(\frac{x}{L}\right)^n dx} = \frac{(n+1)L}{n+2}$$

So, graph shown in option (4) is correct.

**30.** **(3)**

Just before collision

Just after collision




$$\text{Energy loss, } \Delta E = \frac{1}{2}m(2V)^2 + \frac{1}{2}(2m)V^2 - \frac{1}{2}(3m)\,2\left(\frac{2V}{3}\right)^2$$

$$= 3mV^2 - \frac{4mV^2}{3} = \frac{5mV^2}{3}$$

$$\therefore \quad \text{\% Loss in energy} = \frac{\Delta E}{E_i} \times 100\%$$

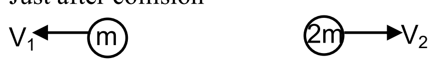
$$= \frac{5mv^2}{3(3mv^2)} \times 100\% = \left(\frac{500}{9}\right)\% \approx 56\%$$

**31.** **(3)**

**Sol:** Case-I

Just before collision


Just after collision




$2V_2 - V_1 = V$

$V_2 + V_1 = V$

$3V_2 = 2V$

$V_2 = \frac{2V}{3}$

$V_1 = \frac{V}{3}$

$P_d = \frac{\frac{1}{2}mV^2 \nu \frac{1}{2}mV_1^2}{\frac{1}{2}mV^2} = \frac{1 \nu \frac{1}{9}}{1} = \frac{8}{9} = 0.89$

**Case-II**

Just before collision


Just after collision


$12V_2 - V_1 = V$

$V_2 + V_1 = V$

$13V_2 = 2V$

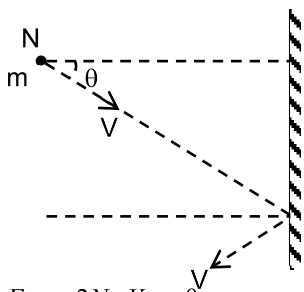
$V_2 = \frac{2V}{13}$

$V_1 = V - \frac{2V}{13} = \frac{11V}{13} \Rightarrow P_c$

$= \frac{\frac{1}{2}mv^2 \nu \frac{1}{2}mv_1^2}{\frac{1}{2}mv^2} = \frac{1 \nu \frac{121}{169}}{1} = \frac{48}{169} = 0.28$

**32. (3)**

**Sol:**




$F_{avg} = 2NmV\cos\theta$

Pressure $= \frac{2NmV\cos\theta}{A}$

$= \frac{2\left(10^{23}\right)\left(3.32\times10^{-27}\right)\frac{1}{\sqrt{2}}\times10^3}{2\times10^{-4}}$

$= 2.35 \times 10^3\ N/m^2$

**33. (1)**

**Sol:** $\vec{P}_1 = p\hat{i}$

$\vec{P}_2 = -p\hat{i}$

as there is no external force so momentum will remain conserved

$\vec{P}_1' + \vec{P}'_2 = \vec{P}_1 + \vec{P}_2$

$\vec{P}_1' + \vec{P}_2' = 0$

Now from option

(A) $\vec{P}_1' + \vec{P}_2' = (a_1 + a_2)\hat{i} + (b_1 + b_2)\hat{j} + c_1\hat{k}$

(B) $\vec{P}_1' + \vec{P}_2' = (c_1 + c_2)\hat{k}$

(C) $\vec{P}_1' + \vec{P}_2' = (a_1 + a_2)\hat{i} + (b_1 + b_2)\hat{j}$

(D) $\vec{P}_1' + \vec{P}_2' = (a_1 + a_2)\hat{i} + 2b_1\hat{j}$

and it is given that $a_1\ b_1\ c_1, a_2, b_2, c_2, \neq 0$

in case of (A) and (D) it is not possible to get $\vec{P}_1' + \vec{P}_2' = 0$

**34. (4)**

**Sol:** $R = u\sqrt{\frac{2h}{g}}$

$\Rightarrow \quad 20 = V_1\sqrt{\frac{2\times5}{10}}$ and $100 = V_2\sqrt{\frac{2\times5}{10}}$

$\Rightarrow \quad V_1 = 20\ m/s,\ V_2 = 100\ m/sec.$

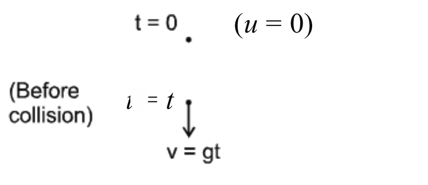
Applying momentum conservation just before and just after the collision

$(0.01)(V) = (0.2)(20) + (0.01)(100)$

$V = 500\ m/s$

**35. (2)**

**Sol:**




$K = \frac{1}{2}mg^2t^2$

$K \propto t^2$ : parabolic graph

then during collision kinetic energy first decreases to elastic potential energy and then increases.

**36.** **(4)**

**Sol:** Self explanatory

**37.** **(4)**

**38.** **(2)**

**Sol:** Net external force is zero so net momentum will remain zero.

**39.** **(2)**

**Sol:** $v_1 = \sqrt{2gh} = \sqrt{2\times10\times10} = 10\sqrt{2}$

$k_2 = \frac{1}{4} k_1 \Rightarrow v_2^2 = \frac{1}{4} v_1^2$

$\therefore v_2 = \frac{v_1}{2} = 5\sqrt{2}$

$|\Delta P| = |-mv_2 - (mv_1)| = m|-v_2 - v_1|$

$|\Delta P| = 50 \times 10^{-3} \times \frac{3}{2} \times 10\sqrt{2}$

$J = \Delta P = 1.05$N-s.

**40.** **(4)**

**Sol:** $0.05 \times v_{p_i} + m \times 0 = 5.05\, v_f$

$\therefore \frac{v_f}{v_i} = \frac{0.05}{5} = 10^{-2}$

$\Rightarrow \frac{\frac{1}{2}m(v_f)^2}{\frac{1}{2}m(v_i)^2} = (10^{-2})^2 = 10^{-4}.$

**41.** **(1)**

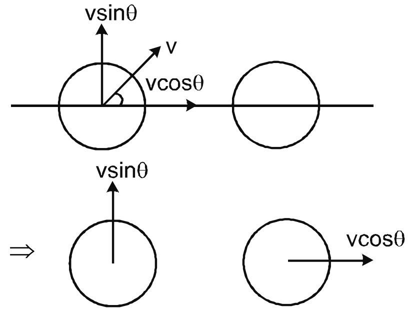
**Sol:** Equation of motion

$M\vec{g} + \vec{R} = M\vec{a}_{cm}$

So, $\vec{a}_{cm} = \frac{M\vec{g} + \vec{R}}{M}$

**42.** **(3)**

**Sol:**




before collision

after collision

So, angle between velocity vectors is 90º

**43.** **(2)**

**Sol:** Internal forces cannot change velocity but can do work.

**44.** **(1)**

**Sol:** $e = \frac{|\text{velocity of separation}|}{|\text{velocity of approach}|}$

For elastic collision $e = 1$

|Velocity of separation| = |velocity of approach|

For inelastic collision $e < 1$

So |velocity of separation| < |velocity of approach|

**45.** **(2)**

**Sol:** we have $m_1 r_1 = m_2 r_2$

$\Rightarrow \quad mr = 2m(3a - r) \quad \Rightarrow \quad r = 2a$

**46.** **(2)**

**Sol:** $\frac{k_2}{k_1} = 4$

$\Rightarrow \left(\frac{v_2}{v_1}\right)^2 = 4$

$\Rightarrow \frac{v_2}{v_1} = 2$

Then $\left(\frac{p_2 - p_1}{p_1}\right)\times100 = \left(\frac{mv_2 - mv_1}{mv_1}\right)\times100$

$= \left(\frac{v_2}{v_1} - 1\right)\times100 = 100\%$

**47.** **(2)**

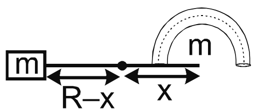
**Sol:** Velocity of heavy mass do not change after collison

$$\frac{v_2 - v_1}{u_2 - u_1} = -e = -1 \quad \Rightarrow \quad \frac{v_2 - v}{0 - v} = -1$$

$\Rightarrow \quad v_2 = 2v$

**48.** **(3)**

**Sol:** Let the tube displaced by x towards left, then block will be displaced by $(R - x)$ towards right;




$mx = m\,(R - x) \qquad \Rightarrow x = \frac{R}{2}$

**49.** **(1)**

**Sol:** If mass = $m$

first ball will stop $\Rightarrow v = 0$

so k.e. = 0 (min)

In other cases there will be some kinetic energy (K.E. can't be negative)

**50.** **(1)**

**Sol:** Area of $F$-$t$ curve = $A$ = Impulse.

Impulse = $dP = A = mv - 0$

$\therefore\ v = \frac{A}{M}$.

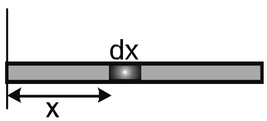
**51.** **(2)**

**52.** **(3)**

**Sol:** If initial velocity of system is not zero then centre of mass moves with constant velocity.

**53.** **(2)**

**Sol:**




$$x_{cm} = \frac{\int dm\, x}{\int dm} = \frac{\int (\lambda dx) x}{\int \lambda dx} = \frac{\int_0^L \lambda_0 x^2 dx}{\int_0^L \lambda_0 x dx} = \frac{2L}{3}$$

**54.** **(1)**

**Sol:** $\frac{1}{2} mv^2 = \frac{1}{2} K x_0^2$

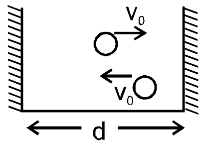
$\Rightarrow V = \sqrt{\frac{K}{m}}\, x_0 \Rightarrow |\Delta \vec{P}| = 2mv = 2\sqrt{Km}\, x_0$

**55.** **(2)**

**Sol:** Net external force on box plus ball system is zero.

**56.** **(2)**

**Sol:** $t = \frac{2d}{v_0}$ (time for successive collision)




$F \times t = dP = mv_0 - (-mv_0)$

$F \times \frac{2d}{v_0} = 2mv_0$

$\therefore\ F = \frac{mv_0^2}{d}$

**57.** **(1)**

**Sol:** $v_{cm} = \dfrac{1 \times 2 + \frac{1}{2} \times 6}{1 + 1/2} = \dfrac{10}{3}\, m/\text{sec}$

**58.** **(3)**

**Sol:** $F_x = \dfrac{\Delta P_x}{\Delta t} = \dfrac{(P_{fx} - P_{ix})}{\Delta t}$

$= \dfrac{-mV \sin 60^\circ - (mV \sin 60^\circ)}{2 \times 10^{-3}} = -250\sqrt{3}N$

$= 250\sqrt{3}$ N towards left

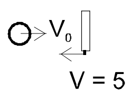
**59.** **(2)**

**Sol:** Net momentum in centre of mass frame should be zero

So $\vec{P} + \vec{P}' = 0 \qquad \Rightarrow \qquad \vec{P}' = -\vec{P}$

**60.** **(1)**

**Sol:**



$V_2 = V_0$

Vel. of Sep = Vel of approach

($\because$ elastic collision)

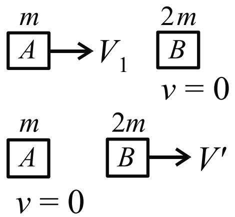
$\therefore \quad 20 + 5 = V - 5$

$\Rightarrow \quad V = 30$ m/s

## *Integer Type Questions (61 to 75)*

**61. (2)**

**Sol:**




$mv_1 = 2mv' \quad \Rightarrow \frac{v'}{v_1} = \frac{1}{2} = 0.5$

**62. (7)**

**Sol:** $F = u\frac{dm}{dt}$

$210 = 300 \times \frac{dm}{dt}$

$\Rightarrow \frac{dm}{dt} = 0.7$ kg/s.

**63. (3)**

**Sol:** $m(L - x) + \frac{m}{3}(-x) = 0$

$mL = \frac{4}{3}mx$

**64. (67)**

**Sol:** By conservation of linear momentum

$0.5 \times 2 = (1.5)v \qquad \Rightarrow v = \frac{2}{3}$ m/s

$\Rightarrow \quad \Delta K = K_i - K_f = \frac{1}{2} \times 0.5 \times (2)^2 - \frac{1}{2} \times 1.5$

$\left(\frac{2}{3}\right)^2 = 0.67$ J

**65. (3)**

**Sol:** COM of uniform solid cone of height h is at height $\frac{h}{4}$ from base, therefore from vertex it is $\frac{3h}{4}$

**66. (2)**

**Sol:** By conservation of linear momentum

$mv_0 + 0 = mv_1 + mv_2$

$v_0 = v_1 + v_2 \qquad \ldots\ldots\ldots(1)$

$\frac{3}{2}\left[\frac{1}{2}mv_0^2\right] = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$

$\frac{3}{2}v_0^2 = v_1^2 + v_2^2 \qquad \ldots\ldots\ldots(2)$

Solving equation (1) and (2)

$v_1 = \frac{v_0}{2}(1+\sqrt{2})$

$v_2 = \frac{v_0}{2}(1-\sqrt{2})$

$\vec{v}_{rel} = \vec{v}_1 - \vec{v}_2$

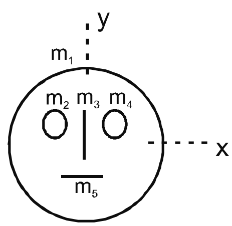
$\frac{v_0}{2}\left[1+\sqrt{2}-1+\sqrt{2}\right]$

$= \frac{v_0}{2} \times 2\sqrt{2}$

$= \sqrt{2}v_0$

**67. (10)**

**Sol:**




$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3 + m_4y_4 + m_5y_5}{m_1 + m_2 + m_3 + m_4 + m_5}$

$\Rightarrow \quad y_{cm} = \frac{6m(0) + m(a) + m(0) + m(a) + m(-a)}{m + m + m + m + 6m}$

$= \frac{a}{10}$

**68. (8)**

**Sol:** Linear mass density, $\lambda = \lambda_0\left(1-\frac{x^2}{L^2}\right)dx$

$$m = \int \lambda dx = \int_0^L \lambda_0\left(1-\frac{x^2}{L^2}\right)dx$$

$$= \lambda_0\left(L-\frac{L^3}{3L^2}\right) = \frac{2L\lambda_0}{3}$$

$$X_C = \frac{1}{m}\int x\, dm$$

$$\frac{1}{m}\int_0^L x\lambda_0\left(1-\frac{x^2}{L^2}\right)dx$$

$$= \frac{\lambda_0}{m}\left[\frac{x^2}{2}-\frac{x^4}{4L^2}\right]_0^L = \frac{3}{8}L$$

As, $X_C = \frac{3L}{\alpha} = \frac{3}{8}L \Rightarrow \alpha = 8$

**69. (1)**

**Sol:** For elastic collision $KE_i = KE_f$

$$\Rightarrow \frac{1}{2}m\times 25+\frac{1}{2}\times m\times 9 = \frac{1}{2}m\times 32+\frac{1}{2}mv^2$$

$$\Rightarrow 34 = 32+v^2$$

$$\Rightarrow v^2 = 2$$

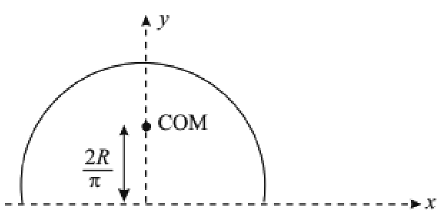
So, $KE_B = \frac{1}{2}\times 0.1\times 2 = 0.1\ J = \frac{1}{10}$

$x = 1$

**70. (2)**

**Sol:** Location of COM = $\left(0, \frac{2R}{\pi}\right)$

Hence $|x| = 2$




**71. (25)**

**Sol:** According to conservation of momentum principle

$P_i = P_f \Rightarrow 2\times 4 = 2\times 1+m_2\times v_2$

$\Rightarrow m_2v_2 = 6$ …(i)

From the coefficient of restitution

$e = \frac{v_2-v_1}{u_1-u_2} \Rightarrow 1 = \frac{v_2-1}{4} \Rightarrow v_2 = 5$ m/s

So, $m_2 = 1.2$ kg

Now, $v_{cm} = \frac{m_1v_1+m_2v_2}{m_1+m_2}$

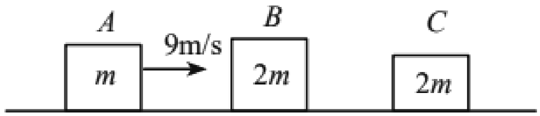
$= \frac{2\times 1+1.2\times 5}{2+1.2} = \frac{8}{3.2} = \frac{2.5}{10}$

$\therefore x = 25$

**72. (3)**

**Sol:** Before collision, $u_A = 9$ m/s, $u_B = 0$

Let after collision velocities of A and B be $v_A$ and $v_B$




Applying conservation of momentum,

$m \times 9 = m \times v_A + 2\, mv_B$

$9 = v_A + 2\, v_B$ ...(i)

Again, $e = \frac{v_B-v_A}{u_A-u_B}$

Since, collision is elastic, therefore $e = 1$

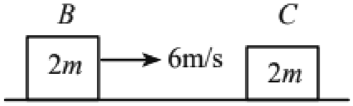
$1 = \frac{v_B-v_A}{9-0}$

$9 = v_B - v_A$ …(ii)

Solving (i) and (ii)

$v_B = 6$ m/s and $v_A = -3$ m/s

Now, applying conservation of momentum between B & C




$2\text{ m} \times 6 + 0 = (2\text{ m} + 2\text{ m})v_C$

$3\text{ m/s} = v_C$

**73. (30)**

**Sol:** Given

m = 5 kg

$P_i$ = 10 kg m/s (initial momentum)

From impulse momentum theorem

$$F\Delta t = \Delta P = P_f - P_i$$

$2 \times 5 = P_2 - 10$

$P$ = 20 kg m/s (final momentum)

Increase in KE = $KE_2 - KE_1$

$$= \frac{P_2^2}{2m} - \frac{P_1^2}{2m}$$

$$= \frac{1}{2\times 5}\times(400-100) = 40-10 = 30J$$

**74. (6)**

**Sol:** From the conservation of momentum: $pi = p_f$

$60 \times v = (60 + 120) \times 2$

$\Rightarrow v = 6$ m/s

**75. (12)**

**Sol:** Using conservation of linear momentum:

$$2\times v_0 = \frac{2v_0}{4} + mv$$

$$mv = \frac{3v_0}{2}$$

$$e = 1 = \frac{v - \frac{v_0}{4}}{v_0}$$

$$v = \frac{5v_0}{4}$$

Hence, $m$ = 1.2 kg

# RIGID BODY MOTION

## Single Option Correct Type Questions (01 to 59)

**1.** **(3)**

**Sol:** $\frac{d\theta}{dt} = 1.5 + 4t$

At $t = 2$

$\omega = 9.5$ rad/s

(We know $\frac{d\theta}{dt} = \omega$)

**2.** **(4)**

**Sol:** $\omega_f = \omega_i + \alpha t$

$60 = 0 + \alpha(5)$

$\alpha = 12$

$\theta = \frac{1}{2}\alpha t^2 = \frac{1}{2} \times 12 \times (5)^2 = 150$ rad

**3.** **(3)**

**Sol:** Linear speed $v = r\omega$

$v$ depends on radius which varies for different particles.

**4.** **(3)**

**Sol:** $v = \omega R$ is the velocity of a point on the outer edge of the disc.

$v = 10 \times 0.2 = 2$m /sec. which will be same as velocity of the string and the block.

**5.** **(2)**

**Sol:** $I = mR^2 = 4$ kgm$^2$

**6.** **(2)**

**Sol:** M.I of both spheres about common tangent

$$I_0 = 2\left[\frac{2}{5}mR^2 + mR^2\right] = \frac{14}{5} \quad mR^2$$

We know $I = \frac{2}{5}mR^2$

So, $I_0 = 7\ I$

**7.** **(3)**

**Sol:** $I_x + I_y = I_z$

$z$ axes is perpendicular to plane of body.

**8.** **(4)**

**Sol:** ($I = mk^2$) where $k$ is the radius of gyration.

**9.** **(2)**

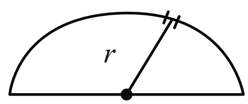
**Sol:** The radius of gyration does not depend on the total mass of a body but depends upon the shape and size of body, distribution of mass within the body and choice of rotation of axis.

**10.** **(3)**

**Sol:** Distance of center of mass from the side is related as $X_{BC} > X_{AB} > X_{AC}$. Moment of Inertia about the shortest side therefore $I_{BC} > I_{AB} > I_{AC}$, $BC$ is greater than the other two sides

**11.** **(1)**

**Sol:**




by parallel axis theorem

$I = I_{cm} + md^2$

$$Mr^2 = I_{CM} + M\left(\frac{2r}{\pi}\right)^2$$

$$I_{CM} = Mr^2\left(1 - \frac{4}{\pi^2}\right)$$

**12.** **(3)**

**Sol:** $I_B = I_A + Md^2$. Then $I_B > I_A$

**13.** **(3)**

**Sol:** $I_x + I_y = I_z$

$2I_x = I_z$

$\therefore \quad I_l = 2 \times 200 = 400 \text{ gm cm}^2$

**14.** **(2)**

**Sol:** $\tau = I\alpha$

$\left(\frac{1}{2}MR^2\right)\alpha = \tau$

$\alpha = 0.25 \text{ rad/s}^2$

**15.** **(3)**

**Sol:** $\vec{F} = 2\hat{i} + 3\hat{j} - \hat{k}$ at point $(2,-3,1)$

torque about point $(0, 0, 2)$

$\vec{r} = \left(2\hat{i} - 3\hat{j} + \hat{k}\right) - 2\hat{k} = (2\hat{i} - 3\hat{j} - \hat{k})$

$\vec{\tau} = \vec{r} \times \vec{F} = (2\hat{i} - 3\hat{j} - \hat{k}) \times (2\hat{i} + 3\hat{j} - \hat{k})$

$\vec{\tau} = (6\hat{i} + 12\hat{k})$

$\left|\vec{\tau}\right| = (6\sqrt{5})$

**16.** **(2)**

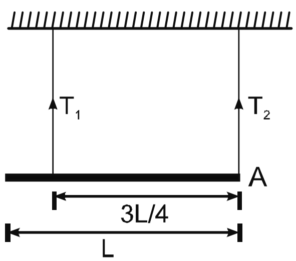
**Sol:** Torque about $O$

$(F \times 40 + F \times 80) - (F \times 20 + F \times 60)$

In clockwise direction $\tau = F \times 40$

**17.** **(3)**

**Sol:**




$\tau_A = 0$ (net torque about $A = 0$)

$T_1 \times \frac{3L}{4} - mg\frac{L}{2} = 0$ ....(1)

$T_1 = \frac{2mg}{3}$

$T_1 + T_2 = mg$ ....(2)

$T_2 = \frac{mg}{3}$

$\frac{T_1}{T_2} = \frac{2}{1}$

**18.** **(1)**

**Sol:** The free body diagram of rod is

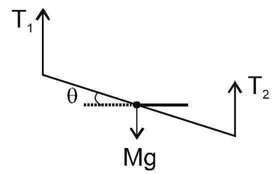
Net torque about centre of mass is zero

$T_1 \times \frac{L}{2}\cos\theta = T_2 \times \frac{L}{2}\cos\theta$ …(i)

and $T_1 + T_2 = Mg$ …(ii)

form (i) and (ii) we get:

$T_1 = T_2 = \frac{Mg}{2}$




**19.** **(1)**

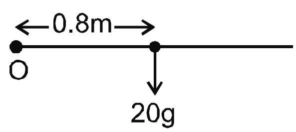
**Sol:** Initial velocity of each point on the rod is zero so angular velocity of rod is zero.

Torque about $O$ (hinged point)

$T = I\alpha$

$20g\,(0.8) = \frac{m\ell^2}{3}\alpha$

$\Rightarrow \; 20g\,(0.8) = \frac{20(1.6)^2}{3}\alpha$



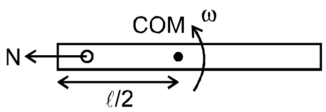

$\Rightarrow \; \frac{3g}{3.2} = \alpha =$ angular acceleration

**20.** **(3)**

**Sol:** Body is rotating uniformly so resultant force on particle is centripetal force which is horizontal and intersecting the axis of rotation.

**21.** **(4)**

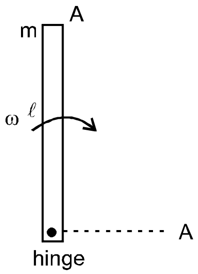
**Sol:**




$$N = \left(m\omega^2 \frac{\ell}{2}\right)$$

**22.** **(2)**

**Sol:**




using energy conservation

$$mg\ \frac{\ell}{2} = \frac{1}{2} I\omega^2$$

$$mg\ \frac{\ell}{2} = \frac{1}{2} \cdot \frac{m\ell^2}{3}\ \omega^2$$

$\ell = 1\ m$ $\qquad\qquad \omega = \sqrt{3g}$

$$V_A = \omega\ell = \sqrt{3g} = \left(\sqrt{3g}\right)$$

**23.** **(2)**

**Sol:** $I_A\, \omega_A = I_B\, \omega_B$

$I_A > I_B$ therefore, $\omega_A < \omega_B$

$$\frac{K_B}{K_A} = \frac{\frac{1}{2} I_B\, \omega_B^2}{\frac{1}{2} I_A\, \omega_A^2} = \frac{\omega_B}{\omega_A} > 1$$

**24.** **(4)**

**Sol:** $\tau = \dfrac{\Delta L}{\Delta t} = \dfrac{2}{5} = 0.4$ N-m

**25.** **(1)**

**Sol:** As no torque acts on a system angular momentum remains conserved

$$I_1\omega_1 = I_2\omega_2 \Rightarrow \frac{I_1}{I_2} = \frac{\omega_2}{\omega_1} \qquad \ldots(i)$$

$$I_1 = Mk_1^2,\ I_2 = Mk_2^2$$

$$\frac{I_1}{I_2} = \frac{k_1^2}{k_2^2} \qquad \ldots(ii)$$

From (i) and (i) we have

$$\frac{k_1}{k_2} = \sqrt{\frac{\omega_2}{\omega_1}}$$

**26.** **(3)**

**Sol:** Conserving angular momentum about center of ring:

$$MR^2\omega = (MR^2 + 2mR^2)\omega'$$

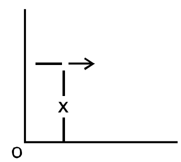
$$\omega' = \frac{\omega M}{M + 2m}$$

**27.** **(3)**

**Sol:** $\vec{\tau} = \dfrac{d\vec{L}}{dt} = \dfrac{4A_0 - A_0}{4} = \left(\dfrac{3A_0}{4}\right)$

**28.** **(2)**

**Sol:**




$\Rightarrow L = (mvx) =$ cont: because $v =$ cont and $x =$ cont.

**29.** **(4)**

**Sol:** $L = I\omega$

$\omega' = 2\omega$

$\dfrac{1}{2}\left(\dfrac{1}{2} I\omega^2\right) = \dfrac{1}{2}\ I'\ \omega'^2$ (kinetic energy is halved)

$$\frac{I\omega^2}{2} = I' \, 4\omega^2 \text{ (as } \omega' = 2\omega)$$

$$I' = \left(\frac{I}{8}\right)$$

$$L' = I' \, \omega' = \frac{I}{8} 2\omega = \frac{I\omega}{4} = \left(L/4\right)$$

**30. (2)**

**Sol:** $KE = \frac{1}{2} mV^2 + \frac{1}{2} I\omega^2$

$$= \frac{1}{2} mV^2 + \frac{1}{2} mR^2 \left(\frac{V}{R}\right)^2$$

$KE = mV^2 = 4$ Joule

**31. (2)**

**Sol:** $KE_t = \frac{1}{2} mV^2$

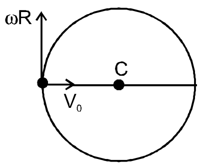
$$KE_r = \frac{1}{2} I\omega^2 = \frac{1}{2}\left(\frac{1}{2}mR^2\right)\left(\frac{V}{R}\right)^2 = \frac{1}{4} mV^2,$$

$$KE_T = \frac{3}{4} mV^2$$

$$\frac{KE \text{ rotation}}{KE \text{ Total}} = \frac{1/4 mV^2}{3/4 mV^2} = \frac{1}{3}$$

**32. (3)**

**Sol:**




For pure rolling $\omega R = V_0$, $V = \sqrt{V_0^2 + (\omega R)^2}$

$$= \left(V_0\sqrt{2}\right)$$

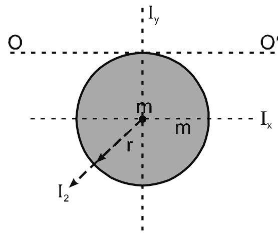
**33. (4)**

**Sol:** As the inclined plane is smooth, the sphere can never roll rather it will just slip down.

Hence, the angular momentum remains conserved about any point on a line parallel to the inclined plane and passing through the centre of the ball.

**34. (4)**

**Sol:**




Perpendicular axis theorem

$$I_2 = I_x + I_y = \frac{mr^2}{2}$$

from symmetry $I_x = I_y$

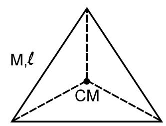
$$\Rightarrow \quad I_x = \frac{mr^2}{4}$$

Parallel axis theorem

$$I_{oo'} = I_x + mr^2 = \frac{mr^2}{4} + mr^2 = \frac{5}{4} mr^2$$

**35. (2)**

**Sol:** $MI$ of the system w.r.t an axis $\perp$ to plane & passing through one corner




$$= \frac{ML^2}{3} + \frac{ML^2}{3} + \left[\frac{ML^2}{12} + M\left(\frac{\sqrt{3}\,L}{2}\right)^2\right]$$

$$= \frac{2ML^2}{3} + \left[\frac{ML^2}{12} + \frac{3ML^2}{4}\right]$$

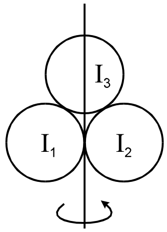
$$= \frac{2ML^2}{3} + \frac{10\,ML^2}{12} = \frac{18ML^2}{12} = \frac{3}{2} ML^2$$

Now, $\frac{3}{2} ML^2 = 3\,Mk^2$

$$k = \frac{\ell}{\sqrt{2}}$$

**36.** **(4)**

**Sol:** $I = I_1 + I_2 + I_3$




$I_1 = I_2 = \frac{3}{2}mr^2$

$I_3 = \frac{mr^2}{2}$

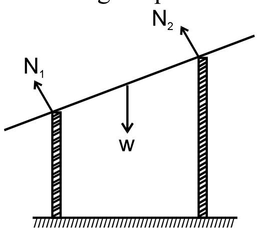
$\therefore\ I = I_1 + I_2 + I_3 = \frac{7}{2}\text{mr}^2$

Moment of inertia = 3 $mk^2$ (where $k$ is radius of gyration.)

$3\ mk^2 = \frac{7}{2}mr^2 \Rightarrow k = \sqrt{\frac{7}{6}}r$

**37.** **(3)**

**Sol:** Balancing torque about the centre of the rod:




$N_1 \cdot \frac{\ell}{4} - N_2 \cdot \frac{\ell}{4} = 0$

$\Rightarrow\ N_1 = N_2$.

**38.** **(1)**

**Sol:** Moment of inertia of solid sphere about any tangent,

$I = I_{cm} + mr^2 = \frac{2}{5}mr^2 + mr^2$

$= \frac{7}{5}mr^2$

Moment of inertia of hollow sphere about any tangent,

$I = I_{cm} + mr^2$

$= \frac{2}{3}mr^2 + mr^2 = \frac{5}{3}mr^2$

M.O.I. of circular ring about its diameter,

$I = \frac{MR^2}{2}$

M.O.I. of circular ring about its diameter,

$I = \frac{MR^2}{4}$

**39.** **(2)**

**Sol:** Given that,

Radius of cylinder, $r = 0.2$ m

Length of cylinder, $L = 0.8$ m

and moment of inertia along $CD$, $I = 2.7$ kg m$^2$.

$I_{CD} = \frac{1}{2}Mr^2 + M\left(\frac{L}{2}\right)^2$

$\Rightarrow 2.7 = M\left(\frac{0.2^2}{2} + \frac{0.8^2}{4}\right)$

$\Rightarrow M = 15$ kg

Density, $\rho = \frac{M}{\pi r^2 L}$

$= \frac{15}{3.14 \times 0.2^2 \times 0.8} = 1.49 \times 10^2\ \text{kg/m}^3$

**40.** **(3)**

**Sol:** (I) $I = \frac{ML^2}{12}$

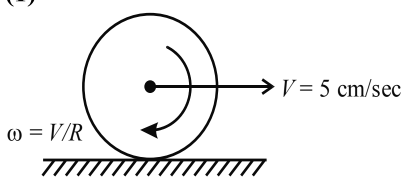
(II) $I = \frac{(2M)L^2}{3}$

(III) $I = \frac{M(2L)^2}{12} = \frac{ML^2}{3}$

(IV) $I = \frac{(2M)(2L)^2}{3} = \frac{8ML^2}{3}$

**41.** **(1)**

**Sol:**




K.E. of the sphere = $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

K.E. = $\frac{1}{2}\left(\frac{2}{5}mR^2 + mR^2\right)\frac{V^2}{R^2}$

K.E. = $\frac{7}{10} \times \frac{1}{2} \times \frac{25}{10^4} = \frac{35}{4} \times 10^{-4}$ J

$= 8.75 \times 10^{-4}$ J

**42.** **(1)**

**Sol:** Let $M$ is mass and $a$ is side of triangle $ABC$, then

$$\frac{I_{DEF}}{I_0} = \frac{\left(\frac{M}{4}\right)\left(\frac{a}{2}\right)^2}{M(a)^2}$$

$$I_{DEF} = \frac{I_0}{16}$$

Moment of inertia of remaining sheet

$$I_0 - \frac{I_0}{16} = \frac{15I_0}{16}$$

**43.** **(2)**

**Sol:** $K_i + U_i = K_f + U_f$

$$0+0 = \frac{1}{2}m_2v^2 + \frac{1}{2}m_1v^2 + \frac{1}{2}I\omega^2 - m_1gh + m_2gh$$

$$(m_1 - m_2)gh = \frac{1}{2}m_2(\omega R)^2 + \frac{1}{2}m_1(\omega R)^2 + \frac{1}{2}I\omega^2$$

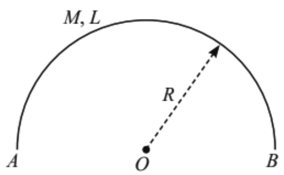
$$\sqrt{\frac{2(m_1-m_2)gh}{\left(m_1+m_2+\frac{I}{R^2}\right)R^2}} = \omega$$

**44.** **(1)**

**Sol:** According to the question, perimeter of semi-circle = Length of wire.

$$\pi R = L \Rightarrow R = \frac{L}{\pi}$$

$$I_0 = MR^2 = M\left(\frac{L}{\pi}\right)^2 = \frac{ML^2}{\pi^2}$$




**45.** **(1)**

**Sol:** $KE = \frac{1}{2}I\omega^2 \Rightarrow \omega = \sqrt{\frac{2(KE)}{I}}$

$$\Rightarrow \omega = \sqrt{\frac{2\times 1200}{1.5}} = 40 \text{ rad/s}$$

$$\omega = \omega_0 + \alpha t$$

$$40 = 0 + (20)t$$

$$\Rightarrow t = \frac{40}{20} = 2\sec$$

**46.** **(1)**

**Sol:** Using torque equation about point $P$, $\tau = \alpha I =$

$$[2M_o(2\ell)^2 + 5M_o\ell^2]\alpha \quad \ldots\text{(i)}$$

$$\tau = M_og\ell - 4M_og\ell \quad \ldots\text{(ii)}$$

From (i) and (ii) we have

$$M_og\ell = 13M_og\ell^2\alpha$$

$$\alpha = \frac{g}{13\ell}$$

**47.** **(3)**

**Sol:** By conservation of Angular momentum, $L_i = L_f$

$$MR^2\omega = (MR^2 + 2mR^2)\omega'$$

$$\omega' = \frac{2M}{M+2m}$$

**48.** **(3)**

**Sol:** Angular momentum $\vec{L} = \vec{r}\times\vec{p} \Rightarrow \vec{L} = mvr(\hat{k})$

Direction & magnitude both remain same for particle moving with constant speed in circular path.

**49.** **(1)**

**Sol:** Force,

$$\vec{F} = m\vec{a} = m[-a\omega_1^2\cos\omega_1 t\hat{i} - b\omega_2^2\sin\omega_t t\hat{j}]$$

$$\vec{F}_{t=0} = -ma\omega_1^2\hat{i}$$

Position of the particle at $t = 0$

$$\vec{r}_{t=0} = (x_0 + a)\hat{i} + y_0\hat{j}$$

$$\vec{\tau} = \vec{r}\times\vec{F} = my_0a\omega_1^2\hat{k}$$

Hence, option (1) is correct answer.

**50.** **(4)**

**Sol:** $K.E_i = K.E_{\text{translational}} + K.E_{\text{rotational}}$

$$K_i = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$K_i = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2 = \frac{7}{10}mv^2 = 140 \text{ J}$$

$$\frac{7}{10}mv_f^2 = 0.05 \times K_i = 0.05 \times 140 \Rightarrow v_f^2 = 20$$

$$\Rightarrow v_f = \sqrt{20} \approx 4.47 \text{ ms}^{-1}$$

**51.** **(2)**

**Sol:** $\sigma = A + Br$

$$I = \int dm\, r^2 = \int_0^a (A+Br)2\pi r^3 dr$$

$$= 2\pi\left(A\frac{a^4}{4} + B\frac{a^5}{5}\right) = 2\pi a^4\left(\frac{A}{4} + \frac{Ba}{5}\right)$$

**52.** **(4)**

**Sol:** Applying angular momentum conservation, about axis of rotation

$L_i = L_f$

$$\frac{ML^2}{12}\omega_0 = \left(\frac{ML^2}{12} + m\left(\frac{L}{2}\right)^2 \times 2\right)\omega$$

$$\Rightarrow \omega = \frac{M\omega_0}{M+6m}$$

**53.** **(2)**

**Sol:** As hollow cylinder and thin cylinder have same moment of inertia and mass.

$$\frac{M}{2}(R_1^2 + R_2^2) = MR^2$$

$$\frac{R_1^2 + R_2^2}{2} = R^2$$

$$\therefore R = \sqrt{\frac{10^2 + 20^2}{2}} = 15.8$$

$R \simeq 16$ cm

**54.** **(4)**

**Sol:** According to question the given data is,

$$\vec{F} = 4\hat{i} - 3\hat{j}$$

$$\vec{r}_1 = 5\hat{i} + 5\sqrt{3}\hat{j},\ \vec{r}_2 = -5\hat{i} + 5\sqrt{3}\hat{j}$$

Torque about '$O$' we know that, $\vec{\tau} = \vec{r} \times \vec{F}$

$$\vec{\tau}_0 = \vec{r}_1 \times \vec{F} = (-15 - 20\sqrt{3})\hat{k} = (15 + 20\sqrt{3})(-\hat{k})$$

Torque about '$Q$'

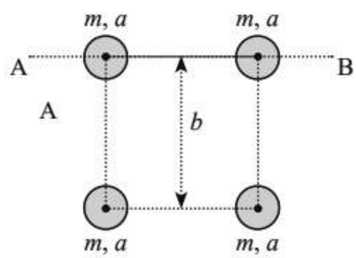
$$\vec{\tau}_Q = \vec{r}_2 \times \vec{F} = (-15 + 20\sqrt{3})\hat{k} = (15 - 20\sqrt{3})(-\hat{k})$$

**55.** **(3)**

**Sol:** Moment of inertia about side $AB$ of the square.

$$I_{AB} = \frac{2}{5}ma^2 \times 2 + \left(\frac{2}{5}ma^2 + mb^2\right) \times 2$$

$$= \frac{8ma^2}{5} + 2mb^2$$




**56.** **(4)**

**Sol:** Here, $dm = \sigma dA = \sigma 2\pi r dr \quad (\sigma = Kr^2)$

So, $dm = = Kr^2 2\pi r dr$

$$= \int_0^R 2\pi K r^3 dr$$

$$M = \frac{2\pi KR^4}{4} = \frac{\pi KR^4}{2} \quad \ldots\text{(i)}$$

Moment of Inertia about the axis of the disc.

$$I = \int dI = \int dmr^2$$

$$\Rightarrow I = 2\pi K \int_0^R r^5 dr = \frac{\pi KR^6}{3} \quad \ldots\text{(ii)}$$

From (i) and (ii) we get

$$I = \frac{2}{3}MR^2$$

Hence, option (4) is correct answer.

**57.** **(1)**

**Sol:** $MoI$ for 2 balls $= 2\left[\frac{2}{5}MR^2 + M(2R)^2\right]$

For rod $= \frac{MR^2}{3}$

$\therefore I_{system} = \frac{137}{15}MR^2$

**58.** **(3)**

**Sol:** From conservation of Angular momentum,

Initial angular momentum = Final angular momentum

$\Rightarrow I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

$\Rightarrow \omega = \frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}$ …(i)

Initial kinetic energy,

$KE_i = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2$ …(ii)

Final kinetic energy,

$KE_f = \frac{1}{2}(I_1 + I_2)\omega^2$ …(iii)

From equation (i), (ii) and (iii),

$\Rightarrow |KE_f - KE_i| = \frac{1}{2}\left(\frac{I_1 I_2}{I_1 + I_2}\right)(\omega_1 - \omega_2)^2$

**59.** **(2)**

**Sol:** $\tau_{net}$ about $B$ is zero at equilibrium

$T_A 100 - mg \times 50 - 2\,mg \times 25 = 0$

$T_A \times 100 = 100\,mg$

$\Rightarrow T_A = 1\,mg$

Hence, option (2) is correct answer.

*Integer Type Questions (60 to 74)*

**60.** **(728)**

**Sol:** $\omega_f = 2460 \times \frac{2\pi}{60} = 82\pi$

$\omega_i = \frac{900 \times 2\pi}{60} = 30\pi$

$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{82\pi - 30\pi}{26} = 2\pi$ rad/sec$^2$

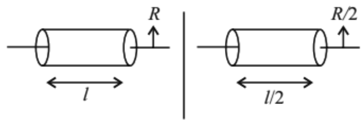
$\theta = \frac{\omega_f^2 - \omega_i^2}{2\alpha} = \frac{(82\pi + 30\pi)(82\pi - 30\pi)}{2 \times 2\pi}$

$= \frac{(112 \times 52)\pi^2}{4\pi} = 2\pi n$

No. of revolution $(n) = \frac{(112 \times 13)\pi}{2\pi} = 728$

**61.** **(32)**

**Sol:**



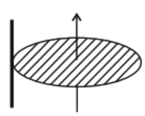

$I_1 = \frac{m_1 R^2}{2}$ and $I_2 = \frac{m_2 (R/2)^2}{2}$

$\Rightarrow \frac{I_1}{I_2} = \frac{4m_1}{m_2} = \frac{4 \cdot \rho\pi R^2 \ell}{\rho \cdot \frac{\pi R^2}{4} \times \frac{\ell}{2}}$

$\frac{I_1}{I_2} = 32$

**62.** **(3)**

**Sol:**



Using theorem of parallel axis,

$I = I_{cm} + Md^2$

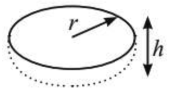
$$I = \frac{MR^2}{2} + MR^2$$

$$I = \frac{3}{2}MR^2$$

$$\Rightarrow x = 3$$

**63. (5)**

**Sol:**




$\because$ Mass of both disc is equal

$\because M_1 = M_2$

$$\Rightarrow (\pi r_1^2)h_1\rho_1 = (\pi r_2^2)h_2\rho_2$$

$$\Rightarrow r_1^2 \times \frac{h_1}{h_2} \times \frac{\rho_1}{\rho_2} = r_2^2$$

$$\left[\therefore \frac{h_1}{h_2} = \frac{1}{0.5} = 2\right]$$

$$\Rightarrow r_1^2 \times 2 \times \frac{\rho_1}{\rho_2} = r_2^2$$

$$\Rightarrow \frac{r_1^2}{r_2^2} = \left(\frac{\rho_2}{2\rho_1}\right) = \left(\frac{5}{6}\right)$$

$$\left[\text{Given, } \frac{\rho_2}{\rho_1} = \frac{5}{3}\right]$$

$$\text{Ratio of M.O.I.} = \frac{\frac{1}{4}Mr_1^2}{\frac{1}{4}Mr_2^2} = \left(\frac{r_1^2}{r_2^2}\right) = \left(\frac{5}{6}\right)$$

**64. (5)**

**Sol:** For solid sphere, Moment of inertia, $I = \frac{2}{5}mR^2$

$$\therefore mk_{sph}^2 = \frac{2}{5}mR^2$$

$$k_{sph} = \sqrt{\frac{2}{5}}R$$

Similarly,

For solid cylinder $mk_{cyl}^2 = \frac{mR^2}{2}$

$$\Rightarrow k_{cyl} = \frac{R}{\sqrt{2}}$$

$$\frac{k_{sph}}{k_{cyl}} = \frac{\sqrt{\frac{2}{5}}}{\frac{1}{\sqrt{2}}} = \frac{2}{\sqrt{5}} = \frac{2}{\sqrt{x}}$$

$$\therefore x = 5$$

**65. (110)**

**Sol:** Moment of inertia of a solid sphere about the center of mass,

$$I_{cm} = \frac{2}{5}MR^2$$

Using parallel axis theorem

$$\Rightarrow I_{PQ} = I_{cm} + Md^2$$

$$I_{PQ} = \frac{2}{5}MR^2 + M(10\text{ cm})^2$$

For radius of gyration

$$I_{PQ} = Mk^2$$

$$k^2 = \frac{2}{5}R^2 + (10\text{ cm})^2$$

$$= \frac{2}{5}(5)^2 + 100 = 110$$

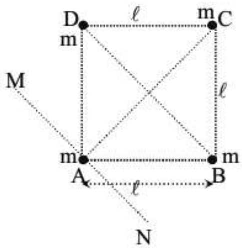
$$\Rightarrow k = \sqrt{110}\text{ cm}$$

$$\therefore x = 110$$

**66. (3)**

**Sol:** $I_{MN} = m(0)^2 + m\left(\sqrt{2}\ell\right) + m\left(\frac{\ell}{\sqrt{2}}\right)^2 \times 2$

$$\Rightarrow I_{MN} = 2m\ell^2 + m\ell^2 = 3m\ell^2$$




**67. (20)**

**Sol:** Using conservation of angular momentum

$$\Rightarrow I_1\omega_1 + I_2\omega_2 = (I_1+I_2)\omega_f$$

$$\Rightarrow \frac{MR^2}{2}\omega_o = \left(\frac{MR^2}{2}+\frac{MR^2}{8}\right)\omega_f$$

$$\Rightarrow \omega_f = \frac{4}{5}\omega_o$$

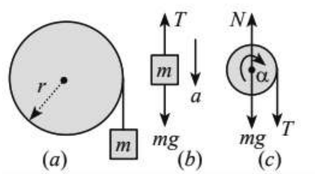
$$\Rightarrow KE_{final} = \frac{1}{2}(I_1+I_2)\omega_f^2 = \frac{MR^2\omega^2}{5}$$

$$\Rightarrow KE_{initial} = \frac{1}{2}I\omega_0^2 = \frac{MR^2\omega^2}{4}$$

$$\Rightarrow \%\,\text{loss} = 20\%$$

**68. (2)**

**Sol:**




Using diagram (a), (b) and (c)

$mg - T = ma$ …(i)

$T \times r = I\alpha$ …(ii)

$a = \alpha r$ …(iii)

Using equation (i), (ii) and (iii).

$$mg - \frac{I\alpha}{r} = ma \Rightarrow mg - \frac{Ia}{r^2} = ma$$

$$a\left(m+\frac{I}{r^2}\right) = mg$$

$$a = \frac{mg}{m+\frac{I}{r^2}}$$

Now $\omega^2 r^2 = 2ah = \dfrac{2mgh}{m+\frac{I}{r^2}}$

$$\omega^2 = \frac{2mgh}{I+mr^2}$$

$$\omega = \sqrt{\frac{2mgh}{I+mr^2}}$$

Here $n = 2$.

**69. (10)**

**Sol:** Given, $\frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 = 7\times10^{-3}$

$$\frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v}{R}\right)^2 = 7\times10^{-3}$$

$$\frac{1}{2}Mv^2\left[1+\frac{2}{5}\right] = 7\times10^{-3}$$

$$\frac{1}{2}1\times v^2\times\frac{7}{5} = 7\times10^{-3}$$

$$\Rightarrow v = 0.1 \text{ m/s}$$

$$= 10 \text{ cm/s}$$

**70. (18)**

**Sol:** $r = 1.5$ m, $F = 12t - 3t^2$ N, $I = 4.5$ kgm$^2$

Torque, $\tau = I\alpha$

$$\alpha = \frac{\tau}{I} = \frac{1.5\times(12t-3t^2)}{4.5} = \frac{1}{3}(12t-3t^2)$$

$$\Rightarrow \alpha = 4t - t^2$$

$$\frac{d\omega}{dt} = 4t - t^2 = \int d\omega = \int\left(4t-t^2\right)_0^t dt$$

$$\omega = 2t^2 - \frac{t^3}{3}$$

For $\omega = 0$,

$$0 = 2t^2 - \frac{t^3}{3} = t^2\left(2 - \frac{t}{3}\right) = 0$$

$t = 0, 6\text{s}$

Since, $\omega = \frac{d\theta}{dt} \Rightarrow d\theta = \omega dt$

$$\Rightarrow \int_0^0 d\theta = \int_0^6 \left(2t^2 - \frac{t^3}{3}\right)dt$$

$$\theta = \left[\frac{2t^3}{3} - \frac{t^4}{12}\right] = \left[\frac{t^2}{3}\left(2t - \frac{t^2}{4}\right)\right]_0^6$$

$$= \frac{36}{3}\left(12 - \frac{36}{4}\right) = 36 \text{ rad.}$$

No. of revolutions $= \frac{36}{2\pi} = \frac{18}{\pi}$

$\Rightarrow K = 18$

**71.** **(10)**

**Sol:** From the free body diagram,

$2g - T = 2a$ …(i)

Rotation equation for disc of mass M

$$T_R = \frac{MR^2}{2}\alpha \quad \text{…(ii)}$$

$$\alpha = \frac{a}{R} \quad \text{…(iii)}$$

Solving (i), (ii) and (iii), we get

$T = g = 10$ N

**72.** **(10)**

**Sol:** Position of the particle,

$$\vec{r} = 10\alpha t^2\hat{i} + 5b(t-5)\hat{i}$$

Velocity of the particle, $\vec{v} = \frac{d\vec{r}}{dt} = 20\alpha t\hat{i} + 5\beta\hat{j}$

Formula of angular momentum, $\vec{L} = m(\vec{r} \times \vec{v})$

According to question, $\vec{L}_{t=t} = \vec{L}_{t=0} \Rightarrow \vec{r} \times \vec{v} = \vec{0}$

$$\Rightarrow 50\alpha\beta t^2\hat{k} - 100\alpha\beta t(t-5)\hat{k} = \vec{0}$$

(At $t = 0$, $\vec{L} = 0$)

$\Rightarrow t = 10$ seconds

**73.** **(3)**

**Sol:** $\vec{\tau} = \vec{r} \times \vec{F}$

$$\vec{r} = (0-2)\hat{i} + (0-(-3))\hat{j} = -2\hat{i} + 3\hat{j}$$

$$\therefore \vec{\tau} = (-2\hat{i} + 3\hat{j}) \times (-P\hat{k}) = P(-3\hat{i} - 2\hat{j})$$

$$\Rightarrow P(a\hat{i} + b\hat{j}) = P(-3\hat{i} - 2\hat{j})$$

$$\frac{a}{b} = \frac{3}{2} \Rightarrow x = 3$$

**74.** **(15)**

**Sol:** Torque acting on the cylinder. $\tau = I\alpha$

$$\Rightarrow FR = mR^2\alpha \ (\because \tau = \text{Force} \times r_\perp)$$

$$\alpha = \frac{F}{mR} = \frac{52.5}{5 \times 0.7} = 15 \text{ rads}^{-2}$$

# GRAVITATION

## Single Option Correct Type Questions (01 to 58)

**1.** **(3)**

**Sol:** $F = \dfrac{GM(M-m)}{r^2}$

For $F_{min}$, $\dfrac{dF}{dm} = 0$

$M - 2m = 0 \Rightarrow \dfrac{m}{M} = \dfrac{1}{2}$

$M/m = 2$

**2.** **(3)**

**Sol:** $\dfrac{G\times 100}{x^2} = \dfrac{G\times 10^4}{(1-x)^2}$

$\Rightarrow (1-x)^2 = 100 \times x^2 \Rightarrow 1 - x = 10x$

$11x = 1$

$x = \dfrac{1}{11}$ m

**3.** **(4)**

**Sol:** $-\left[\dfrac{G\times 10^2}{(1/2)} + \dfrac{G\times 10^3}{(1/2)}\right] = -147 \times 10^{-9}$ J / kg

**4.** **(3)**

**Sol:** The acceleration due to gravity at a distance $x$ ($x < R$) from centre of earth (of radius R) is

$g' = g\left(1 - \dfrac{d}{R}\right)$ $\quad\therefore g' = \dfrac{g}{2}$

**5.** **(3)**

**Sol:** Given that $m' = 4m_e$ & $R' = R_e$

$g \propto \dfrac{m}{R^2} \quad \Rightarrow \dfrac{g'}{g} = \dfrac{m'\ R_e}{(R')^2\ m_e}$

$g' = 4g$

Energy needed $= W = mg'h$

$W = 2 \times (4g) \times 2 = 160$ J

**6.** **(3)**

**Sol:** $PE = \dfrac{-GM_e m}{R}$

$\Delta PE = PE_f - PE_i$

$= \dfrac{-GM_e m}{(2R)} - \left(-\dfrac{GM_e m}{R}\right)$

$= \dfrac{GM_e m}{2R} \quad \because \left(\dfrac{GM_e}{R^2} = g\right)$

$= \dfrac{mgR}{2}$

**7.** **(1)**

**Sol:** Total Mechanical energy = – (kinetic energy)

$\therefore$ TME $= -E_k$

for escape, TME = 0.

i.e., If, $E_k$ is provided then TME. becomes Zero.

Hence. the minimum amount of energy that is added so that it escapes the earth's gravitational field is $E_k$.

**8.** **(1)**

**Sol:** $T^2 \propto r^3$

$\left(\dfrac{T_1}{T_2}\right)^2 = \left(\dfrac{r_1}{r_2}\right)^3$

$\left(\dfrac{1}{8}\right)^2 = \left(\dfrac{10^4}{r}\right)^3$

$r = 4 \times 10^4$ km

$$T = \frac{2\pi r}{v}$$

$$v_1 - v_2 = \frac{2\pi r_1}{T_1} - \frac{2\pi r_2}{T_2}$$

$$= 2\pi\left(\frac{10^4}{1} - \frac{4\times10^4}{8}\right) = \pi \times 10^4 \text{ km/hr}$$

**9.** **(1)**

**Sol:** $$\omega_{rel} = \frac{(v_\perp)_{rel}}{\text{distance between } S_2 \,\&\, S_1}$$

$$= \frac{\pi\times10^4}{4\times10^4 - 10^4} = \frac{\pi}{3} \text{ rad/hr}$$

**10.** **(3)**

**Sol:** From energy conservation

$PE_i + KE_i = PE_f + KE_f$

$$-\left(\frac{GM_1}{d/2} + \frac{GM_2}{d/2}\right)\text{m} + \frac{1}{2}\text{ mv}^2 = 0 + 0$$

$$v^2 = \frac{4G}{d}(M_1 + M_2)$$

$$v = \sqrt{\frac{4G(M_1 + M_2)}{d}}$$

**11.** **(4)**

**Sol:** Satellite orbital velocity = $\sqrt{gR}$

escape velocity = $\sqrt{2gR}$

% change in velocity of satellite to move infinity = $\dfrac{\sqrt{2gR} - \sqrt{gR}}{\sqrt{gR}} \times 100 = 41.4\%$

**12.** **(2)**

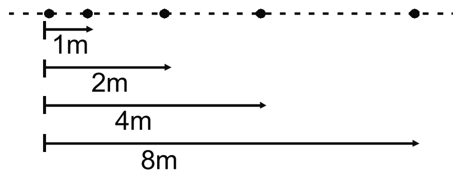
**Sol:** $dV = -Edr$

$$\int_{V_i}^{V} dV = \int_{d_i}^{r} \frac{k}{r}dr = k[\ln r]_{d_i}^{r}$$

$$V = V_i + k \ln\frac{r}{d_i}$$

**13.** **(4)**

**Sol:**




$V = V_1 + V_2 + V_3 + V_4 + \ldots\ldots$

$$= -\frac{GM}{1} - \frac{GM}{2} - \frac{GM}{4} - \frac{GM}{8} - \frac{GM}{8} - \frac{GM}{32} - \ldots\ldots$$

$$= -GM\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \ldots\ldots\right) \rightarrow$$ G.P. of infinite series

$$= -GM\left(\frac{1}{1 - 1/2}\right)$$

$V = -GM(2) = -2GM$

**14.** **(3)**

**Sol:** Angular momentum of satellite remains constant.

**15.** **(2)**

**Sol:** $v_e = \sqrt{g_e R_e \times 2}$

$$\frac{v_p}{v_e} = \sqrt{\frac{g_p R_p}{g_e R_e} \times \frac{2}{2}}$$

$$\frac{v_p}{v_e} = \sqrt{\frac{10 g_e}{g_e}} \Rightarrow v_p = \sqrt{10}\, v_e$$

**16.** **(3)**

**Sol:** $v_{esc} = \sqrt{2gR}$

$$v_{esc} = \sqrt{\frac{2GM_e R}{R^2}}$$

$$v_{esc} = \sqrt{\frac{2G\left(\frac{4}{3}\pi R^3 \rho\right)R}{R^2}}$$

$$v_{esc} \propto \sqrt{\rho R^2}$$

$$\frac{v}{v_0} = \sqrt{\frac{\rho(2R)^2}{\rho R^2}}$$

$v = 2v_0$

**17. (3)**

**Sol:** Initial total energy = Initial kinetic energy + initial potential energy

$$= \frac{1}{2}\,m\,(0)^2 + \left(-\frac{GMm}{R_0}\right) = -\frac{GMm}{R_0}$$

Total energy, when it reaches the surface of earth $= \frac{1}{2}\,mv^2 + \left(-\frac{GMm}{R}\right)$

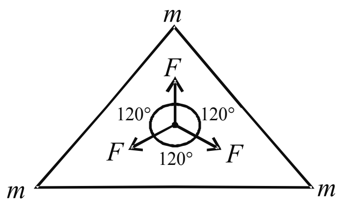
Applying energy conservation,

$$\frac{1}{2}mv^2 - \frac{GMm}{R} = -\frac{GMm}{R_0}$$

$$v = \sqrt{2GM\left\{\frac{1}{R} - \frac{1}{R_0}\right\}}$$

**18. (4)**

**Sol:**

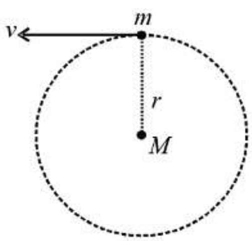



Due to geometry net force is zero.

**19. (2)**

**Sol:** $\frac{GMm}{r^2} = \frac{mv^2}{r}$

$$v = \sqrt{\frac{GM}{r}}$$

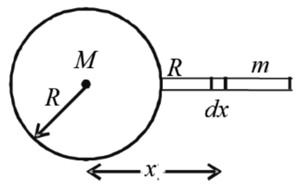



$$T = \frac{2\pi r}{v} = \frac{2\pi r^{\frac{3}{2}}}{\sqrt{GM}} = \frac{2\pi r^{\frac{3}{2}}}{\sqrt{G\rho \times \frac{4}{3}\pi r^3}}$$

$$T \propto \frac{1}{\sqrt{\rho}}$$

**20. (1)**

**Sol:** $F = \int_R^{2R} \frac{GM\left(\frac{m}{R}\right)dx}{x^2} = \frac{GMm}{2R^2}$




**21. (1)**

**Sol:** $\frac{g\left(1 - \frac{2h}{R_e}\right) - g}{g} = -0.1 \times \frac{1}{100}$

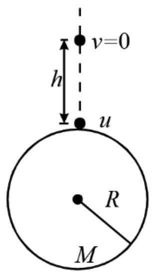
$$\Rightarrow \quad -\frac{2h}{R_e} = -\frac{1}{1000}$$

$$\Rightarrow \quad h = \frac{R_e}{2000} = \frac{6400}{2000}\text{ km} = 3.2\text{ km.}$$

**22. (1)**

**Sol:** Let the object of mass m projected with speed, $u = \sqrt{gR}$ reach a height '$h$' above surface of earth.

Then from conservation of energy




$$\frac{1}{2}mu^2 - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$u^2 = gR = \frac{GM}{R}$$

$$\Rightarrow \quad \frac{1}{2}\frac{GMm}{R} - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

or $h = R$

**23.** **(1)**

**24.** **(3)**

**Sol:** Let, $\omega_E$ = angular velocity of earth,

$\omega_S$ = angular velocity of satellite.

Then $6 = \frac{2\pi}{(\omega_E + \omega_S)} \Rightarrow \omega_E + \omega_S = \frac{\pi}{3}$

$\Rightarrow \omega_S = \frac{\pi}{3} - \frac{\pi}{12}$

$(\therefore \omega_E = \frac{2\pi}{24} = \frac{\pi}{12}$ rad per hour)

$\Rightarrow \omega_S = \frac{\pi}{4}$ radian per hour.

**25.** **(3)**

**26.** **(4)**

**Sol:** $E_1 = -mgR_e$ (on earth surface)

In circular orbit:

$$E_2 = -\frac{GM_e m}{2.(2R_e)} = -\frac{mgR_e}{4} \left(\frac{GM_e}{R_e^2} = g\right)$$

Minimum energy required

$E = E_2 - E_1$ ; $E = \frac{3}{4} mgR_e$

**27.** **(4)**

**Sol:** As gravitational force provides centripetal force

$$\frac{mv^2}{r} = \frac{GMm}{r^3}$$

i.e., $v^2 = \frac{GM}{r^2}$

So that $T = \frac{2\pi r}{v} = 2\pi r\sqrt{\frac{r^2}{GM}}$

$\therefore T^2 \propto r^4$

**28.** **(1)**

**Sol:** Till the particle reaches the centre of planet, force on both bodies are in direction of their respective velocities, hence kinetic energies of both keep on increasing. After the particle crosses the centre of planet, forces on both are retarding in nature. Hence as the particle passes through the centre of the planet, sum of kinetic energies of both the bodies is maximum. Therefore statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

**29.** **(1)**

**Sol:** (A) Time period, $T$ is : $T^2 = \frac{4\pi^2}{GM_{earth}} R^3$

(B) Orbital speed $v$ is $v^2 = \frac{GM_{earth}}{R}$

(C) Total energy = $-\frac{GM_{earth}\ m_s}{2R}$

(D) Magnitude of Gravitational field at centre of satellite = $\frac{GM_{earth}}{R^2}$ ($R$ = radius of orbit)

**30.** **(2)**

**Sol:** inside a uniform spherical shell

$E_{in} = 0$

$V_{in}$ = constant = $\frac{GM}{R}$

**31.** **(4)**

**Sol:** For a planetary motion, Total mechanical Energy is conserved

Angular momentum about the sun = constant

$\frac{dA}{dt}$ about the sun = constant

**32.** **(2)**

**Sol:** Since the centripetal force will disappear hence the satellite will move tangentially to the original orbit with speed

**33.** **(3)**

**Sol:** $\frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}$

or $\frac{T_1}{5} = (4)^{3/2}$ or $T_1 = 40$ hr.

**34.** **(3)**

**Sol:** Escape velocity is independent of direction of projection.

**35.** **(4)**

**Sol:** $\frac{mv^2}{R+x} = \frac{GMm}{(R+x)^2}\times\frac{R^2}{R^2} \Rightarrow v = \left[\frac{gR^2}{R+x}\right]^{1/2}$

**36.** **(1)**

**Sol:** $T \propto R^{3/2}$,Time period is independent of mass of satellite

**37.** **(2)**

**Sol:** $\Delta PE = \frac{GMm}{R} - \frac{GMm}{2R} = \frac{mgR}{2}$

**38.** **(3)**

**Sol:** $g\left[1-\frac{d}{R}\right] = g\left[1-\frac{2h}{R}\right]$

**39.** **(4)**

**Sol:** $W = \frac{GMm}{r} = 6.67 \times 10^{-11} \times 100 \times 10 / 0.1 = 6.67 \times 10^{-7}$ J

**40.** **(3)**

**Sol.** Acceleration due to gravity

$$g = \frac{GM}{R^2} = \frac{4}{3}\pi G\rho R \left(\because M = \rho\times\frac{4}{3}\pi R^3\right)$$

$$\therefore \frac{g_2}{g_1} = \frac{\rho_2}{\rho_1}\times\frac{R_2}{R_1} = \frac{1}{2}\times 1.5 = \frac{3}{4}$$

**41.** **(2)**

**Sol:** $V = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2GM_e\times 10}{\frac{R_e}{10}}}$

$= \sqrt{\frac{Gm_e}{R_e}}\times 10 = 11\times 10$ km/s

**42.** **(4)**

**Sol:** Acceleration due to gravity at height $h$ from earth surface.

$$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$\frac{g}{9} = \frac{g}{\left(1+\frac{h}{R}\right)^2} \qquad \Rightarrow \quad h = 2R$$

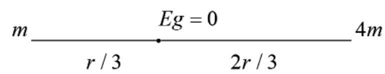
**43.** **(4)**

**Sol:** $\frac{Gm}{x^2} = \frac{G(4m)}{(r-x)^2}$

$\frac{1}{x} = \frac{2}{r-x}$

$r - x = 2x$

$x = \frac{r}{3}$



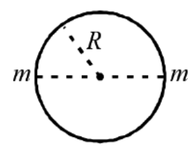

$V_g = -\frac{Gm}{r/3} - \frac{G(4m)}{2r/3}$

$V_g = -\frac{3Gm}{r} - \frac{6Gm}{r} = \frac{9Gm}{r}$

**44.** **(1)**

**Sol:** $\frac{Gm^2}{(2R)^2} = m\omega^2 R$

$\frac{Gm^2}{4R^3} = \omega^2$




$\omega = \sqrt{\frac{Gm}{4R^3}}$

$v = \omega R$

$v = \sqrt{\frac{Gm}{4R^3}} \times R = \sqrt{\frac{Gm}{4R}}$

**45.** **(4)**

**Sol:** $W = 0 - \left(-\frac{GMm}{R}\right) = \frac{GMm}{R}$

$= gR^2 \times \frac{m}{R} = mgR$

$= 1000 \times 10 \times 6400 \times 10^3$

$= 64 \times 10^9$ J

$= 6.4 \times 10^{10}$ J

So, energy required = $6.4 \times 10^{10}$ J

**46. (1)**

**Sol:** $E_f = \frac{1}{2}mv_0^2 - \frac{GMm}{3R} = \frac{1}{2}m\frac{GM}{3R} - \frac{GMm}{3R}$

$= \frac{GMm}{3R}\left(\frac{1}{2}-1\right) = \frac{-GMm}{6R}$

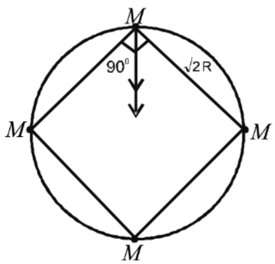
$E_i = \frac{-GMm}{R} + K_i$

$E_i = E_f$

$K_i = \frac{5GMm}{6R}$

**47. (4)**

**Sol:**




$2\frac{GM^2}{(\sqrt{2}R)^2}\frac{1}{\sqrt{2}} + \frac{GM^2}{4R^2} = \frac{Mv^2}{R}$

$\frac{GM^2}{\sqrt{2}R^2} + \frac{GM^2}{4R^2} = \frac{Mv^2}{R}$

$v = \frac{1}{2}\sqrt{\frac{GM}{R}\left[1+2\sqrt{2}\right]}$

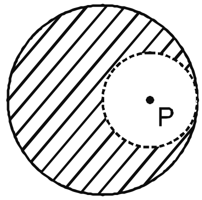
**48. (2)**

**Sol:** Potential at point P due to complete solid sphere

$= -\frac{GM}{2R^3}\left(3R^2 - \left(\frac{R}{2}\right)^2\right)$

$= -\frac{GM}{2R^3}\left(3R^2 - \frac{R^2}{4}\right)$

$= -\frac{GM}{2R^3}\left(\frac{11R^2}{4}\right) = -\frac{11GM}{8R}$




Potential at point P due to cavity part

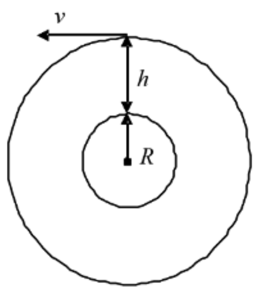
$= -\frac{3}{2}\frac{G\frac{M}{8}}{\frac{R}{2}} = \frac{-3GM}{8R}$

So, potential due to remaining part at point P

$= \frac{-11GM}{8R} - \left(\frac{-3GM}{8R}\right) = \frac{-11GM+3GM}{8R} = \frac{-GM}{R}$

**49. (3)**

**Sol:**




$v = \sqrt{\frac{GM}{(R+h)}} = \sqrt{\frac{GM}{R}}$

$v = \sqrt{\frac{GM}{R}}$

$\frac{1}{2}mv^2 - \frac{GMm}{R+h} = 0 \qquad (R+h \approx R)$

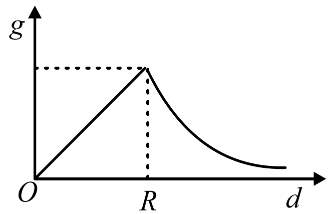
$v = \sqrt{\frac{2GM}{R}}$

$\Delta v = \sqrt{\frac{GM}{R}}\left(\sqrt{2}-1\right) = \sqrt{gR}\left(\sqrt{2}-1\right)$

**50.** **(1)**

**Sol:** $g = \dfrac{GMd}{R^3}$ $\quad d < R$

$g = \dfrac{GM}{d^2}$ $\quad d \geq R$




**51.** **(1)**

**Sol:** Gravitational field is a conservative force field. In a conservative force field work done is path independent.

$\therefore \quad W_I = W_{II} = W_{III}$

**52.** **(4)**

**Sol:** For binary star the time period of the two stars are equal.

**53.** **(3)**

**Sol:** $\rho = \rho_0 \qquad r \leq R \;= 0$

$r > R$

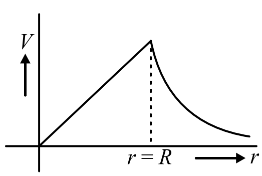
**Case I**

$r \leq R \qquad \Rightarrow \qquad F_C = \dfrac{mV^2}{r}$

$mg\dfrac{r}{R} = \dfrac{mV^2}{r}$ ($g$ = acceleration due to gravity at surface of sphere)

$V = \sqrt{\dfrac{g}{R}}\,r \qquad$ for $r \leq R$

**Case II**




$r > R \qquad \Rightarrow \qquad \dfrac{GMm}{r^2} = \dfrac{mV^2}{r}\,V$

$= \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{g}{r}}\,R$

**54.** **(2)**

**Sol:** $v_e = \sqrt{2}\,v$

$KE = \dfrac{1}{2}mv_e^2 = \dfrac{1}{2}m\left(\sqrt{2}v\right)^2 = mv^2$

**55.** **(2)**

**Sol:** $V_{es} = \sqrt{\dfrac{2GM}{R}} = \sqrt{\dfrac{2.G\rho.\frac{4}{3}\pi R^3}{R}} = \sqrt{\dfrac{4G\rho}{3}}\,R$

$V_{es} \propto R$

Surface area of $P = A = 4\pi R_P^2$

Surface area of $Q = 4A = 4\pi R_Q^2$

$\Rightarrow R_Q = 2R_p$

mass of $R$ is $M_R = M_P + M_Q$

$\rho\dfrac{4}{3}\pi R_R^3 = \rho\dfrac{4}{3}\pi R_P^3 + \rho\dfrac{4}{3}\pi R_Q^3$

$\Rightarrow R_R^3 = R_P^3 + R_Q^3$

$= 9R_P^3$

$R_R = 9^{1/3} R_P \Rightarrow R_R > R_Q > R_P$

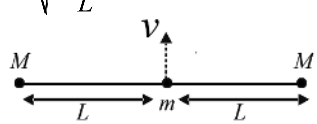
Therefore, $V_R > V_Q > V_P$

$\dfrac{V_R}{V_P} = 9^{1/3}$ and $\dfrac{V_P}{V_Q} = \dfrac{1}{2}$

**56.** **(2)**

**Sol:** $-\dfrac{GM.2m}{L} + \dfrac{1}{2}mv^2 = 0 + 0$

$\Rightarrow \quad v = \sqrt{\dfrac{4GM}{L}}$




**57.** **(3)**

**Sol.** Initially, $F = \dfrac{Gm^2}{r^2}$ …(i)

When one-third mass of one object is transferred to the other, then now force

$F' = \dfrac{G \times \left(\frac{2m}{3}\right)\left(\frac{4m}{3}\right)}{r^2} = \dfrac{8}{9}\dfrac{Gm^2}{r^2} = \dfrac{8}{9}F$

**58.** **(1)**

**Sol.** Formula based

## *Integer Type Questions (59 to 73)*

**59. (6)**

**Sol:** $\Delta L = \frac{F\ell}{AY} = \frac{mg\ell}{AY}$ ($Y$ = young's modulus)

$\therefore \quad \frac{\Delta\ell_1}{g_1} = \frac{\Delta\ell_2}{g_2} \Rightarrow \frac{10^{-4}}{10} = \frac{6\times10^{-5}}{g_2}$

$g_2 = \frac{6\times10^{-4}}{10^{-4}} = 6\text{ m/sec}^2$

**60. (64)**

**Sol:** Escape velocity of a planetary system is given by,

$V_{es} = \sqrt{\frac{2GM}{R}}$ Where, $M$ is the mass of the planet, $R$ is the radius of the planet

$\Rightarrow \quad V_{es}\sqrt{R} = \text{Constant}$

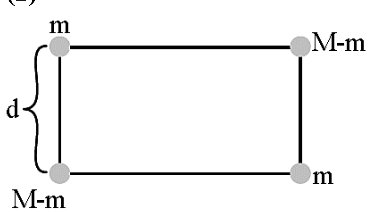
$\Rightarrow$

$V_{es}\cdot\sqrt{R} = 10V_{es}\sqrt{R'} \Rightarrow R' = \frac{R}{100} = 64\text{ km}$

Hence, Thus, the radius in kilometers to which the present radius of the earth ($R$ = 6400 km) is to be compressed so that the escape velocity is increased to ten times is 64 km.

**61. (2)**

**Sol:**




$U = -\frac{Gm(M-m)}{d}\times4 - \frac{Gm^2}{(d\sqrt{2})} - \frac{G(M-m)^2}{\sqrt{2}d}$

For $U$ to be maximum.

$\frac{dU}{dm} = 0 \Rightarrow m = \frac{M}{2} \Rightarrow \frac{M}{m} = 2$

**62. (3)**

**Sol:** According to question the given data is

$\frac{x}{5}\frac{GM^2}{R}$ …(i)

Energy given = $U_f - U_i$

$= 0 - \left(-\frac{3}{5}\frac{GM^2}{R}\right) = \frac{3}{5}\frac{GM^2}{R}$ …(ii)

Comparing eq.(i) to eq.(ii) we get $x = 3$

**63. (16)**

**Sol:** $KE_i + PE_i = KE_f + PE_f$

$\frac{1}{2}mu_0^2 + \left(-\frac{GMm}{10R}\right) = \frac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right)$

$v^2 = u_0^2 + \frac{2GM}{R}\left[1 - \frac{1}{10}\right]$

$v = \sqrt{u_0^2 + \frac{9}{5}\frac{GM}{R}}$

$= \sqrt{12^2 + \left(\frac{9}{5}\right)\frac{(11.2)^2}{2}}$

$= \sqrt{144 + 0.9(11.2)^2} = \sqrt{256.896}$

= 16.028 km/s = 16

**64. (10)**

**Sol:** Using conservation of energy:

$\Rightarrow \quad \frac{1}{2}mv_i^2 - \frac{GMm}{R} = 0 - \frac{GMm}{11R}$

$\Rightarrow \quad v_i^2 - \frac{20}{11}\frac{GM}{R}$

$V_e = \sqrt{\frac{10}{11}}\sqrt{\frac{2GM}{R}}$

$\therefore \quad V_i = \sqrt{\frac{10}{11}}v_e$

**65. (9)**

**Sol:** Circular orbits

$T = 2\pi\sqrt{\frac{R^3}{GM_S}}$

Binary stars

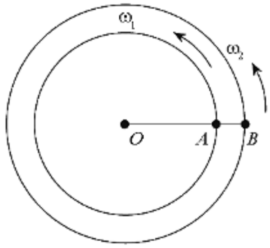
$$nT = 2\pi\sqrt{\frac{(9R)^3}{G(3M_S + 6M_S)}}$$

$$n \times 2\pi\sqrt{\frac{R^3}{GM_S}} = 9 \times 2\pi\sqrt{\frac{R^3}{GM_S}}$$

**66. (3)**

**Sol:** $T_1$ = 1 hour [For $A$ satellite]

So, $\omega_1 = 2\pi$ rad/hour




$T_2$ = 8 hour [For $B$ satellite]

$\omega_2 = \frac{\pi}{4}$ rad/hour

As $T^2 \propto R^3$

$$\left(\frac{R_1}{R_2}\right)^3 = \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{1}{8}\right)^2$$

$$\frac{R_1}{R_2} = \left(\frac{1}{8}\right)^{2/3} = \left(\frac{1}{2}\right)^2$$

$\Rightarrow$ $R_2 = 8 \times 10^3$ Km

$V_1 = \omega_1 R_1 = 4\pi \times 10^3$ Km/h

$V_2 = \omega_2 R_2 = 2\pi \times 10^3$ Km/h

$$\omega_{relative} = \frac{V_1 - V_2}{R_2 - R_1} = \frac{2\pi \times 10^3}{6 \times 10^3}$$

$\Rightarrow$ $\frac{\pi}{3}$ rad/hour

$x = 3$

**67. (200)**

**Sol**: Gravity at depth

$$g' = g\left(1 - \frac{d}{R}\right) = g\left(1 - \frac{R}{2R}\right) = \frac{g}{2}$$

So weight, $W' = mg = \frac{mg}{2} = 200\,\text{N}$

$\{\because mg = 400\text{ N}\}$

**68. (198)**

**69. (8)**

**Sol:** Acceleration due to gravity at a height h above the surface of earth,

$$g' = \frac{g}{\left[1 + \frac{h}{R}\right]^2}$$

So, weight of the body at given height is

$$mg' = \frac{mg}{\left[1 + \frac{h}{R}\right]^2} = \frac{18}{\left[1 + \frac{1}{2}\right]^2} = 8\text{ N}$$

**70. (2)**

**Sol**: At the surface of earth time period, $T = 2\pi\sqrt{\frac{\ell}{g}}$

At a height h above the surface of earth = $R$

$$g' = \frac{g}{\left(1 + \frac{h}{R}\right)^2} = \frac{g}{4}$$

$\Rightarrow$ $xT = 2\pi\sqrt{\frac{\ell}{(g/4)}}$

$\Rightarrow$ $xT = 2T$

$\Rightarrow$ $x = 2$

**71. (64)**

**Sol**: $$g' = \frac{gR^2}{\left(R + \frac{R}{4}\right)^2} = \frac{16g}{25}$$

$\therefore$ Weight $= Mg' = \frac{16}{25} \times 100 = 64\,\text{N}$

**72. (48)**

**Sol:** $$g\left(1 - \frac{d}{R}\right) = 4 \times \frac{g}{\left(1 + \frac{3R}{R}\right)^2}$$

$\Rightarrow$ $1 - \frac{d}{R} = \frac{1}{4}$

$d = 4800$ km

**73.** **(32)**

**Sol:** $\because \quad t \propto \frac{1}{\sqrt{g}} \Rightarrow \frac{t_1}{t_2} = \frac{4}{6} = \sqrt{\frac{g_2}{g_1}}$

and, $\frac{g_2}{g_1} = \frac{g_0}{g_0\left(1+\frac{h}{R}\right)^2}$

$\Rightarrow \quad \left(1+\frac{h}{R}\right) = \frac{6}{4}$

$\Rightarrow \quad 1+\frac{h}{R} = \frac{3}{2} \Rightarrow h = \frac{R}{2} = 3200 \text{ km}$

# PROPERTIES OF MATTER-SOLIDS

*Single Option Correct Type Questions (01 to 45)*

**1.** **(1)**

**Sol:** $L = 4$ m

$Y = 9 \times 10^{10}$

$\frac{F}{A} = Y\frac{\Delta\ell}{\ell}$

$F = AY\frac{\Delta\ell}{\ell}$

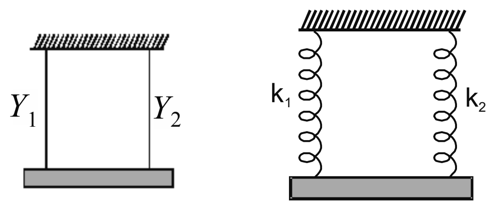
$= \pi(2 \times 10^{-3})^2 \times 9 \times 10^9 \times \frac{1}{100}$

$= \pi \times 4 \times 10^{-6} \times 9 \times 10^7$

$= 360\ \pi$ N.

**2.** **(2)**

**Sol:**



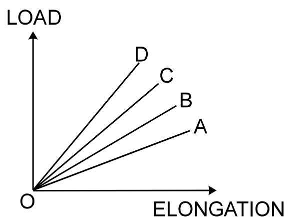

$K_{eq} = K_1 + K_2$

$\frac{Y2A}{\ell} = \frac{Y_1A}{\ell} + \frac{Y_2A}{\ell}$

$Y = \frac{Y_1 + Y_2}{2}$

**3.** **(3)**

**Sol:**




$\frac{F/A}{\Delta\ell/\ell} = \text{Y}$

$\frac{F}{\Delta\ell} = \frac{YA}{\ell} = \text{slope}$

$\Rightarrow$ $Y$ & $\ell$ are same for all then

slope $\alpha$ $A$

**4.** **(3)**

**Sol:** $F = \eta A\frac{x}{h} = 0.4 \times 10^{11} \times 1 \times .005 \times \frac{.02 \times 10^{-2}}{1}$

$= 4 \times 10^4$ N

**5.** **(3)**

**Sol:** $\frac{\Delta V}{V} = \frac{p}{B} = \frac{1 \times 10^5}{1.25 \times 10^{11}} = 8 \times 10^{-7}$

**6.** **(4)**

**Sol:** $V = 1/2\ K(2)^2$

$V_1 = 1/2\ K(10)^2$

then $V_1 = 25V$

**7.** **(4)**

**Sol:** $K = \frac{AY}{\ell}$ , $K_2 = \frac{4AY}{\ell/2} = 8K$

$2 = 1/2\ K\ (1)^2$ ; $U = 1/2(8\ K)(1)^2$

$= 4K$ ; $K = 4$, $U = 16$ J

**8.** **(3)**

**Sol:** $\frac{F}{A} = Y\frac{\Delta\ell}{\ell}$

If $Y$ & $\frac{\Delta\ell}{\ell}$ are constant

$F = AY\frac{\Delta\ell}{\ell}$

$\Rightarrow$ $F \propto A$

$\Rightarrow$ $F^1 = 4F$

**9.** **(4)**

**Sol:** $\frac{p_1}{p_2} = \frac{m_1 v_1}{m_2 v_2}$, $m \propto r^3$, $v \propto r^2$ $\Rightarrow p \propto r^5$ then

$\frac{p_1}{p_2} = \frac{1}{32}$

**10.** **(2)**

**Sol:** $46.4 \times 10^{-6}\ \text{atm}^{-1} = \frac{1}{B}$

$B = \frac{1}{46.4 \times 10^{-6}} \Rightarrow B = \frac{\Delta P}{\Delta v / v}$

$\Rightarrow \frac{\Delta v}{v} = \frac{\Delta p}{B} = 46.4 \times 10^{-6}$

**11.** **(4)**

**Sol:** depth = 200 m

$\frac{\Delta V}{V} = \frac{0.1}{100} = 10^{-3}$

density = $1 \times 10^3$

$g = 10$

$B = \frac{\Delta p}{\Delta v / v} = \frac{hg\rho}{\Delta v / v}$

$\Rightarrow B = 200 \times 10 \times 10^3 \times 1000 = 2 \times 10^9$

**12.** **(2)**

**Sol:** $V_T \alpha r^2$

$V_T \alpha \frac{\rho \frac{4}{3}\pi r^3}{r}$

$V_T \alpha \frac{m}{r}$

**13.** **(4)**

**Sol:** $\frac{r_1}{r_2} = \frac{1}{2}$

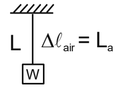
$PE$ per unit volume = $\frac{1}{2Y}\left(\frac{F}{A}\right)^2$

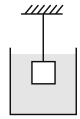
$PE \propto 1/A^2$

$\frac{PE_1}{PE_2} = \frac{A_2^2}{A_1^2} = 16 : 1$

**14.** **(1)**

**Sol:**



$\Delta \ell_{water} = L_w$

$L_a = \frac{WL}{YA}$

$L_w = \frac{\left[W - \frac{W}{\rho}\rho_w\right] L}{YA} = \frac{W[1 - \frac{\rho_w}{\rho}]\, L}{YA}$

$\frac{L_w}{L_a} = \left[1 - \frac{\rho_w}{\rho}\right]$

$\frac{\rho}{\rho_w} = \frac{L_a}{L_a - L_w}$

**15.** **(3)**

**Sol:** $v = 5 \times 10^{-4}$ m/s

$v = \frac{2}{9\eta} r^2 \rho g$

$r^2 = \frac{5 \times 9 \times 18 \times 10^{-5} \times 10^{-4}}{5 \times 2 \times 900 \times 10} = 9 \times 10^{-12}$

$r = 3 \times 10^{-6}$ m

**16.** **(1)**

**Sol:** $Y = \frac{Stress}{Strain}$

$(\text{Strain})_{\text{steel}} < (\text{strain})_{\text{rubber}}$

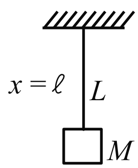
**17.** **(4)**

**Sol:** For incompressible fluid $\Delta V$ is zero.

**18.** **(1)**

**Sol:** loss in $PE = Mg\ell$

$PE = Mg\ell$




Elastic $PE = \frac{1}{2}Kx^2$

$= \frac{1}{2}\frac{Mg}{A} \times \frac{\ell}{L} \times AL = Mg\ell/2$

Heat = $Mg\ell - Mg\ell/2 = Mg\ell/2$

**19. (4)**

**Sol:** Elastic energy stored in the wire is

$U = \frac{1}{2}$ stress × strain × volume

$= \frac{1}{2}\frac{F}{A} \times \frac{\Delta l}{L} \times AL = \frac{1}{2} F\Delta l$

$= \frac{1}{2} \times 200 \times 1 \times 10^{-3} = 0.1$

**20. (2)**

**Sol:** $u = \frac{1}{2}\frac{(stress)^2}{Y} = \frac{S^2}{2Y}$

**21. (2)**

**Sol:** Tension in wire remains same

**22. (3)**

**Sol:** $F = \frac{YAx}{\ell}$ and $F_2 = \frac{Y(3A)x}{(\ell/3)} = 9F$

**23. (1)**

**Sol:** $\frac{P}{\alpha\Delta\theta} = Y$

$P = Y\alpha\Delta\theta = 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100 = 2.2 \times 10^{8}$ Pa

**24. (1)**

**Sol:** $T = 2\pi\sqrt{\frac{\ell}{g}}$

$T_M = 2\pi\sqrt{\frac{\ell + \Delta\ell}{g}}$ ; $\Delta\ell = \frac{Mg\ell}{AY}$

$\frac{T_M}{T} = \sqrt{\frac{\ell + \Delta\ell}{\ell}}$

$\left(\frac{T_M}{T}\right)^2 = 1 + \frac{\Delta\ell}{\ell}$

$\frac{1}{Y} = \left(\left(\frac{T_M}{T}\right)^2 - 1\right)\frac{A}{Mg}$

**25. (1)**

**Sol:** $\Delta P = \frac{mg}{a}$

$K = -\frac{\frac{mg}{A}}{\frac{4\pi r^2 dr}{\frac{4}{3}\pi r^3}}$

$\frac{dr}{r} = -\frac{mg}{3KA}$

**26. (3)**

**Sol:** $\Delta\ell = \left(\frac{\ell}{YA}\right)\cdot W$

The graph is straight line passing through origin, the slope of which is $\frac{\ell}{YA}$ .

$\therefore$ Slope $= \left(\frac{\ell}{YA}\right)$ $\therefore$ $Y = \left(\frac{\ell}{A}\right)\left(\frac{1}{slope}\right)$

$= \left(\frac{1.0}{10^{-6}}\right)\frac{(80-20)}{(4-1)\times 10^{-4}} = 2.0 \times 10^{11}$ N/m$^2$

**27. (3)**

**Sol:** $Y = \frac{\left(\frac{F}{A}\right)}{\frac{\Delta\ell_1}{L}}$ ...(i)

$Y = \frac{\left(\frac{F}{4A}\right)}{\frac{\Delta\ell_2}{2L}}$ ...(ii)

$\frac{\Delta\ell_1}{\Delta\ell_2} = 2$

**28. (1)**

**Sol:** Strain $= \frac{0.04}{100}$

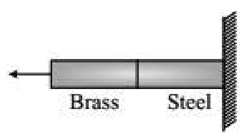
Energy per unit volume is

$\frac{E}{V} = \frac{1}{2} \times Y \times \text{strain}^2$

$= \frac{1}{2} \times 7 \times 10^{10}\frac{(0.04)^2}{(100)^2} = 56 \times 10^2$

**29. (2)**

**Sol:**




$k_1 = \frac{y_1 A_1}{\ell_1} = \frac{120 \times 10^9 \times A}{1}$

$k_2 = \frac{y_2 A_2}{\ell_2} = \frac{60 \times 10^9 \times A}{1}$

$$k_{eq} = \frac{k_2 k_2}{k_1 + k_2} = \frac{120 \times 60}{180} \times 10^9 \times A$$

$$k_{eq} = 40 \times 10^9 \times A$$

$$F = k_{eq}(x)$$

$$F = (40 \times 10^9) A.(0.2 \times 10^{-3})$$

$$\frac{F}{A} = 8 \times 10^6 \text{ N/m}^2$$

**30.** **(3)**

**Sol:** Bulk modulus, $B = \frac{-\Delta P}{\frac{\Delta V}{V}}$

$$\therefore \Delta P = -B \frac{\Delta V}{V}$$

Given, $\frac{-\Delta V}{V} = 0.02$

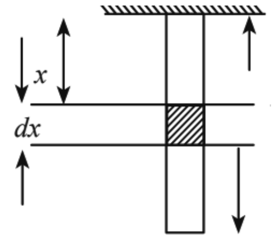
$\Delta P = -3 \times 10^{10}(0.02)$

$\Delta P = 6 \times 10^8 \text{ Nm}^{-2}$

**31.** **(2)**

**Sol:** We have given a uniform heavy rod of weight, $W = 10$ kg m/s$^2$, Cross-sectional area of rod, $A = 100$ cm$^2$, length of rod, $\ell = 20$ cm, Young's modulus of the material of the rod, $Y = 2 \times 10^{11}$ N/m$^2$

$$Y = \frac{F\ell}{A\Delta\ell} \Rightarrow \frac{F\ell}{AY} = \Delta\ell$$




For elemental mass of length, $dx$ change in its length

$$d(\Delta\ell) = \frac{\frac{W}{\ell}(\ell - x).dx}{AY}$$

$$\therefore \Delta\ell = \int d(\Delta\ell)$$

$$\int_0^\ell \frac{W}{A\ell y}(\ell - x)dx$$

$$\Delta\ell = \frac{1}{2}\frac{W\ell}{AY}$$

On putting values we get

$$\Delta\ell = 5 \times 10^{-10} \text{ m}$$

**32.** **(3)**

**Sol:** By using Hooke's Law

$F \alpha \Delta L$

$$\frac{F_1}{F_2} = \frac{\Delta L_1}{\Delta L_2}$$

$$\Rightarrow \frac{10}{20} = \frac{L_1 - L}{L_2 - L}$$

$$\Rightarrow L = 2L_1 - L_2$$

**33.** **(4)**

**Sol:** $\frac{du}{dv} = \frac{1}{2}\text{ stress} \times \frac{\text{stress}}{y} = \frac{1}{2}\frac{F^2}{A^2 y}$

$$\frac{du}{dv} \propto \frac{1}{d^4}$$

$$\frac{\left(\frac{du}{dv}\right)_1}{\left(\frac{du}{dv}\right)_2} = \frac{d_2^4}{d_1^4} = \frac{1}{4}$$

$$\frac{d_1}{d_2} = (4)^{1/4}; \frac{d_1}{d_2} = \sqrt{2} : 1$$

**34.** **(1)**

**Sol:** Young's modulus is independent of dimensional parameter of a body.

**35.** **(1)**

**Sol:** $\frac{F}{A} = \text{stress}; \frac{400 \times 4}{\pi d^2} = 379 \times 10^6$

$$d^2 = \frac{1600}{\pi \times 379 \times 10^6} = 1.34 \times 10^{-6}$$

$$d = \sqrt{1.34} \times 10^{-3} = 1.15 \times 10^{-3} \text{ m}$$

**36.** **(4)**

**Sol:** Bulk modulus $B = \dfrac{\rho g h}{\frac{\Delta V}{V}}$

$= \dfrac{10^3 \times 9.8 \times 2 \times 10^3}{1.36 \times 10^{-2}} = 1.44 \times 10^9 \text{ N/m}^2$

**37.** **(4)**

**Sol:** Tensile stress in wire will be

$= \dfrac{\text{Tensile force}}{\text{Cross-section area}}$

$\dfrac{mg}{\pi R^2} = \dfrac{4(3.1\ \pi)}{\pi \times 4 \times 10^{-6}} \text{Nm}^{-2} = 3.1 \times 10^6 \text{Nm}^{-2}$

**38.** **(1)**

**Sol:** Stress $= \dfrac{\text{Weight}}{\text{Area}}$

$\Rightarrow \dfrac{10}{2.5 \times 10^{-4}} = \dfrac{25}{A}$

$\Rightarrow A = 6.25 \times 10^{-4}$

**39.** **(3)**

**Sol:** $\dfrac{\Delta v}{v} = \dfrac{\Delta p}{B} = \dfrac{1}{20}$

$\dfrac{\Delta \ell}{\ell} = \dfrac{1}{3}\dfrac{\Delta p}{B} = \dfrac{1}{60}$

$\dfrac{\Delta \ell}{\ell} \times 100 = \dfrac{1}{60} \times 100 = 1.67\%$

**40.** **(3)**

**Sol:** Energy of catapult $= \dfrac{1}{2} \times \left(\dfrac{\Delta \ell}{\ell}\right)^2 \times Y \times A \times \ell$

= Kinetic energy of the ball $= \dfrac{1}{2} m v^2$ therefore,

$\dfrac{1}{2} \times \left(\dfrac{20}{42}\right)^2 \times Y \times \pi \times 3^2 \times 10^{-6} \times 42 \times 10^{-2}$

$= \dfrac{1}{2} \times 2 \times 10^{-2} \times (20)^2$

$Y = 3 \times 10^6 \text{ Nm}^{-2}$

**41.** **(1)**

**Sol:** Since, $T_1 \propto (\ell_1 - \ell)$, and $T_2 \propto (\ell_2 - \ell)$

$\dfrac{T_1}{T_2} = \dfrac{\ell_1 - \ell}{\ell_2 - \ell} \Rightarrow \ell = \dfrac{T_1 \ell_2 - T_2 \ell_1}{T_1 - T_2}$

**42.** **(4)**

**Sol:** We know that K $= -V\dfrac{dp}{dv}$

Also as mass remains constant we have $\dfrac{dv}{v} = \dfrac{-d\rho}{\rho}$

This we get, $K = -\rho \dfrac{dp}{d\rho}$

Hence, $dp = p$

So, $d\rho = \dfrac{\rho p}{K}$

**43.** **(2)**

**Sol:** So force on each columns will be

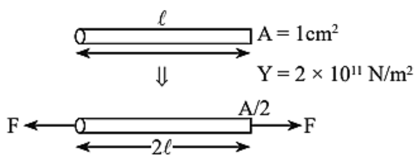
$= \dfrac{mg}{4} = 125 \times 10^3 \text{N.}$

Thus Strain

$\varepsilon = \dfrac{F}{AY} = \dfrac{125 \times 10^3}{2.355 \times 2 \times 10^{11}} = 2.65 \times 10^{-7}$

**44.** **(1)**

**Sol:**




At steady state:

$F = \dfrac{YA}{2} = \dfrac{2 \times 10^{11} \times 10^{-4}}{2} = 10^7 \text{ N}$

**45.** **(3)**

**Sol:** Energy $= \dfrac{1}{2}$ stress $\times$ strain $\times$ volume

$U = \dfrac{1}{2} \times Y \times \text{strain}^2 A \times \ell$

$\Rightarrow A = \dfrac{2U}{Y(\text{strain})^2 \times \ell}$

$= \dfrac{2 \times 80}{2 \times 10^{11} \times \left(\dfrac{2 \times 10^{-2}}{20}\right)^2 \times 20}$

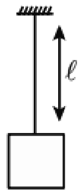
$= 40 \times 10^{-6} \text{ m}^2 = 40 \text{ mm}^2$

### *Integer Type Questions (46 to 59)*

**46.** **(60)**

**Sol:** Let $\Delta\ell$ is the decrease in length of the rod due to decrease in temperature.

$\Rightarrow \Delta\ell = \ell\alpha\Delta T$




Given, $\alpha = 2 \times 10^{-5}\ K^{-1}$, $\Delta T = (210 - 160) = 50$ K

$\Rightarrow \Delta\ell = 1 \times 2 \times 10^{-5} \times 50 = 10^{-3}$ m

$\because$ Young's modulus $Y = \dfrac{F/A}{\Delta\ell/\ell}$

$\Rightarrow\ 2\times10^{11} = \dfrac{Mg/3\times10^{-6}}{10^{-3}/1}$

$\Rightarrow Mg = 2 \times 10^{11} \times 3 \times 10^{-9}$

$\Rightarrow M = 60$ kg

**47.** **(2)**

**Sol:** Given, $10\ell_2 = 11\ell_1 \Rightarrow \ell_2 = 1.1\ \ell_1$

Let the natural length be '$\ell_0$.

When $T_1 = 100$ N, Extension = $\ell_1 - \ell_0$

Then $100 = K(\ell_1 - \ell_0)$ …(i)

When $T_1 = 120$ N, Extension = $\ell_2 - \ell_0$

Then $120 = K(\ell_2 - \ell_0)$ …(ii)

$\dfrac{120}{100} = \dfrac{\ell_2 - \ell_0}{\ell_1 - \ell_0}$

$1.2 = \dfrac{1.1\ell_1 - \ell_0}{\ell_1 - \ell_0}$

$0.1\ \ell_1 = 0.2\ \ell_0$

$\ell_0 = \dfrac{\ell_1}{2}$

$\therefore\quad x = 2$

**48.** **(20)**

**Sol:** According to energy conservation

$\dfrac{1}{2}.\dfrac{YA}{L}.x^2 = \dfrac{1}{2}mv^2$

Putting all values in above equation we get,

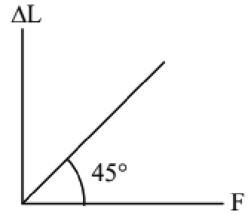
$\dfrac{0.5\times10^9\times10^{-6}\times(0.04)^2}{0.1} = \dfrac{20}{1000}v^2$

$\therefore v^2 = 400 \Rightarrow v = 20$ m/s

The velocity of the projected stone is 20 m/s.

**49.** **(5)**

**Sol:**




Using the graph:

$F = \Delta L$ at every point of the graph

$\because Y = \dfrac{FL}{A\Delta L}$

$\Rightarrow Y = \dfrac{L}{A}$ $\quad(\because F = \Delta L)$

$\Rightarrow Y = \dfrac{62.8\times10^{-2}}{\pi(2\times10^{-3})^2}$

$\therefore\ Y = 5 \times 10^4$ N/m²

**50.** **(2)**

**Sol:** As we know that, $Y = \dfrac{FL}{A\Delta L}$

$\Delta L = 0.04 \text{ m} = \dfrac{FL}{AY}$

If length and diameter both are double

$\Delta L' = \dfrac{F.2L}{4A.Y} = \dfrac{FL}{2YA} = 0.02 \text{ m} = 2 \text{ cm}$

**51.** **(25)**

**Sol:** Strain $= \dfrac{\text{stress}}{Y} = \dfrac{\dfrac{62.8\times10^3}{3.14\times(0.02)^2}}{2\times10^{11}}$

$= 2.5 \times 10^{-4}$

$= 25 \times 10^{-5}$

**52. (2)**

**Sol:** Slope of the curve = $\frac{\Delta L/W}{L} = \frac{\Delta L/L}{W} = \frac{1}{YA}$

$$Y = \frac{1}{(\text{slope})\times A}$$

$$Y = \frac{1}{(0.25\times10^{-5})\times(2\times10^{-6})}$$

$Y = 2 \times 10^{11}$ N/m$^2$

**53. (48)**

**Sol:** Shear modulus = $25 \times 10^9$ N/m$^2$

Formula of shear modulus

$$\eta = \frac{F/A}{x/\ell} \Rightarrow x = \frac{F\ell}{\eta A}$$

$$= \frac{18\times10^4\times60\times10^{-2}}{25\times10^9\times60\times15\times10^{-4}}$$

$= 48 \times 10^{-6}$ m = 48 μm

**54. (500)**

**Sol:** $B = \frac{-P}{\left(\frac{\Delta V}{V}\right)}$

$$B = \frac{-(\rho g h)}{\left(\frac{-0.5\%\text{ of }V_0}{V_0}\right)}$$

$$\Rightarrow \quad h = \frac{9.8\times10^8\times0.005}{10^3\times9.8} = 500\text{ m}$$

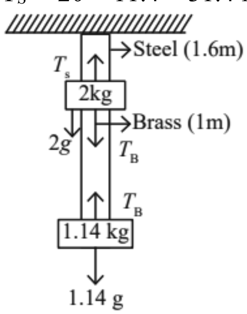
Hence, depth = 500 m

**55. (20)**

**Sol:** Tension in steel wire

$T_s = 2g + T_B$

$T_S = 20 + 11.4 = 31.4$ N




For steel wire $\Delta L = \frac{T_S L}{Ay}$

$$\Delta L = \frac{31.4\times1.6}{\pi(0.2\times10^{-2})^2\times2\times10^{11}} = 20\times10^{-6}\text{ m}$$

**56. (15)**

**Sol:** We have m = 10$g$, $\ell$ = 50 cm, $A$ = 2 mm$^2$, $Y = 1.2 \times 10^{11}$ N/m$^2$ and $\Delta x = x \times 10^{-5}$ m

And, $\Delta x = \frac{T\ell}{AY} = \frac{V^2 m}{AY}$ $(\because T\ell = mv^2)$

$$\frac{3600\times10\times10^{-3}}{2\times10^{-6}\times1.2\times10^{11}} = 15\times10^{-5}\text{ m}$$

So, $x = 15$

**57. (11)**

**Sol:** Tensile stress, $\sigma = \frac{F}{A} = \frac{4mg}{\pi D^2} \Rightarrow m = \frac{\pi D^2\sigma}{4g}$

$$m = 3.14\times\frac{(14\times10^{-3})^2\times7\times10^5}{4\times9.8} = 11\text{ kg}$$

**58. (1)**

**Sol:** Bulk modulus of water, $B_{water}$

$$= \frac{-\Delta P}{\left(\frac{\Delta V}{V}\right)} = \frac{-\Delta P}{\frac{0.01}{100}}$$

Bulk modulus for the liquid, $B_{liquid} = \frac{-\Delta P}{\frac{0.03}{100}}$

$$\Rightarrow \frac{B_{water}}{B_{liquid}} = 3$$

$\therefore x = 1$

**59. (4)**

**Sol:** $Y = \frac{\text{stress}}{\text{strain}} = \frac{\frac{T}{A}}{\frac{\Delta\ell}{\ell}}$

$$\therefore T = y\left(\frac{\Delta\ell}{\ell}\right)A$$

For thermal stress $\Delta\ell = \ell\alpha\Delta T$

$$\therefore T = Y\frac{\ell\alpha\Delta T.A}{\ell} = Y\alpha\Delta T.A$$

$T = 2 \times 10^{11} \times 10^{-5} \times 200 \times 10^{-4} = 4 \times 10^4$ N

# PROPERTIES OF MATTER-FLUIDS

## Single Option Correct Type Questions (01 to 58)

**1.** **(2)**

**Sol:** $V_T \alpha r^2$

$$V_T \alpha \frac{\rho \frac{4}{3}\pi r^3}{r}$$

$$V_T \alpha \frac{m}{r}$$

**2.** **(2)**

According to stokes law $F_D = 6\pi\eta Rv$.

**3.** **(4)**

**Sol:** $V_T \alpha (\sigma_S - \sigma_L)$

$$\frac{0.2}{V} = \frac{19.5-1.5}{10.5-1.5}$$

$V = 0.1$ m/s

**4.** **(1)**

**Sol:** Let $\rho_l \leftarrow$ density of water

$\rho'_l \leftarrow$ density of glycerin

$V\rho g = 6\pi\eta rv + V\rho_\ell g$

$Vg(\rho - \rho_\ell) = 6\pi\eta rv$

$Vg(\rho - \rho'_\ell) = 6\pi\eta' rv'$

$$V'\eta' = \frac{(\rho-\rho'_\ell)}{(\rho-\rho_\ell)} \times v\eta$$

$$V' = \frac{(\rho-\rho_\ell')}{(\rho-\rho_\ell)} \times \frac{v\eta}{\eta'}$$

$$= \frac{(7.8-1.2)}{(7.8-1)} \times \frac{10\times 8.5\times 10^{-4}}{13.2}$$

$V' = 6.25 \times 10^{-4}$ cm/s.

**5.** **(4)**

**Sol:** In equilibrium,

$mg = qE$

In absence of electric field,

$mg = 6\pi\eta rv$

$\Rightarrow qE = 6\pi\eta rv$

$$m = \frac{4}{3}\pi R r^3 d. = \frac{qE}{g}$$

$$\frac{4}{3}\pi\left(\frac{qE}{6\pi\eta v}\right)^3 d = \frac{qE}{g}$$

After substituting value we get,

$q = 8 \times 10^{-19}$ C

**6.** **(3)**

**Sol:** As the both points are at the surface of liquid and these points are in the open atmosphere. So, both points possess similar pressure and equal to 1 atm. Hence the pressure difference will be zero.

**7.** **(3)**

**Sol:** $\rho g(H - h)$

Because pressure varies with height.

**8.** **(1)**

**Sol:** $$\frac{m_1 g}{A_1} = \frac{m_2 g}{A_2}$$

Solving, $m_2 = 3.75$ kg.

**9.** **(2)**

**Sol:** Since pressure depends only on height,

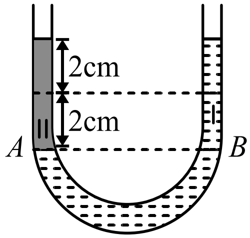
$\therefore F_A = F_B$

Also $Vol_A > Vol_B$

$\therefore W_A > W_B$

**10.** **(2)**

**Sol:**




Pressure of line $AB$ is same

$1.1 \times \rho g\,(4) = \sigma g \times 4$

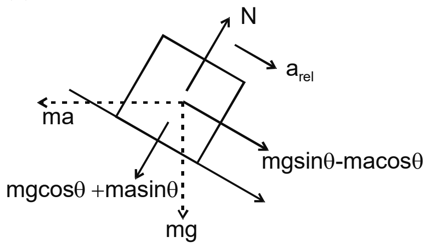
($\sigma$ is density of II liquid)

$\Rightarrow \quad \sigma = 1.1\,\rho$

$\Rightarrow \quad \dfrac{\sigma}{\rho} = 1.1$

**11.** **(1)**

**Sol:**




$ma_{rel} = mg \sin\theta - ma\cos\theta$

but for water surface $\tan\theta = a/g$

$\Rightarrow \quad a_{rel} = 0$

**12.** **(3)**

**Sol:** If two different bodies $A$ and $B$ are floating in the same liquid then

$$\frac{\rho_A}{\rho_B} = \frac{(f_{in})_A}{(f_{in})_B} = \frac{1/2}{2/3} = \frac{3}{4}$$

**13.** **(3)**

**Sol:** For the floatation, $V_0 d_0 g = V_{in} d g$

$\Rightarrow \quad V_{in} = V_0\,\dfrac{d_0}{d}$

$\therefore \quad V_{out} = V_0 - V_{in}$

$= V_0 - V_0\,\dfrac{d_0}{d} = V_0\left[\dfrac{d-d_0}{d}\right]$

$\Rightarrow \quad \dfrac{V_{out}}{V_0} = \dfrac{d-d_0}{d}$

**14.** **(4)**

**Sol:** $\Delta v = v_f - v_i = \dfrac{m}{y} - \dfrac{m}{x}$.

**15.** **(1)**

$F = \sigma V g - \rho V g = ma$

**16.** **(1)**

**Sol:** Let $\rho_S$, $\rho_L$ be the density of silver and liquid. Also, $m$ and $V$ be the mass and volume of silver block.

$\therefore$ Tension in string = $mg$–bouyant force

$T = \rho_S V g - \rho_L V g = (\rho_S - \rho_L)\,Vg$

Also, $V = \dfrac{m}{\rho_s}$

$\therefore \quad T = \left(\dfrac{\rho_S - \rho L}{\rho_S}\right) mg$

$= \dfrac{(10-0.72)\times 10^3}{10\times 10^3} \times 4 \times 10$

$= 37.12$ N.

**17.** **(3)**

**Sol:** In either case he carries same mass and hence same weight. (Buoyant force is internal force of bucket and fish system)

**18.** **(1)**

**Sol:** $d_A = 2$ cm and $d_B = 4$ cm

$\therefore \quad r_A = 1$ cm and $r_B = 2$ cm

From equation of continuity, $au$ = constant

$\therefore \quad \dfrac{u_A}{u_B} = \dfrac{\pi(r_B)^2}{\pi(r_A)^2} = \left(\dfrac{2}{1}\right)^2$

$\Rightarrow \quad u_A = 4u_B$

**19.** **(3)**

**Sol:** Range = $x = vt$

$x = \sqrt{2gD}\,\sqrt{\dfrac{2(H-D)}{g}}$

$x = 2\sqrt{D(H-D)}$.

**20.** **(3)**

**Sol:** Applying continuity equation:

$V_1 A_1 = V_2 A_2$

$A_1 = A_2$, So $V_1 = V_2$

Applying bernaulli's equation:

$P_1 + \rho g h_1 + 1/2\,\rho v_1^2 = P_2 + \rho g h_2 + 1/2\,\rho v_2^2$

since $v_1 = v_2$ ; and $h_1 = h_2$ $\Rightarrow$ $P_1 = P_2$.

**21. (1)**

**Sol:** $v_A = v_B$ (since area is uniform)

From Bernoulli's principle

$$\frac{v_A^2}{2} + gh + \frac{p_A}{\rho} = \frac{v_B^2}{2} + 0 + \frac{p_B}{\rho}$$

$\Rightarrow \quad p_A < p_B.$

**22. (3)**

**Sol:** $\Delta U = mgh$

$\Delta U = (\sigma_b - \sigma_\ell)\, Vgh$

**23. (1)**

**Sol:** Increasing the temperature of water from $2^0$C to $3^0$C increases its density and increase in the volume of iron

[due to thermal expansion]

**24. (1)**

**Sol:** As there is no gravity; the pressure difference will be only due to the acceleration.

**25. (3)**

**Sol:** Faces of cube in the direction of acceleration will have least pressure

**26. (2)**

$$\rho = \rho_0\left(1 - \frac{r^2}{R^2}\right), 0 < r \le R$$

As, sphere is floating, so weight of liquid is balanced by buoyancy force.

$\Rightarrow$ mg = B

$$\Rightarrow \int \rho\left(4\pi r^2 dr\right) g = \rho_L \frac{4}{3}\pi R^3 g$$

$$\Rightarrow \int_0^R \rho_0 4\pi\left(r^2 - \frac{r^4}{R^2}\right) dr$$

$$= \rho_0 4\pi\left(\frac{r^3}{3} - \frac{r^5}{5R^2}\right)_0^R$$

$$\Rightarrow \rho_L = \frac{2}{5}\rho_0$$

**27. (1)**

**Sol:** $W_{app} = mg - F_B$

$W_{app} = \rho Vg - \rho_w Vg$

$= (\rho - \rho_w)\, Vg$

$= (7\rho_w - \rho_w)\, Vg = 6\, \rho_w Vg$

**28. (1)**

**Sol:** By pascal law assertion is correct and since reason is one of the assumption considered in fluid. Due to this reason is correct explanation of assertion.

**29. (1)**

**Sol:** From archimedes principle statement-2 is correct explanation of statement-1

**30. (1)**

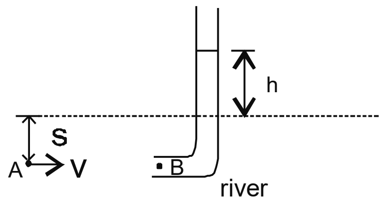
**Sol:** As the oil is poured till it covers the object completely, pressure in water at all points keeps on increasing. As a result upward force on object exerted by water increases and the object moves up for the given duration. Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

**31. (3)**

**Sol:** Use equation of continuity and concept "pressure is greater at lower and broader section".

**32. (2)**

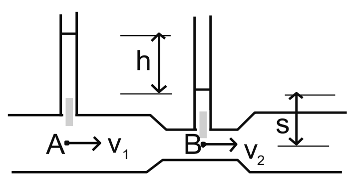
**Sol:** (I) Applying Bernoulli's equation between $A$ and $B$




$$\frac{p_a + s\rho g}{\rho} + \frac{v^2}{2} = \frac{p_a + s\rho g + h\rho g}{\rho}$$

$v^2 = 2gh$

(II) Applying Bernoulli's equation between $A$ and $B$



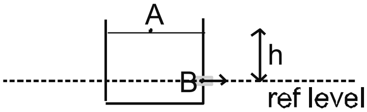
$$\frac{p_a + s\rho g + h\rho g}{\rho} + \frac{v_1^2}{2} = \frac{p_a + s\rho g}{\rho} + \frac{v_2^2}{2}$$

$\therefore \quad v_2^2 - v_1^2 = 2gh$

Also, from continuity eq, $v_2 = 2v_1$

$\therefore \quad v_1^2 = \frac{2gh}{3}$

(III) Applying Bernoulli's equation between $A$ and $B$




$$\frac{p_a}{\rho} + gh = \frac{p_a}{\rho} + \frac{v^2}{2}$$

$v^2 = 2gh$

(IV) $h = \frac{\omega^2 r^2}{2g}$

$\therefore \quad v^2 = \omega^2 r^2 = 2gh$

**33.** **(3)**

**Sol:** In a static fluid, pressure remains same at the same level, ie, pressure do not vary with $x$-coordinate.

**34.** **(1)**

**Sol:** $P = \rho(2h)g$

$\frac{F}{A_2} = \rho(2h)g$

$F_{base} = 2h\rho g A_2$

$F_{wall} = h\rho g\,[A_2 - A_1]$, at the level $x$

**35.** **(4)**

**Sol:** $x = 2\sqrt{H(H-h)}$

$x_1 = 2\sqrt{70\times 20}$

$x_2 = 2\sqrt{60\times 30}$

$x_3 = 2\sqrt{40\times 50}$

$x_4 = 2\sqrt{50\times 40}$

or $\quad x_3 = x_4 =$ maximum

$x_1 =$ minimum

**36.** **(3)**

**Sol:** Since solid ball floats in between the two liquids hence $\rho_1 < \rho_3 < \rho_2$

**37.** **(2)**

**Sol:** For equilibrium, weight should be balanced by buoyant force.
density of oil < density of water
and ball should be in between oil and water.

**38.** **(1)**

**39.** **(4)**

**Sol:** $\ell$ will decrease because the block moves up. $h$ will decrease because the coin will displace the volume of water ($V_1$) equal to its own volume when it is in the water whereas when it is on the block it will displace the volume of water ($V_2$) whose weight is equal to weight of coin and since density of coin is greater than the density of water so $V_1 < V_2$.

**40.** **(1)**

**Sol:** As the stream falls down, its speed will increase and cross-section area will decrease.
Thus, it will become narrow.
Similarly, as the stream will go up, speed will decrease and cross-section area will increase.
Thus, it will become broader.
Hence, Statement-1 is correct and Statement-2 is correct explanation also.

**41.** **(1)**

**Sol:** Molecule on the surface experiences a net force.

**42.** **(4)**

**43.** **(1)**

**Sol:** Surface tension is a property based on intermolecular force, at critical temperature intermolecular force is zero, hence surface tension is zero.

**44.** **(2)**

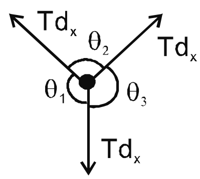
**Sol:** $W = T\Delta A$

$2 \times 10^{-4} = (60 - 30) \times 10^{-4}\, T \times 2$

$T = \frac{2}{30\times 2} = \frac{1}{30} = 3.3 \times 10^{-2}$ N/m

**45.** **(1)**

**Sol:** Look at a very small element at the junction of 3 bubbles.




All 3 forces of same magnitude (surface tension is same) are acting along the tangential directions on the small element.
Now by LAMI's theorem

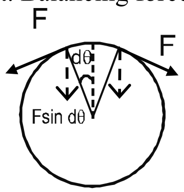
$\theta_1 = \theta_2 = \theta_3 = \frac{360}{3} = 120^\circ$

**46.** **(1)**

**Sol:** For an actue angle of contact, liquid rises.

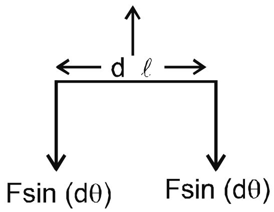
**47.** **(4)**

**Sol:** The small portion of film is approximately a straight part. Balancing forces on it:




$F$ denotes tension.

$T$ denotes surface tension.




$T \times 2\ (d\ell)$ is the surface tension force because 2 layers are formed.

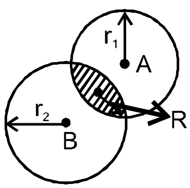
So, $2F \sin (d\theta) = T \times [2 \times R(2d\theta)]$

we get; for small $d\theta$, $\sin (d\theta) \approx d\theta$.

so, $F = T \times 2R$.

**48.** **(4)**

**Sol:** Equating pressures on the shaded portion:

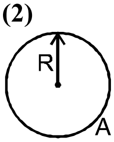


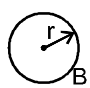

$$\frac{4\sigma}{r_1} - \frac{4\sigma}{r_2} = \frac{4\sigma}{R}$$

get, $R = \dfrac{r_2 r_1}{r_2 - r_1}$

**49.** **(2)**

**Sol:**




By equating volume:

$$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$$

get, $r = R/2$.

Now pressure difference in $A = \dfrac{4\sigma}{R}$

and that in $B = \dfrac{4\sigma}{R/2} = 2 \times$ pressure difference in $A$.

**50.** **(3)**

**Sol:**


$R = 4$ cm.

$r = 3$ cm.

$P_r = \dfrac{4\sigma}{r}$ ; $\qquad P_R = \dfrac{4\sigma}{R}$

{∵ outside is vacuum}

The two bubbles are coalescing;

so conserving the number of the moles.

$$\frac{P_r \cdot \frac{4}{3}\pi r^3}{T} + \frac{P_R \cdot \frac{4}{3}\pi R^3}{T} = \frac{P_{final} \times \frac{4}{3}\pi (r')^3}{T}$$

Putting, $P_{\text{final}} = \dfrac{4\sigma}{r'}$

we get, $r' = \sqrt{r^2 + R^2} = \sqrt{3^2 + 4^2} = 5$ cm.

**51.** **(2)**

**Sol:** Initial surface energy

$U_1 = 2 \times 4\pi R^2 T = 8\pi R^2 T$

Final surface energy,

$U_2 = 2 \times 4\pi(2R)^2 T = 32\ \pi R^2 T$

Hence, required energy $= 32\pi R^2 T - 8\pi R^2 T$

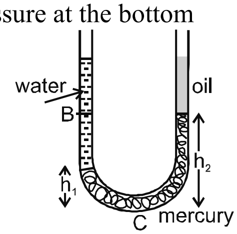
$= 24\pi R^2 T$

**52.** **(1)**

**Sol:** Since pressure inside bubble of smaller radius is more, the common interface should bulge inside bubble of larger radii. Hence statement-2 is correct explanation of statement-1.

**53.** **(3)**

**Sol.** Pressure at the bottom



$P_C = P_B + \rho_w g\,(h_2 - h_1) + \rho_{Hg} g h_1$

$= P_A + \rho_{Hg} g \cdot h_2$

$\Rightarrow \quad P_B - P_A$

$= \rho_{Hg} g\,(h_2 - h_1) - \rho_w g\,(h_2 - h_1)$

$= (\rho_{Hg} - \rho_\omega)\, g\,(h_2 - h_1) > 0.$

Hence statement 1 is correct and statement 2 is wrong.

**54.** **(3)**

**Sol:** The excess pressure inside the soap bubble in inversely proportional to radius of soap bubble i.e. $P \propto 1/r$, $r$ being the radius of bubble. It follows that pressure inside a smaller bubble is greater than that inside a bigger bubble. Thus, if these two bubbles are connected by a tube, air will flow from smaller bubble to bigger bubble and the bigger bubble grows at the expense of the smaller one.

**55.** **(4)**

**Sol:** $W = T\Delta A$

$= 0.03\,(2 \times 4\pi \times (5^2 - 3^2))\,10^{-4}$

$= 24\pi\,(16) \times 10^{-6}$

$= 0.384\,\pi \times 10^{-3}$ Joule

$= 0.4\,\pi$ mJ

**56.** **(3)**

**Sol:** $2.\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$R = 2^{1/3}$ r

$S.E. = T \cdot 4\pi R^2$

$T \cdot 4\pi\, 2^{2/3}\, r^2$

$T \cdot 2^{8/3}\, \pi r^2$

**57.** **(4)**

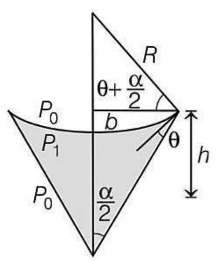
**Sol:** $2TL = mg$

$T = \frac{mg}{2L} = \frac{1.5 \times 10^{-2}}{2 \times 30 \times 10^{-2}} = \frac{1.5}{600}$

$= 0.025$ N/m

**58.** **(4)**

**Sol:** Using geometry:




$$\frac{b}{R_e} = \cos\left(\theta + \frac{\alpha}{2}\right)$$

Using Pressure method:

$$P_0 - \frac{2S}{R_c} + h\rho g = P_0$$

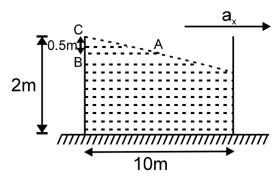
$$\Rightarrow \quad h = \frac{2S}{b\rho g}\cos(\theta + \alpha/2)$$

## Integer Type Questions (59 to 73)

**59.** **(20)**

**Sol:** $v = u + a_x t,\ a_x = \frac{v}{t}$

$\tan\theta = \frac{a_x}{g} = \frac{v}{tg} = \frac{0.5}{5}$ (in triangle $ABC$)

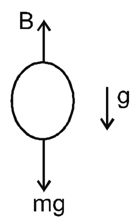



$\Rightarrow \quad t = \frac{10 \times 20}{10} = 20$ sec.

**60.** **(0)**

**Sol:** Equation of motion $mg - B = mg$

$\Rightarrow \quad B = 0$




**61.** **(5)**

**Sol:** Let $h$ = height of water column

then, $\rho_w g h + \rho_{Hg} g(10 - h) = \rho_{Cu} g 10$

$\Rightarrow \quad h + 13.6\,(10 - h) = 73$

$\Rightarrow \quad 63 = 12.6\,h \Rightarrow h = 5$ cm

**62.** **(1)**

**Sol:** From equation of continuity,

$(A \times 3) = (A \times 1.5) + (1.5\,A \times V)$

$\Rightarrow \quad V = 1$ m/s

**63. (3)**

**Sol.** $\rho Vg = 60$ …(i)

$(\rho - \sigma)\, Vg = 40$ …(ii)

but specific gravity = $\frac{\rho}{\sigma}$

dividing (i) & (ii) $\frac{\rho}{\sigma} = 3$.

**64. (3)**

**Sol:** $\rho$ = density of the body.

$\sigma$ = density of water

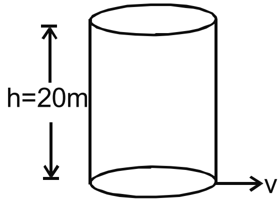
If two bodies are in equilibrium then.

$$\frac{m_1}{\rho_1}(\rho_1 - \sigma) = \frac{m_2}{\rho_2}(\rho_2 - \sigma)$$

$\frac{36}{9}(9-1) = \frac{48}{\rho_2}(\rho_2 - 1)$ solving we get $\rho_2 = 3$.

**65. (20)**

**Sol:** As, $P.E. = K.E.$




$$mgh = \frac{1}{2}mv^2$$

$$v = \sqrt{2gh}$$

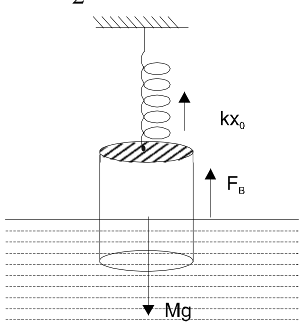
$$= \sqrt{2 \times 10 \times 20}$$

$= 20$ m/s

**66. (2)**

**Sol:** $kx_0 + F_B = mg$

$$kx_0 + \frac{L}{2}\sigma Ag = Mg$$




$$x_0 = \frac{Mg - \frac{\sigma LAg}{2}}{k} = \frac{Mg}{k}\left(1 - \frac{\sigma LA}{2M}\right)$$

**67. (20)**

**Sol:** Water fills the tube entirely in gravity less condition.

**68. (2)**

**Sol:** When body (sphere) is half immersed, then upthrust = weight of sphere

$$\Rightarrow \frac{V}{2} \times \rho_{liq} \times g = V \times \rho \times g \therefore \rho = \frac{\rho_{liq}}{2}$$

When body (sphere) is fully immersed then, Upthrust = wt. of sphere + wt. of water poured in sphere

$$\Rightarrow V \times \rho_{liq} \times g = V \times \rho \times g + V' \times \rho_{liq} \times g$$

$$\Rightarrow V \times \rho_{liq} = \frac{V \times \rho_{liq}}{2} + V' \times \rho_{liq}$$

$$\Rightarrow V' = \frac{V}{2}$$

So $n = 2$.

**69. (2)**

**Sol:** $F_{th} = \frac{\sqrt{2}dp}{dt} = \sqrt{2}v\frac{dm}{dt} = \sqrt{2}v\ [\rho A v]$

$$\left[\because L = \frac{d}{dt}Ax = Av\right]$$

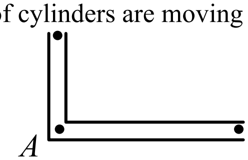
$= \sqrt{2}v\ [\rho L]$.

So $n = 2$.

**70. (2)**

**Sol:** No sliding $\Rightarrow$ pure rolling

Therefore, acceleration of the tube = $2a$ (since COM of cylinders are moving at '$a$')




$P_A = P_{atm} + \rho(2a)\, L$

(From horizontal limb)

Also; $P_A = P_{atm} + \rho g H$ (From vertical limb)

$$\Rightarrow a = \frac{gH}{2L}$$

So $n = 2$.

**71.** **(2)**

**Sol:** The time period of simple pendulum in air

$$T = t_0 = 2\pi\sqrt{\left(\frac{\ell}{g}\right)} \quad ...(i)$$

$\ell$, being the length of simple pendulum.

In water, effective weight of bob

$w'$ = weight of bob in air – upthrust

$\Rightarrow \quad \rho V g_{eff} = mg - m'g$

$= \quad \rho Vg - \rho' Vg = (\rho - \rho')\, Vg$

where $\rho$ = density of bob,

$\rho'$ = density of water

$$\therefore \quad g_{eff} = \left(\frac{\rho - \rho'}{\rho}\right)g = \left(1 - \frac{\rho'}{\rho}\right)g$$

$$\therefore \quad t = 2\pi\sqrt{\frac{\ell}{\left(1 - \frac{\rho'}{\rho}\right)g}} \quad ...(ii)$$

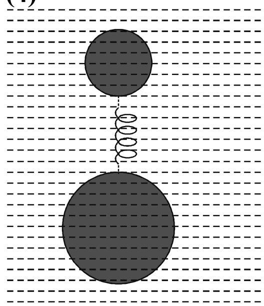
Thus, $\dfrac{t}{t_0} = \sqrt{\dfrac{1}{\left[\left(1 - \frac{\rho'}{\rho}\right)\right]}}$

$$= \sqrt{\left(\frac{1}{1 - \frac{1000}{(4/3)\times 1000}}\right)} = 2$$

$\Rightarrow \quad t = 2t_0$

**72.** **(4)**

**Sol:**



On small sphere

$$\frac{4}{3}\pi R^3(\rho)g + kx = \frac{4}{3}\pi R^3(2\rho)g \quad ...(i)$$

On second sphere (large)

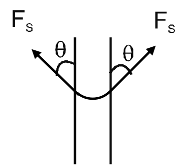
$$\frac{4}{3}\pi R^3(3\rho)g = \frac{4}{3}\pi R^3(2\rho)g + kx \quad ...(ii)$$

By equation (i) and (ii)

$$x = \frac{4\pi R^3 \rho g}{3k}$$

**73.** **(2)**

**Sol:** Since the contact angle in both cases remains the same.




$F_S \cos\theta = Mg$

$\Rightarrow \quad T \times 2\,\pi R\cos\theta = Mg \quad .......(i)$

After doubling the radius

$T \times 2\pi\,(2R)\cos\theta = M'g \quad .......(ii)$

$= M' = 2M.$

# THERMODYNAMICS & KINETIC THEORY OF GASES

## Single Option Correct Type Questions (01 to 61)

**1.** **(4)**

$\Delta\ell = 6.241 - 6.230 = 0.011$ cm

$\Delta\ell = \ell \cdot \alpha\Delta\theta$

$0.011 = 6.230 \times 1.4 \times 10^{-5}(\theta - 27)$

$\theta \approx 153.11$ nearest is 152.7ºC.

**2.** **(2)**

$mc\Delta T + mL = 40\% \text{ of } k.E$

$$m[125(327-127)+2.5\times10^4] = 0.4\times\frac{1}{2}\times mv^2$$

$$\Rightarrow [125\times200]+25\times10^3] = 0.2v^2$$

$$v^2 = \frac{2\times25\times10^3}{0.2}$$

$v = 5 \times 100$

$v = 500$ m/s

**3.** **(1)**

$m[540 + (100 - 31)] = 200 \times [31 - 25]$

$$m = \frac{1200}{609} \approx 2\ gm$$

**4.** **(3)**

Formula of thermal resistance, $R = \dfrac{\ell}{KA}$

$$R_{eq} = R_1 + R_2 = \frac{\ell}{K_1A} + \frac{\ell}{K_2A}$$

$$= \frac{\ell}{A}\left(\frac{1}{K_1} + \frac{1}{K_2}\right) = \frac{2\ell}{KA}$$

$$\Rightarrow K = \frac{2K_1K_2}{K_1 + K_2}$$

**5.** **(2)**

As $\Delta U$ is a state function i.e., it depends on initial and final position. In process $A$ and $B$ initial and final position are same.

$\therefore\ \Delta U_1 = \Delta U_2$

**6.** **(4)**

As $\Delta U = nR\Delta T$

For closed path,

$\Delta T = 0\ \therefore\ \Delta U = 0.$

**7.** **(1)**

$T \,\alpha\, P$ or $V$ = constant

$\therefore\ W = 0.$

**8.** **(2)**

$\Delta U = 0$ $\therefore\ T$ = constant

clearly, option (2) is correct.

**9.** **(4)**

In isothermal expansion

$T$ = constant $\Delta U = 0$ $W = \Delta Q$

$\therefore$ option (4) is correct.

**10.** **(2)**

In process $AB$

$T$ = constant

$P$ = increases, $P \,\alpha\, \dfrac{1}{V}$

or $V$ = decreases $\Delta Q = \Delta W$

$\Delta W = -\,ve.$

or $\Delta Q = -\,ve$

$\therefore$ heat is rejected out of the system.

**11.** **(4)**

$\Delta U = \Delta Q - \Delta W$ is same in both methods as it is a state function

**12. (3)**

$\Delta Q = \Delta W$

($T$ = constant; $\Delta U = 0$) if heat is released then $W = -ve$

**13. (4)**

$dQ = dW + dU$

$dQ = PdV + dU$

$dQ = nRdT + dU$

$$dQ = \frac{2dU}{f} + dU$$

$$\frac{dU}{dQ} = \frac{1}{\left(\frac{2}{f}+1\right)}$$

$$\frac{dU}{dQ} = \frac{5}{7}$$

**14. (2)**

As volume becomes constant

$\Rightarrow W = 0 \Rightarrow \Delta Q = \Delta U$

$\therefore$ As, $\Delta Q < 0$

$\therefore \Delta U < 0 \Rightarrow T\downarrow \therefore P\downarrow$

**15. (2)**

$B \rightarrow A$

$\Delta Q = 0$

$0 = -30 + \Delta U_{BA}$

$\Delta U_{BA} = 30\ J$

$\therefore \Delta U_{AB} = -\Delta U_{BA} = -30\ J$

**16. (3)**

For free expansion,

$\Delta U = 0$ or $\Delta T = 0$

$\therefore U$ or $T$ = constant

**17. (1)**

For free expansion,

$Q = 0$, $W = 0$, $\Delta U = 0$

**18. (1)**

As $W.D.$ in isobaric > $W.D.$ in Isothermal > $W.D$ in adiabatic

or $W_2 > W_1 > W_3$

Hence option (1) is correct.

**19. (4)**

For polytropic process ,

$$C = \frac{R}{\gamma-1} + \frac{R}{1-x}$$

$\Rightarrow$ As $PV^{\gamma} = K \Rightarrow$ Put $x = \gamma \therefore C = 0$

**20. (4)**

Area of cycle = $|W|$

$$= \frac{\pi(4-3)(4-2)}{2} + \frac{\pi(2-1)(3-2.5)}{2}$$

$$= \frac{2.5\pi}{2} = \frac{5\pi}{4}\ atm\ L$$

$$W = -\left(\frac{5\pi}{4}\right)\ atm\ L$$

**21. (2)**

Translation $K.E. = \frac{3}{2}\ nRT$

**22. (1)**

Process ...(i) is isobaric

$\Delta U_1 = \Delta Q - \Delta W$ = positive

process (ii) is isothermal

$\Delta U_2 = 0$

Process (iii) is adiabatic

$\Delta Q = 0$

$\Delta U_3 = -\Delta W$ = negative

$\therefore \Delta U_1 > \Delta U_2 > \Delta U_3$

**23. (3)**

$W.D.$ = π × Pressure Radius × volume Radius (area of ellipse)

$$W = \pi\left(\frac{P_2-P_1}{2}\right)\left(\frac{V_2-V_1}{2}\right)$$

$$= \frac{\pi}{4}\ (P_2 - P_1)\ (V_2 - V_1)$$

**24. (2)**

Slope $= -\gamma\ \frac{dP}{dV}$

As slope of $A$ > slope of $B$

$\therefore \gamma$ of $A > \gamma$ of $B$

or $A \rightarrow$ Helium

$B \rightarrow$ Hydrogen

**25. (3)**

$VP^n$ = constant

$dV\ P^n + VnP^{n-1}\ dP = 0$

$-\frac{VdP}{dV} = \frac{P}{n}$ = bulk modulus

**26.** **(1)**

For adiabatic process $PV^\gamma$ = constant

$V^\gamma \frac{dp}{dV} + p\gamma V^{\gamma-1} = 0$

$\frac{dp}{dV} = -\gamma \frac{p}{V}$

$\frac{dp}{p} = -\gamma \frac{dV}{V}$

**27.** **(1)**

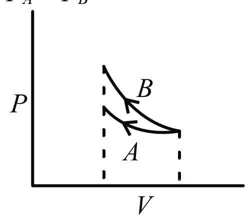
Heat given = 400 × 4.2 $J$ = 1680 $J$

$\Delta Q = \Delta W + \Delta U$

$\Delta U$ = 1680 – 1000 = 680 $J$

**28.** **(3)**

$P_A < P_B$




**29.** **(3)**

$B = -\frac{dp}{dV}.V$

isothermal bulk modulus of elasticity,

$B = +p = 1.5 \times 10^5\ N/m^2$

adiabatic bulk modulus of elasticity

$B = \gamma p = 1.4 \times 1.5 \times 10^5$

$= 2.1 \times 10^5\ N/m^2$

**30.** **(4)**

$\text{Process}_{1\to2}$ and $\text{Process}_{3\to4}$ are isochoric process.

$W_{12} = 0$

$W_{34} = 0$

$W_{23} = n R (T_3 - T_2) = 3 R (2400–800) = 4800 R$

$W_{41} = nR (T_1 - T_4) = 3 R (400–1200) = –2400 R$

$W = (4800 - 2400) R = 2400 R = 20\ kJ$

**31.** **(1)**

If the rate at which molecules of same mass having same rms velocity striking a wall decreases, then the rate at which momentum is imparted to the wall decreases. This results in lowering of pressure. Hence statement-2 is correct.

In statement-1 the rms velocity of gas remains same on increasing the volume of container by piston, since the given process is isothermal. Now the piston is at a greater distance from opposite wall and hence time taken by gas molecules from near the opposite wall to reach the piston will be more. Thus rate of molecules striking the piston decreases. Hence statement-1 is correct and statement-2 is correct explanation.

**32.** **(4)**

I-Q; II-R; III-P; IV-Q

As $Q = nCdT$

and $dT = \frac{Q}{nC}$

Therefore, molar heat capacity $C$ is the determining factor for rate of change of temperature of a gas, as heat is supplied to it. It is minimum for isochoric process of a monoatomic gas $\left(C_v = \frac{3}{2}R\right)$, resulting in greatest slope $\left(\frac{dT}{Q}\right)$ i.e. curve 1.

For isobaric process of monoatomic gas and isochoric process of diatomic gas, their heat capacities are same $\left(\frac{5}{2}R\right)$, therefore both are represented by curve 2.

For isobaric process of diatomic gas $C_p = \frac{7}{2}R$ that is represented by curve 3.

$Q$ axis represent isothermal process and $\Delta T$ axis represent adiabatic process.

**33.** **(2)**

I-P, S; II-P, Q, R, S; III-R, S; IV-S

(I) Adiabatic expansion

$dW > 0, dQ = 0, dU < 0$

(II) Adiabatic free expansion

Adiabatic means $dQ = 0$

free expansion means $dW = 0$

So, from $dQ = dU + dW \Rightarrow dU = 0$

(III) Isochoric cooling; isochoric means $dW = 0$,

cooling means $dQ < 0$, so $dU < 0$

$(\because dQ = dU + dW)$

(IV) Isobaric expansion $dW > 0$, $dU > 0$

First law is valid in every process

**34.** **(3)**

Using the relation

$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

$$\Rightarrow \frac{1+1}{\gamma - 1} = \frac{1}{\left(\frac{5}{3} - 1\right)} + \frac{1}{\left(\frac{7}{5} - 1\right)}$$

$$\Rightarrow \frac{2}{\gamma - 1} = \frac{3}{2} + \frac{5}{2}$$

$$\Rightarrow \frac{2}{\gamma - 1} = 4$$

$$\Rightarrow \gamma = \frac{3}{2}$$

$$\therefore \gamma = \frac{24}{16}$$

**35.** **(1)**

Heat cannot flow itself from a lower temperature to a body of higher temperature. This corresponds to second law of thermodynamics.

**36.** **(4)**

Given: $P \propto T^3$ .......(i)

In adiabatic process

$T^{\gamma} P^{1-\gamma} = \text{constant}$

$$T \alpha \frac{1}{P^{(1-\gamma)/\gamma}}$$

$T^{(\gamma/\gamma-1)} \propto P$ .......(ii)

Comparing equations (i) and (ii), we get

$$\therefore \frac{\gamma}{\gamma - 1} = 3$$

$3\gamma - 3 = \gamma$

$2\gamma = 3$

$$\frac{C_P}{C_P} = \gamma = \frac{3}{2}$$

**37.** **(3)**

Work does not characterize the thermodynamic state of matter, it is a path function gives only relationship between two quantities.

**38.** **(1)**

Meyer's formula is

$C_P - C_V = R$

and $\gamma = \frac{C_P}{C_V}$

Therefore, using above two relations, we find

$$C_V = \frac{R}{\gamma - 1}$$

For a mole of monoatomic gas, $\gamma = \frac{5}{3}$

$$\therefore C_V = \frac{R}{(5/3) - 1} = \frac{3}{2} R$$

When these two moles are mixed, then the heat required to raise the temperature to 1ºC is

$$\therefore C_V = \frac{3}{2} R + \frac{5}{2} R = 4R$$

Hence, for one mole, heat required is

$$= \frac{4R}{2} = 2R$$

$\therefore C_V = 2R$

$$\Rightarrow \frac{R}{\gamma - 1} = 2R$$

$$\Rightarrow \gamma = \frac{3}{2}$$

**Alternative :**

$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

Here, $n_1 = 1$, $n_2 = 1$, $\gamma_1 = \frac{5}{3}$, $\gamma_2 = \frac{7}{5}$

$$\therefore \frac{1+1}{\gamma - 1} = \frac{1}{(5/3) - 1} + \frac{1}{(7/5) - 1}$$

$\Rightarrow \frac{2}{\gamma-1} = \frac{3}{2} + \frac{5}{2}$

$\Rightarrow \frac{2}{\gamma-1} = \frac{8}{2}$

$\Rightarrow \frac{2}{\gamma-1} = 4$

$\Rightarrow \gamma = \frac{2}{4} + 1$

Hence, $\gamma = \frac{3}{2}$

**39.** **(2)**

In thermodynamic system, entropy and internal energy are state functions, entropy ($\Delta S$) can be zero for adiabatic process. Work done in adiabatic process may be non-zero.

**40.** **(3)**

There will be no change in number of moles if the vessels are joined by valve. Therefore, from gas equation

$PV = nRT$

$\Rightarrow \frac{P_1V_1}{RT_1} + \frac{P_2V_2}{RT_2} = \frac{P(V_1+V_2)}{RT}$

$\Rightarrow \frac{P_1V_1T_2 + P_2V_2T_1}{T_1T_2} = \frac{P(V_1+V_2)}{T}$

$\Rightarrow T = \frac{P(V_1+V_2)T_1T_2}{(P_1V_1T_2 + P_2V_2T_1)}$

Internal energy of the system remains same before and after opening of valve, so

$\frac{-n_1RT_1}{2} + \frac{-n_2RT_2}{2} = \frac{-(n_1+n_2)RT}{2}$

$\Rightarrow n_1T_1 + n_2T_2 = (n_1 + n_2)T$

$P_1V_1 + P_2V_2 = P(V_1 + V_2)$

Hence $T = \frac{(P_1V_1 + P_2V_2)T_1T_2}{(P_1V_1T_2 + P_2V_2T_1)}$

**41.** **(4)**

Statement (4) is wrong. Concept of entropy is associated with second law of thermodynamics.

**42.** **(2)**

$C_v = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$

For helium, $n_1 = \frac{16}{4} = 4$ and $\gamma_1 = \frac{5}{3}$

For oxygen, $n_2 = \frac{16}{32} = \frac{1}{2}$ and $\gamma_2 = \frac{7}{5}$

$C_{v_1} = \frac{R}{\gamma_1 - 1} = \frac{R}{\frac{5}{3}-1} = \frac{3}{2}R$

$C_{v_2} = \frac{R}{\gamma_2 - 1} = \frac{R}{\frac{7}{5}-1} = \frac{5}{2}R$

$\therefore\ C_v = \frac{4\times\frac{3}{2}R + \frac{1}{2}\times\frac{5}{2}R}{4+\frac{1}{2}} = \frac{6R + \frac{5}{4}R}{\frac{9}{2}}$

$= \frac{29R\times 2}{9\times 4} = \frac{29R}{18}$

Now $C_v = \frac{R}{\gamma-1}$

$\Rightarrow \gamma - 1 = \frac{R}{\frac{29}{18}R} + 1$

$\Rightarrow \frac{C_p}{C_v} = \frac{18}{19} + 1 = \frac{18+19}{29} = 1.62$

**43.** **(3)**

$PT^2 = C$

$\left(\frac{nRT}{V}\right)T^2 = C$

using $PV = nRT$ in $PT^2 = C$

$\Rightarrow\ T^3 \propto V$

Differentiating we get

$3\frac{dT}{T} = \frac{dV}{V}$

Coefficient of volume expansion ($\gamma$) =

$$\frac{1}{V}\frac{dV}{dT} = \frac{3}{T}$$

**44.** **(3)**

Equating internal energy,

$$1\times\frac{5}{2}RT_0 + 1\times\frac{3}{2}R\left(\frac{7}{3}T_0\right) = 1\times\frac{3}{2}RT_f + \frac{5}{2}RT_f$$

$$\Rightarrow T_f = \frac{3}{2}T_0$$

$\therefore$ (3) is correct.

**45.** **(1)**

For adiabatic,

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

Putting values, we get $\gamma = 1.4$, hence diatomic.

**46.** **(1)**

According to Meyer's relation,

$$C_p - C_v = \frac{R}{m} = \frac{R}{28}$$

**47.** **(1)**

From first law of thermodynamics,

$Q = \Delta U + W$

$50 = \Delta U + 20$

$\therefore \Delta U = U_f - U_i = 30$ cal

For path *ibf*,

or $Q = \Delta U + W$

$W = Q - \Delta U$

$= 36 - 30 = 6$ cal.

**48.** **(2)**

$n$ (moles) = 2

$A$ to $B$ is isobaric process

$W_{AB} = P\Delta V = nR\Delta T$

$= (2)(R)(200) = 400\ R$

$W_{AB} = 400\ R$

$(W_{AB})_{\text{on the gas}} = -400\ R$

**49.** **(1)**

$$V = \frac{m}{d} = \frac{1}{4}m^3$$

$kE$ for diatomic,

$$kE = \frac{5}{2}PV = \frac{5}{2}\times 8\times 10^4 \times \frac{1}{4} = 5\times 10^4\ J$$

**50.** **(2)**

$\Delta Q = M\,S\,\Delta T$

$= 100\times 10^{-3}\times 4184\times 20 = 8.4\times 10^3$

$\Delta Q = 8.4\ kJ$, $\Delta W = 0$

$\Delta Q = \Delta U + \Delta W$

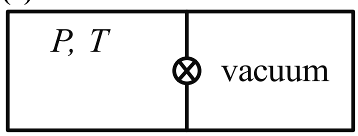
$\therefore \Delta U = 8.4\ kJ.$

**51.** **(4)**

$$\frac{1}{2}Mv^2 = C_V.\Delta T \Rightarrow \frac{1}{2}Mv^2 = \frac{R}{\gamma - 1}.\Delta T$$

$$\Delta T = \frac{M.v^2(\gamma - 1)}{2R} = \frac{(\gamma - 1)Mv^2}{2R}$$

**52.** **(4)**




It is the free expansion

So, $T$ remain constant

$P_1V_1 = P_2V_2$

$$P\frac{V}{2} = P_2(V)$$

$$P_2 = \left(\frac{P}{2}\right).$$

**53.** **(1)**

$$\eta = \frac{p_0v_0}{\frac{f}{2}(p_0v_0) + \frac{f}{2}(2p_0)v_0 + 2p_0v_0}$$

$$= \frac{1}{\frac{3}{2} + 3 + 2}$$

$$= \frac{200}{13} = 15.4\%$$

**54.** **(4)**

$$\Delta U = \frac{f}{2}nR\Delta T$$

For cyclic process $\Delta U = 0$

For process $CA$

$$\Delta U = 1\times\frac{5}{2}R(-200) = -500\ R$$

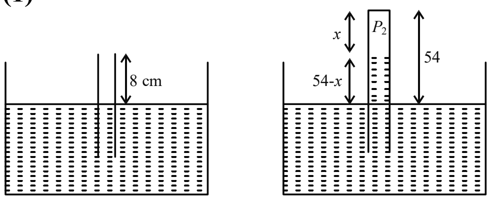
For process $AB$ : -

$$\Delta U = 1\times\frac{5}{2}R\times(+400) = 1000\ R$$

For process $BC$ -

$$\Delta U = 1 \times \frac{5}{2}R \times (-200) = -500R$$

**55. (1)**




For air trapped in tube $P_1V_1 = P_2V_2$

$P_1 = P_{atm} = \rho g76$

$V_1 = A.\ 8$ ($A$ = area of cross section)

$P_2 = P_{atm} - \rho g\,(54 - x) = \rho g\,(22 + x)$

$V_2 = A.\ x$

$\rho g76.\ A8 = \rho g(22 + x)\ Ax$

$x^2 + 22x - 76 \times 8 = 0$

$\Rightarrow x = 16\ cm.$

**56. (3)**

$$p = \frac{1}{3}\frac{U}{V}$$

$$\frac{nRT}{V} \propto \frac{1}{3}T^4$$

$VT^3$ = const

$\frac{4}{3}\pi R^3\ T^3$ = constant

$TR$ = constant

$$T \propto \frac{1}{R}$$

**57. (3)**

since $\tau = \dfrac{1}{n\pi\sqrt{2}v_{rms}d^2}$

$n \propto \dfrac{1}{V}$ and $v_{rms} \propto \sqrt{T}$

$$\Rightarrow \tau \propto \frac{V}{\sqrt{T}}$$

Since $TV^{\gamma-1}$ = constant $\Rightarrow$ $\tau \propto V^{\frac{\gamma+1}{2}}$

**58. (1)**

$$C = C_V + \frac{R}{1-n}$$

$$C - C_V = \frac{C_p - C_v}{1-n}\ ;\ 1 - n = \frac{C_p - C_v}{C - C_v}$$

$$n = 1 - \frac{C_p - C_v}{C - C_v} = \frac{C - C_p}{C - C_v}$$

**59. (4)**

$$P - P_0 = -\frac{P_0}{V_0}(V - 2V_0)$$

$$P = 3P_0 - \frac{P_0V}{V_0} \qquad \text{......(1)}$$

$$\frac{nRT}{V} = 3P_0 - \frac{P_0}{V_0}V$$

$$nRT = 3P_0V - \frac{P_0}{V_0}V^2$$

differentiate w.r.t. Volume

$$3P_0 - \frac{2P_0}{V_0}V = 0$$

$$V = \frac{3V_0}{2}$$

Put in (1)

$$P = 3P_0 - \frac{P_0}{V_0}\left(\frac{3V_0}{2}\right) = \frac{3P_0}{2}$$

$PV = nRT$

$$\frac{9P_0V_0}{4} = nRT$$

$$T = \frac{9P_0V_0}{4\ nR}$$

**60. (4)**

$C = (M_0)s$

For $H_2$ as well as $N_2$

$C_P - C_V = R$

$(M_0)\, S_P - (M_0)\, S_V = R$

$$S_P - S_V = \frac{R}{M_0}$$

For $H_2$ gas

$$S_P - S_V = \frac{R}{2} = a$$

For $N_2$ gas

$$S_P - S_V = \frac{R}{28} = b$$

So $\frac{a}{b} = \frac{\frac{R}{2}}{\frac{R}{28}} = 14 \qquad \Rightarrow a = 14b$

**61. (3)**

Here length increases by 0.02%

$$\Delta \ell = \ell \alpha \Delta T \ \Rightarrow \frac{\Delta \ell}{\ell} = \alpha \Delta T = 0.02\%$$

$$\Delta \rho = -\rho 3 \alpha \Delta T$$

$$\Rightarrow \left| \frac{\Delta \rho}{\rho} \right| = 3\alpha \Delta T = 3(0.02\%) = 0.06\%$$

## *Integer Type Questions (62 to 76)*

**62. (90)**

Energy released by water = 0.3 × 25 × 4200 = 31500 J let m kg ice melts m × 3.5 × $10^5$ = 31500

$$m = \frac{31500 \times 10^{-5}}{3.5}$$

$m = 0.09$ kg = 90 gm

$x = 90$

**63. (8)**

Given: $y = 2 \times 10^{11}$ Nm$^{-2}$

$\alpha = 10^{-5}$ °C$^{-1}$

Force = $Ay\alpha\Delta T$

Force = $(10 \times 10^{-4}) \times (2 \times 10^{11}) \times 10^{-5} \times 400$

$F = 8 \times 10^5$ N

$x \times 10^5 = 8 \times 10^5$

Thus, the value of $x = 8$

**64. (21)**

It is given that,

$L_1 = 4$ cm, $L_2 = 2.5$ cm, $K_1 = K$, $K_2 = 2$ K

$$K_{eq} = \frac{L_1 + L_2}{\frac{L_1}{K_1} + \frac{L_2}{K_2}} = \frac{4 + 2.5}{\frac{4}{K} + \frac{2.5}{2K}}$$

$$K_{eq} = \frac{6.5}{\frac{8 + 2.5}{2K}} = \frac{6.5}{10.5} \times 2K$$

$$= \frac{13 \times 2}{21} K = \left(1 + \frac{5}{21}\right) K$$

By equating the above equation with

$$k_{eq} = \left(1 + \frac{5}{\alpha}\right)$$

We get, $\alpha = 21$

**65. (4)**

$PV = NkT$

$$E = \frac{3}{2}\, kT$$

$$N = \frac{3PV}{2E} \ (P = h\rho g) = 4 \times 10^{18}$$

**66. (28)**

Given, $rms$ speed $= \sqrt{\frac{\alpha + 5}{\alpha}} \times$ average speed

$$\Rightarrow \sqrt{\frac{3RT}{M}} = \sqrt{\frac{\alpha+5}{\alpha}}\sqrt{\frac{8}{\pi}\frac{RT}{M}}$$

$\Rightarrow \alpha = 28$

**67. (25)**

First law of thermodynamics

$\Delta Q = \Delta U + \Delta W$

$$Q = \Delta U + \frac{Q}{5} \Rightarrow \Delta U = \frac{4Q}{5}$$

$\Delta U = nC_v\Delta T$

$$\Rightarrow \frac{4Q}{5} = \frac{5R}{2}\Delta T \Rightarrow \Delta T = \frac{8Q}{25R}$$

$$\therefore Q = nC\Delta T = 1\times C\times\frac{8Q}{25R} \Rightarrow C = \frac{25R}{8} \Rightarrow x = 25$$

**68. (3)**

$$\left(0.1\times\frac{3}{2}R\times 200\right)+\left(0.05\times\frac{3}{2}R\times 400\right) = 0.15\times\frac{5}{2}R.T_f$$

$$\Rightarrow (20+20) = 0.15\,T_f$$

$$\Rightarrow T_f = \frac{40}{15}\times 100 = 266.67$$

**69. (100)**

Heat absorbed in cyclic process = Work done = area of circle of radius 10 = 100 $\pi$ *Joule*

**70. (14)**

$$V_{\text{rms}} \text{ for } N_2 = \sqrt{\frac{3KT}{28}} = \sqrt{\frac{3\times K\times 573}{28}}$$

$$v_{\text{rms}} \text{ for } H_2 = \sqrt{\frac{3KT_1}{2}}$$

$v_{\text{rms}}$ for $N_2$ = $V_{\text{rms}}$ for $H_2$

$$\therefore \frac{3KT_1}{2} = \frac{3K\times 573}{28} \Rightarrow T_1 = \frac{573}{14}K$$

$T_1$ = 40.93 kelvin

**71. (400)**

Given, $T$ = 27°C = 300 $K$, $P$ = 1 atm = $10^5$ $N/m^2$

$v_{\text{rms}}$ = 200 $m/s$

As we know, $\frac{200}{v'_{rms}} = \sqrt{\frac{T}{T'}} = \sqrt{\frac{300}{400}}$

$$v'_{rms} = 200\times\frac{2}{\sqrt{3}}$$

On comparing with $\frac{x}{\sqrt{3}}ms^{-1}$, we get $x$ = 400.

**72. (255)**

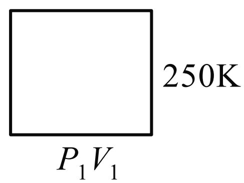
The common equilibrium pressure existing in the mixture

$$P = \frac{P_1V_1+P_2V_2}{V_1+V_2} = \frac{2\times 4.5\times 5.5}{10}$$

$$= \frac{9+16.5}{10} = 25.5\times 10^{-1}\ atm$$

**73. (5)**

Using, $PV = nRT$, we have




$$n_0 = \frac{P_1V_1}{R\times 250}$$

$$n' = 0.75\,n_0 + 0.5n_0$$

= 1.25 $n_0$ moles

$$P_2 \times 2V_1 = (1.25)\frac{P_1V_1}{R\times 250}\times R\times 2000$$

$$\Rightarrow \frac{P_2}{P_1} = 5$$

**74. (25)**

Mean free path, $\lambda \propto \frac{1}{d^2}$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{d_2^2}{d_1^2} = \frac{25}{100} = 25\times 10^{-2}$$

**75. (12)**

$V_{\text{rms}}$ speed of the molecule of a gas, $V_{rms} = \sqrt{\frac{3RT}{M}}$

$V_{rms} \propto \sqrt{T}, T_1 = 127°C = 400\ K$

$V_{rms1} = 2V_{rms}, m = 0.056\ kg = 56g$

$T_2 = 4T_1 = 4 \times 400 = 1600\ K$

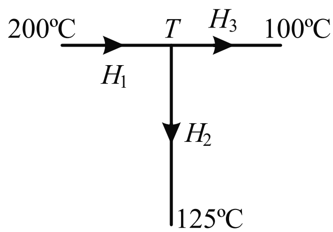
$$Q = nC_v\Delta T = \left(\frac{m}{M}\right)C_v\Delta T = \left(\frac{56}{28}\right)\frac{5}{2}R\Delta T$$

$$= \left(\frac{56}{28}\right)\frac{5}{2}R\Delta T$$

$$= 2\times\frac{5}{2}\times 2\times 1200 = 12\times 10^3\ \text{cal} = 12\ k\ \text{cal}$$

**76. (2)**

At point $T$




$$\Rightarrow H_1 = H_2 + H_3$$

$$\Rightarrow \frac{200-T}{5} = \frac{T-125}{10} + \frac{T-100}{5}$$

$$\Rightarrow T = 145^o C \Rightarrow H_2 = \frac{145-125}{10} = 2W$$

# OSCILLATIONS & WAVES

## Single Option Correct Type Questions (01 to 60)

**1.** **(1)**

**Sol:** The speed of sound in air is $v = \sqrt{\frac{\gamma RT}{M}}$

$\frac{\gamma}{M}$ of $H_2$ is greatest in the given gases, hence speed of sound in $H_2$ shall be maximum.

**2.** **(3)**

**Sol:** The pitch of a sound is our ear's response to the frequency of the sound waves. The pitch is the reason behind the shrillness in voices of different individuals.

The quality of a sound is that characteristics that enables us to distinguish one sound from another having the same pitch and loudness.

The loudness of a sound is determined by its amplitude.

**3.** **(1)**

**Sol:** When a sound wave gets reflected from a rigid boundary, the particles at the boundary are unable to vibrate. Thus, a reflected wave is generated which interferes with the oncoming wave to produce zero displacement at the rigid boundary. At these points (zero displacement), the pressure variation is maximum. Thus, a reflected pressure wave has the same phase as the incident wave.

**4.** **(4)**

**Sol:** Antinodes are the points on stationary wave with maximum displacement and maximum pressure change. Nodes are the point of zero displacement of particle and here pressure is also minimum.

**5.** **(2)**

**Sol:** $\Delta x$ = Path difference between 2 waves reaching $B$.

Path difference $(\Delta x) = \pi r - 2r$

$\Delta x = r(\pi - 2)$

for constructive interference $n\lambda = \Delta x$

$n\lambda = r(\pi - 2)$ $\quad\quad$ $\lambda = \frac{r(\pi - 2)}{n}$

$n = \frac{v}{\lambda} = \frac{vn}{r(\pi - 2)}$

**6.** **(1)**

**Sol:** Due to large speed of sound there is very little time to transfer sound wave from one point to other point so no heat exchange occur.

**7.** **(1)**

**Sol:** In sound waves, pressure and the density equations are 90° out of phase of displacement equation.

If the displacement equation is $y = A\cos(kx - \omega t)$

then, the pressure equation is $\Delta p = BAK\sin(kx - \omega t)$

and, the density equation is $\Delta\rho = \frac{BAK}{v^2}\sin(kx - \omega t)$

Where, $A$ = amplitude of displacement wave, $B$ = bulk modulus, $K$ = wave number, $v$ = wave velocity.

Thus, we can see that when displacement will be zero at the displacement node, the pressure and density of gas above and below average/normal is maximum. So, the assertion is true.

When particles on the opposite sides of the displacement node approach each other, the gas between them is compressed and pressure rises so that at the displacement node gas undergoes. The maximum amount of compression. This is the reason which causes the pressure and density to be maximum above or below the normal level. Thus, the reason is true and is the correct explanation of the assertion.

**8.** **(1)**

**Sol:** We know $v = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{\gamma P}{d}}$

**9.** **(4)**

**Sol:** $V_{O_2} = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{7}{5}\frac{RT}{32}} = 460$

$$V_{He} = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{\frac{5}{3}RT}{4}}$$

$$= \sqrt{\frac{5}{12}\times 460\times 460\times 32\times\frac{5}{7}} = 1419 \text{ m/s}$$

**10.** **(3)**

**Sol:** $f_c = f_0$

(both first overtone)

or $3\left(\frac{v_c}{4L}\right) = 2\left(\frac{v_0}{2L_0}\right)$

$$\therefore \quad L_0 = \frac{4}{3}\left(\frac{v_0}{v_c}\right)L = \frac{4}{3}\sqrt{\frac{\rho_1}{\rho_2}}L$$

as $v \propto \frac{1}{\sqrt{\rho}}$.

**11.** **(2)**

**Sol:** Fundamental frequency of close organ pipe

$= \frac{V_1}{4\ell_1}$

Second harmonic frequency of string $= \frac{2V_2}{2\ell_2}$

So, $\frac{V_1}{4\ell_1} = \frac{V_2}{\ell_2} = \frac{320}{4\times 0.8} = \frac{1}{0.5}\sqrt{\frac{50}{\mu}}$

$$2500 = \frac{50}{\mu}$$

$$\mu = \frac{1}{50} = \frac{m}{0.5}$$

$m = 10$ gm.

**12.** **(2)**

**Sol:** $\frac{V}{4(\ell + e)} = \text{f}$

$$\Rightarrow \ell + \text{e} = \frac{V}{4f}$$

$$\Rightarrow \ell = \frac{V}{4f} - e$$

here e = (0.6)r = (0.6) (2) = 1.2 cm

so $\ell = \frac{336\times 10^2}{4\times 512} - 1.2 = 15.2$ cm

**13.** **(1)**

**Sol:** $V_{CD} = \sqrt{\frac{3.2g}{8\times 10^{-3}}} = \sqrt{4000} \cong 63$ m/sec

$$V_{AB} = \sqrt{\frac{6.4g}{10\times 10^{-3}}} \cong \sqrt{6400} \cong 80 \text{ m/sec}$$

**14.** **(2)**

**Sol:** $R_A = \frac{V}{V_A}$ , $R_B = \frac{V}{V_B}$

as $V_A > V_B$ , $R_A < R_B$

**15.** **(4)**

**Sol:** The tension in the string over pulleys is the same in each part say = $T$. Thus the tension in the string $CD = 2T$.

$V \propto \sqrt{T}$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{T/2}{T}} = \frac{1}{\sqrt{2}}$$

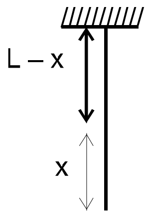
**16.** **(3)**

**Sol:** The new wave formed has the resultant amplitude which is equal to the vector sum of their individual amplitudes

$a_{res} = = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

**17.** **(2)**

**Sol:**




For the pulse;

$v = \sqrt{\frac{\mu x g}{\mu}} = \sqrt{xg} = \frac{dx}{dt}$

$\frac{dx}{dt} = \sqrt{xg} \Rightarrow \int_o^x \frac{dx}{\sqrt{x}} = \sqrt{g}\int_o^t dt$

$t = 2\sqrt{\frac{x}{g}}$ …(1)

for the particle

$L - x = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2(L-x)}{g}}$ …(2)

from (1) & (2) we get

$\Rightarrow \quad x = \frac{L}{3}$ from the bottom

**18.** **(1)**

**19.** **(1)**

**20.** **(2)**

**Sol:** The equations can be checked by taking value of time ($t$) equal to zero.

**21.** **(2)**

**Sol:** Maximum wavelength is when string has only 1 antinode and at time $\ell = \frac{\lambda}{2}$

$\frac{\lambda}{2} = \ell$

$\lambda = 80$ cm

**22.** **(4)**

**Sol:** By equation

$f = \frac{1}{0.04}$ and $\lambda = 0.5$

$\Rightarrow \quad v = \frac{1}{0.04} \times 0.5 = \frac{25}{2}$

by $v = \sqrt{\frac{T}{\mu}}$

$\Rightarrow \left(\frac{25}{2}\right)^2 = \frac{T}{0.04} \Rightarrow T = \frac{625}{4} \times 0.04$

$T = 6.25$ N

**23.** **(4)**

**Sol:** $Y = A\sin(\omega t - kx) + A\sin(\omega t + kx)$

$Y = 2A\sin\omega t\cos kx$ (standing wave)

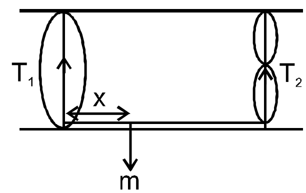
For nodes $\cos kx = 0$

$\frac{2\pi}{\lambda}.x = (2n+1)\frac{\pi}{2}$

$\therefore \quad x = \frac{(2n+1)\lambda}{4}$ , $n = 0,1,2,3,........$

**24.** **(1)**

**Sol:**




$\frac{\lambda_1}{2} = \ell \Rightarrow \lambda_1 = 2\ell$

$\lambda_2 = \ell \Rightarrow \therefore \frac{\lambda_1}{\lambda_2} = 2$

$\frac{v_1/f}{v_2/f} = 2$

$\frac{v_1}{v_2} = 2 = \sqrt{\frac{T_1/\mu}{T_2/\mu}} \Rightarrow \frac{T_1}{T_2} = 4$ ——(1)

Now moment about $P$: $T_1 x = T_2(\ell - x)$

$\ell - x = 4x \qquad x = \ell_l/5$

**25.** **(2)**

**Sol:** After 2 sec. distance between pulses

$D = D_1 + D_2 = (2 \times 2) - (2 \times 2) = 0$

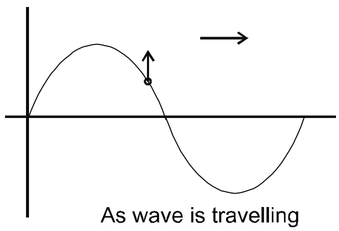
As their amplitude is same

$\therefore$ P.E. = 0

$\therefore$ Total energy will be purely kinetic

**26.** **(1)**

**Sol:**




$v = \omega\sqrt{A^2 - y^2}$

$v_P = 2\pi f\sqrt{A^2 - y^2}$

$v_P = 2\pi\left(\frac{V}{\lambda}\right)\sqrt{A^2 - y^2} = \frac{2\pi}{0.5} \times 0.1$

$\sqrt{(0.1)^2 - (0.05)^2}$

$v_P = \frac{\sqrt{3}\pi}{50}\hat{j}$ m/s

**27.** **(1)**

**Sol:** $y = a\sin(\omega t - kx)$

$y = b\cos(\omega t - kx) = b\sin(\omega t - kx + \frac{\pi}{2})$

So phase difference is of $\pi/2$

**28.** **(2)**

**Sol:** $T = 2\pi\sqrt{\frac{m}{k}}$, $F = kx$

We know, $T = 6.4$ N, $x = 0.1$ m, $t = \pi/4$ sec.

Solving we get $m = 1$kg

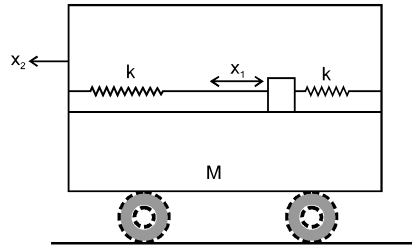
**29.** **(2)**

**Sol:** $k_{eq} = \frac{(2k)(2k)}{2k + 2k} + k + 2k = 4k$

$f = \frac{1}{2\pi}\sqrt{\frac{k_{eq}}{M}} = \frac{1}{2\pi}\sqrt{\frac{4k}{M}}$

**30.** **(3)**

**Sol:** Let displacement of block is $x_1$ and of cart is $x_2$ as shown




by linear momentum conservation

$mv_1 = Mv_2 \qquad \Rightarrow v_2 = \frac{mv_1}{M}$

$\frac{dx_2}{dt} = \frac{mdx_1}{Mdt}$ So $x_2 = \frac{mx_1}{M}$

For 1st particle. Force equation can be written as

$F = 2k(x_1 + x_2) = m\omega^2 x_1$

$2k\left(x_1 + \frac{m}{M}x_1\right) = m\omega^2 x_1$

$\Rightarrow \omega^2 = 2k\left(\frac{M + m}{Mm}\right)$

So, $T = 2\pi\sqrt{\frac{Mm}{2k(M + m)}}$

**31.** **(1)**

**Sol:** Given $F = -k\sqrt{x}$ ——(1)

For SHM $F = -k_1 x$ ——(2)

From eqn. (1) and (2) $k = k_1\sqrt{x}$

$\therefore F = -k_1\sqrt{x}\sqrt{x} = -k_1 x$.

Here $k = k_1\sqrt{x} \qquad \Rightarrow k \propto \sqrt{x}$

As $x$ increases $k$ increases.

**32.** **(4)**

**Sol:** $x = x_0 \sin^2 \omega t = \frac{x_0(1 - \cos 2\omega t)}{2}$

So, $A = \frac{x_0}{2}$

Time period $= \frac{2\pi}{\omega_1} = \frac{2\pi}{2\omega} = \pi/\omega$

**33.** **(3)**

**Sol:** $T = 2\pi\sqrt{\frac{\ell}{g_{\text{eff}}}}$ ; $g_{\text{eff}} = g - \frac{qE}{m}$ i.e.

$$T = 2\pi\sqrt{\frac{\ell}{g - \frac{qE}{m}}}$$

**34.** **(4)**

**Sol:** $\frac{1}{2}mv^2 = \frac{1}{2}k_1x_1^2$

$\frac{1}{2}mv^2 = \frac{1}{2}k_1 x_2^2$

$k_1x_1^2 = k_2x_2^2$

$\frac{x_1}{x_1} = \sqrt{\frac{k_2}{k_1}}$

**35.** **(3)**

**Sol:** Given

$y = 4\cos^2(\frac{t}{2})\sin(1000t)$

Using $2\cos^2\theta = 1+\cos2\theta$, we get

$y = 2\times2\cos^2(\frac{t}{2})\sin(1000t)$

$y = 2\times(1+\cos t)\sin(1000t)$

$y = 2\sin(1000t) + 2\sin(1000t)\cos t$

$y = 2\sin(1000t) + \sin(1000t + t) + \sin(1000t - t)$

[Using $2\sin A\cos B = \sin(A+B) + \sin(A-B)$]

$y = 2\sin(1000t) + \sin(1001t) + \sin999t$

$y = \sin(1000t) + \sin(1000t) + \sin(1001t) + \sin(999t)$

Thus, the given expression is composed of four SHMs, out of which two are the same. This means that the given expression is the result of 3 independent harmonics.

**36.** **(4)**

**Sol:** PE is related to reference. Only when PE at mean position is taken zero, the assertion is true.

**37.** **(4)**

**Sol:** The mean position of the particle in statement-1 is $x = -\frac{b}{a}$ and the force is always proportional to displacement from this mean position. The particle executes SHM about this mean position. Hence statement-1 is false

**38.** **(3)**

**Sol:** $v_m = A\omega$

$\Rightarrow A = \frac{v_m}{\omega} = \frac{2\pi}{2\pi} \times (0.2) = 0.20\text{m}$

$T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow m = \frac{T^2k}{4\pi^2} = 0.2$ kg

At $t = 0.1$, acc. is maximum

$\Rightarrow = -\omega^2A = -200$ m/s$^2$

Maximum energy $= \frac{1}{2}mv_m^2 = 4$ J

**39.** **(3)**

**Sol:** Kinetic energy of particle of mass m in SHM at any point is

$= \frac{1}{2}m\omega^2(a^2 - x^2)$

and potential energy $= \left(\frac{1}{2}m\omega^2x^2\right)$

where a is amplitude of particle and x is the distance from mean position.

So, at mean position, x = 0

K.E. $= \frac{1}{2}m\omega^2a^2$ (maximum)

P.E. = 0 (minimum)

**40.** **(4)**

**Sol:** $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T \propto \sqrt{\ell}$

$\frac{T_2}{T_1} = \sqrt{\frac{\ell_2}{\ell_1}} = \sqrt{1.21} \Rightarrow T_2 = 1.1T_1$

$\therefore$ % change $= \frac{T_2 - T_1}{T_1}\times100$

$= \frac{1.1T_1 - T_1}{T_1}\times100 = 10\%$

**41.** **(2)**

**Sol:** Time period of spring

$T = 2\pi\sqrt{\left(\frac{m}{k}\right)}$

$k$, being the force constant of spring.

For first spring

$$t_1 = 2\pi\sqrt{\left(\frac{m}{k_1}\right)} \quad \ldots(i)$$

For second spring

$$t_2 = 2\pi\sqrt{\left(\frac{m}{k_2}\right)}$$

The effective force constant in their series combination is

$$k = \frac{k_1k_2}{k_1+k_2}$$

∴ Time period of combination

$$T = 2\pi\sqrt{\left[\frac{m(k_1+k_2)}{k_1k_2}\right]}$$

$$\Rightarrow \quad T^2 = \frac{4\pi^2 m(k_1+k_2)}{k_1k_2} \quad \ldots(ii)$$

From equations (i) and (ii), we obtain

$$t^2_1 + t^2_2 = 4\pi^2\left(\frac{m}{k_1}+\frac{m}{k_2}\right) \quad \ldots(iii)$$

$$\Rightarrow \quad t^2_1 + t^2_2 = 4\pi^2\,\mathrm{m}\left(\frac{1}{k_1}+\frac{1}{k_2}\right)$$

$$\Rightarrow \quad t^2_1 + t^2_2 = \left(\frac{4\pi^2 m(k_1+k_2)}{k_1k_2}\right)$$

from equation (ii) and (iii) we have

∴ $t^2_1 + t^2_2 = T^2$

**42.** **(2)**

**Sol:** $$\frac{d^2x}{dt^2} = -\alpha x \quad \ldots(i)$$

We know $a = \dfrac{d^2x}{dt^2} = -\omega^2 x \quad \ldots(ii)$

From Eq. (i) and (ii), we have

$\omega^2 = \alpha$

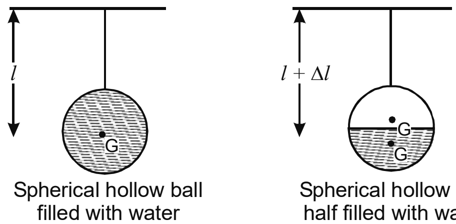
$\omega = \sqrt{\alpha}$

or $\dfrac{2\pi}{T} = \sqrt{\alpha}$

∴ $T = \dfrac{2\pi}{\sqrt{\alpha}}$

**43.** **(1)**

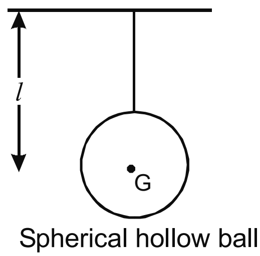
**Sol:** $T < T_1 > T_2$




G → Centre of gravity when water is fully filled.

G′ → Centre of gravity when water is half filled.

$T = 2\pi\sqrt{\dfrac{l}{g}}$ $\qquad T_1 = 2\pi\sqrt{\dfrac{l+\Delta l}{g}}$




$T_2 = 2\pi\sqrt{\dfrac{l}{g}}$

and $T_1 > T_2$

Hence, time period first increases and then decreases to the original value.

**44.** **(3)**

**Sol:** The coin will leave contact at any point when the acceleration of platform is more than $g$ and in the same direction of $g$. At the highest point both of the conditions are satisfied.

**45.** **(4)**

**Sol:** $f=\frac{1}{2\pi}\sqrt{\frac{k_1+k_2}{m}}$,

$f_{new}=\frac{1}{2\pi}\sqrt{\frac{4k_1+4k_2}{m}}=2f.$

**46.** **(1)**

**Sol:** $K_{av}=\frac{\int_0^{T/4}\frac{1}{2}m[a\omega\cos(\omega t)]^2dt}{\int_0^{T/4}dt}$

$=\frac{ma^2\omega^2}{2.\frac{T}{4}}\int_0^{T/4}\cos^2(\omega t)dt$

$=\frac{2ma^2\omega^2}{T}.\frac{T}{8}=\frac{1}{4}ma^2\omega^2$

$=\frac{1}{4}\text{ma}^2(2\pi f)^2=\pi^2\text{ma}^2f^2.$

**47.** **(4)**

**Sol:** C.O.L.M.

$MV_{\max}=(m+M)V_{\text{new}},\ V_{\max}=A_1\omega_1$

$V_{\text{new}}=\frac{MV_{\max}}{(m+M)}$ … (i)

$V_{\text{new}}=A_2.\omega_2$ … (ii)

from (i) & (ii) we get:-

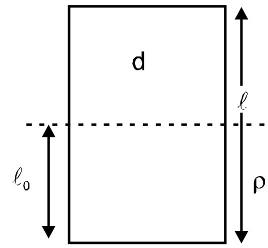
$\frac{M.A_1}{(m+M)}\sqrt{\frac{K}{M}}=A_2\sqrt{\frac{K}{(m+M)}}$

$A_2=A_1\sqrt{\frac{M}{(m+M)}}$

$\frac{A_1}{A_2}=\left(\frac{m+M}{M}\right)^{1/2}$

**48.** **(1)**

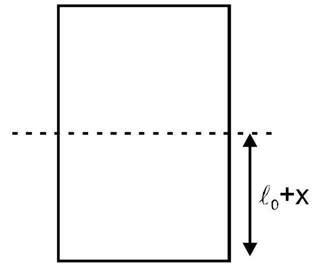
**Sol:**




At equilibrium

$F_b=mg$

$\rho A\ell_0g=dA\ell g$ ..........(i)




Restoring force,

$F=mg-F_b'$

$F=mg-\rho A(\ell_0+x)g$

$dA\ell a=dA\ell g-\rho A\ell_0g-\rho gAx$ (from (i) $\rho A\ell_0g$

$=dA\ell g$)

$a=-\frac{\rho g}{d\ell}x$

$\omega=\sqrt{\frac{\rho g}{d\ell}}$

$T=2\pi\sqrt{\frac{\ell d}{\rho g}}$

**49.** **(4)**

**Sol:** $x=A\cos\omega t$

displacement in t time $=A-A\cos\omega t$

for $t=\tau$

$A[1-\cos\omega\tau]=a$

for $t=2\tau$

$A[1-\cos2\omega\tau]=3a$

$\frac{1-\cos\omega\tau}{1-\cos2\omega\tau}=\frac{1}{3}$

$\frac{1-\cos\omega\tau}{2\sin^2\omega\tau} = \frac{1}{3}$

Say $x = \cos\omega t$

$\frac{1-x}{2(1-x^2)} = \frac{1}{3}$

$\Rightarrow \frac{1}{2(1+x)} = \frac{1}{3}$

$\Rightarrow 3 = 2 + 2x \Rightarrow x = \frac{1}{2} = \cos\omega\tau$

$\omega\tau = \frac{\pi}{3} \Rightarrow \frac{2\pi}{T}\tau = \frac{\pi}{3}$

$\Rightarrow T = 6\tau$

**50.** **(3)**

**Sol:** $v = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2}$

$v = \sqrt{5}\frac{A\omega}{3}$

$v_{new} = 3v = \sqrt{5}\,A\omega$

So the new amplitude is given by

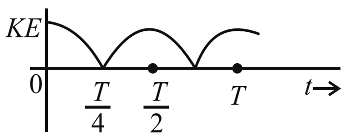
$v_{new} = \omega\sqrt{A_{new}^2 - x^2} \Rightarrow \sqrt{5}\,A\omega$

$= \omega\sqrt{A_{new}^2 - \left(\frac{2A}{3}\right)^2}$

$A_{new} = \frac{7A}{3}$

**51.** **(1)**

**Sol:**




$x = A\sin(\omega t + \phi)$

$\phi = 0, \pi$

$x = \pm A\sin\omega t$

$KE = \frac{1}{2}m\omega^2(A^2 - x^2)$

$= \frac{1}{2}KA^2\cos^2\omega t$

**52.** **(1)**

**Sol:** Potential energy is minimum (in this case zero) at mean position ($x = 0$) and maximum at extreme positions ($x = \pm A$)

At time $t = 0$, $x = A$. Hence P.E. should be maximum. Therefore graph $I$ is correct.

Further in graph III, P.E. is minimum at $x = 0$. Hence this is also correct.

**53.** **(4)**

**Sol:** From graph

$T = 8$ second., $A = 1$ cm, $x = A$

$\sin\omega t. = 1\sin\frac{2\pi}{8}t.$

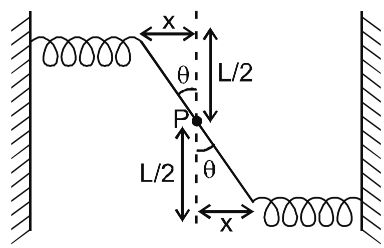
$a = -\omega^2 x = -\left(\frac{2\pi}{8}\right)^2 \sin\left(\frac{2\pi}{8}\right)t$ cm/s$^2$

At, $t = \frac{4}{3}$ second

$a = -\left(\frac{2\pi}{8}\right)^2 \sin\frac{\pi}{3} = -\frac{\sqrt{3}\pi^2}{32}$ cm/s$^2$.

**54.** **(3)**

**Sol:**




Torque about $P = (kx)\frac{L}{2} + \frac{L}{2}(kx)$

$= kxL = \frac{L^2}{2}k\theta$

$(\because x = \frac{L}{2}\sin\theta \simeq \frac{L}{2}\theta)$

$\tau = I\alpha$

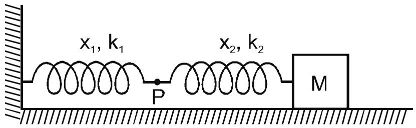
$$\Rightarrow -\frac{KL^2}{2}\theta = \frac{ML^2}{12}\alpha \;\Rightarrow\; \frac{-6K\theta}{M}$$

$$= \alpha \;\Rightarrow \alpha = -\frac{6K}{M}\;\theta = -\omega^2\theta$$

$$\Rightarrow \omega = \sqrt{\frac{6K}{M}} \text{ and } f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{6K}{M}}$$

**55.** **(4)**

**Sol:**




Extensions in springs are $x_1$ and $x_2$ then

$k_1x_1 = k_2x_2$

and $x_1 + x_2 = A$

$$\Rightarrow x_1 + \frac{k_1x_1}{k_2} = A \qquad \Rightarrow x_1 = \frac{k_2A}{k_1+k_2}$$

**56.** **(2)**

**Sol:** Linear momentum

$P = mv = m\omega\sqrt{A^2 - x^2}$

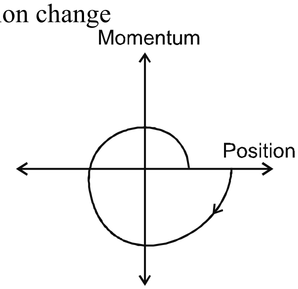
$\Rightarrow \quad P^2 + m^2\omega^2x^2 = m^2\omega^2A^2$

represents a circle on $P$–$x$ diagram with radius of circle $R = A$ ($\because\ m^2\omega^2 = 1$)

ω of spring mass system remains constant and equal to $\sqrt{\frac{k}{m}}$

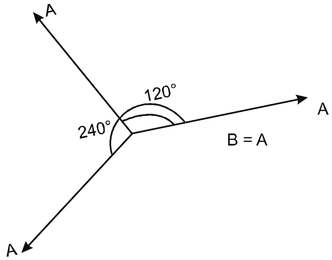
Amplitude of oscillation inside liquid will decrease due to viscous force

So radius of circular arcs will decrease as position change




**57.** **(2)**

**Sol:**




So, $B = A,\ \phi = 240° = \frac{4\pi}{3}$

**58.** **(1)**

**Sol:** Time of flight for projectile

$$T = \frac{2u\sin\theta}{g} = 1 \text{ sec.}$$

$$\frac{2u\sin 45}{g} = 1 \text{ sec.}$$

$$u = \frac{g}{\sqrt{2}}$$

$u = \sqrt{50}$ m/s

**Alternative solution:**

$x = A\cos\omega\, t$

$x = 0.2\cos\frac{\pi}{3}\times 1$

$x = 0.1$

New position of block at time $t = 1$ sec

$= 4.9 + 0.1 = 5$ m

The distance which the pebble have to cover will be

10m – 5m = 5m

Thus range $R = \frac{v^2\sin 2\theta}{g}$

$$v = \sqrt{\frac{Rg}{\sin 2\theta}} = \sqrt{\frac{5(10)}{\sin\frac{\pi}{2}}}$$

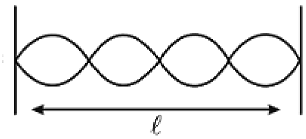
$\Rightarrow v = \sqrt{50}$ m/sec.

**59.** **(2)**

**Sol:** $\therefore\ v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{70}{7\times10^{-3}}} = 100$ m/sec.

**60.** **(2)**

**Sol:** 4th harmonic




$$4\frac{\lambda}{2} = \ell$$

$$2\lambda = \ell$$

$$\frac{2\pi}{\lambda} = 0.157 \Rightarrow \lambda = 40$$

$$\therefore \ \ell = 2\lambda = 80\,\text{m}$$

## Integer Type Questions (61 to 75)

**61.** **(200)**

**Sol:** $f_1 \lambda_1 = f_2 \lambda_2$ (as velocity of sound is constant for both child and man)

$(300)(1) = (f_2)(1.5)$

$200\text{ Hz} = f_2$

**62.** **(1)**

**Sol:** $f \alpha \sqrt{T}$

$$f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}} \Rightarrow \frac{\Delta f}{f} = \frac{1}{2}\frac{\Delta T}{T} \Rightarrow \Delta f$$

$$= \frac{202}{2} \times \frac{1}{101} = 1$$

**63.** **(10)**

**Sol:** $\frac{P}{4\pi r^2} = I$ for an isotropic point sound source.

$\Rightarrow P = I.4\pi r^2$

$= (0.008\text{ w/m}^2)(4.\pi.10^2) = 10.048$

$\cong$ 10 watt.

**64.** **(16)**

**Sol:**

For maximum intensity,

the path difference $x = n\lambda$

Where n is integer i.e., 0,1,2,3......

From geometry:- $\Delta x$ at $c = 0$ & $\Delta x$ at $A = 4\lambda$

So at any general point between $A$ & $C$ (on the boundary of the ellipse) the value of $\Delta$x will be between 0 and $4\lambda$

For maxima between $A$&$C$ we will get the points

For $\Delta x = \lambda$

$\Delta x = 2\lambda$

$\Delta x = 3\lambda$

$\Rightarrow$ On one quadrant of the ellipse, there'll be four maxima.

So, total maxima on the boundary of the ellipse will be = 4×4 =16

**65.** **(100)**

**Sol:** $\beta_1 = 10 \log \frac{I_1}{I_0}$ $\qquad \beta_2 = 10 \log \frac{I_2}{I_0}$

$$\beta_1 - \beta_2 = 10 \log \frac{I_1}{I_2} = 20$$

$$\log \frac{I_1}{I_2} = 2 \quad \Rightarrow \quad \frac{I_1}{I_2} = 100$$

**66.** **(600)**

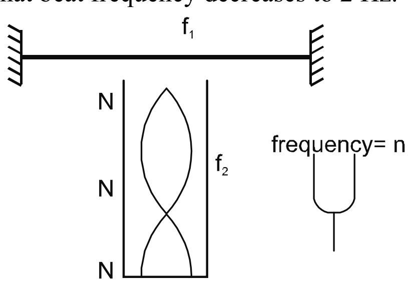
**Sol:** The frequency is a characteristic of source. It is independent of the medium. So, frequency remains same.

**67.** **(344)**

**Sol:** As string and tube are in resonance $f_1 = f_2$

$|f_1 - n| = 4$ Hz.

When $T$ increases, $f_1$ also increases. It is given that beat frequency decreases to 2 Hz.



$\Rightarrow\ n - f_1 = 4$

$n = 4 + f_1$

as $f_1 = f_2$

$n = 4 + f_2$

$$f_2 = \frac{3V}{4\ell} = \frac{3\times 340}{4\times(3/4)} = 340$$

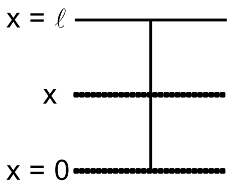
$n = 344$

**68. (5)**

**Sol:** $v = \frac{\omega}{k} = \frac{100}{20} = 5$ m/sec

**69. (2)**

**Sol:** Let mass per unit length be $\lambda$.




$T = \lambda g x \quad v = \sqrt{\frac{T}{\lambda}} = \sqrt{gx}$

$v^2 = gx,$

So, $2v\frac{dv}{dx} = g$

$$a = \frac{vdv}{dx} = \frac{g}{2}$$

$$\ell = \frac{1}{2}\frac{g}{2}t^2 \Rightarrow t = \sqrt{\frac{4\ell}{g}} = 2\sqrt{2} \text{ sec}$$

**70. (25)**

**Sol:** $f = \frac{5}{2L}\sqrt{\frac{9g}{\mu}}$

now $f' = \frac{3}{2L}\sqrt{\frac{Mg}{\mu}}$

as $f = f' \quad \Rightarrow \quad M = 25$ Kg

**71. (5)**

**Sol:** $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{0.5}{10^{-3}/0.2}} = 10$ m/sec.

$v = f\lambda$

$10 = (100)\lambda$

$\Rightarrow\ \lambda = 0.1$ m $= 10$ cm

distance between two successive nodes

$= \frac{\lambda}{2} = 5$ cm

**72. (2)**

**Sol:** The time period of simple pendulum in air

$$T = t_0 = 2\pi\sqrt{\left(\frac{\ell}{g}\right)} \qquad \ldots\text{(i)}$$

$\ell$, being the length of simple pendulum.

In water, effective weight of bob

$w'$ = weight of bob in air-upthrust

$\Rightarrow \rho V g_{eff} = mg - m'g$

$= \rho V g - \rho' V g = (\rho - \rho')Vg$

where $\rho$ = density of bob,

$\rho'$ = density of water

$$\therefore\ g_{eff} = \left(\frac{\rho - \rho'}{\rho}\right)g = g\left(1 - \frac{\rho'}{\rho}\right)$$

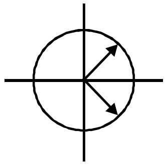
$$\therefore\ t = 2\pi\sqrt{\frac{\ell}{\left[\left(1 - \frac{\rho'}{\rho}\right)g\right]}} \qquad \ldots\text{(ii)}$$

Thus $\frac{t}{t_0} = \sqrt{\frac{1}{\left[\left(1 - \frac{\rho'}{\rho}\right)\right]}}$

$$= \sqrt{\left(\frac{1}{1 - \frac{1000}{(4/3)\times 1000}}\right)} = 2 \quad \Rightarrow t = 2\,t_0$$

**73.** **(3)**

**Sol:**



$x_1 = A\sin(\omega t + \phi_1)$

$x_2 = A\sin(\omega t + \phi_2)$

$$x_1 - x_2 = A\left[2\sin\left[\omega t + \frac{\phi_1+\phi_2}{2}\right]\sin\left[\frac{\phi_1-\phi_2}{2}\right]\right]$$

$$A = 2A\sin\left(\frac{\phi_1-\phi_2}{2}\right)$$

$$\frac{\phi_1-\phi_2}{2} = \frac{\pi}{6}$$

$$\phi_1-\phi_2 = \frac{\pi}{3}$$

So $n = 3$.

**74.** **(6)**

**Sol:** $T_1 = 2\pi\sqrt{\frac{\ell}{g}} = 2\pi\sqrt{\frac{\ell}{10}}$

upward acceleration $\frac{d^2y}{dt^2} = 2k$

$= 2 \times 1 = 2\ \text{m/s}^2$

$\therefore$ Acceleration w.r.t. point of suspension

$= 12\ \text{m/s}^2$

$T_2 = 2\pi\sqrt{\frac{\ell}{12}}$ $\therefore \frac{T_1}{T_2} = \sqrt{\frac{12}{10}}$

$\therefore \left(\frac{T_1}{T_2}\right)^2 = \frac{6}{5}$.

So $n = 6$.

**75.** **(3)**

**Sol:** In 1st case amplitude of SHM is $a$.

In 2nd case amplitude of SHM is $2a$

Total energy $= \frac{1}{2}$ k(amplitude)$^2$

$$E_1 = \frac{1}{2}k(2a)^2$$

$$E_2 = \frac{1}{2}k(1)^2$$

$$E_1 = 4\ E_2$$

**Alternative solution:**

Linear momentum $P = mv = m\omega\sqrt{A^2 - x^2}$

$\Rightarrow P^2 = m^2\omega^2(A^2 - x^2)$

$\Rightarrow P^2 + (m\omega)^2x^2 = m^2\omega^2A^2$ ...(i)

Equation of circle (bigger)

$P^2 + x^2 = (2a)^2$

$P^2 + x^2 = 4a^2$ ...(ii)

Equation of circle (smaller)

$P^2 + x^2 = a^2$ ...(iii)

Comparing (i) and (ii)

Amplitude $A = 2a$

and $(m\omega)^2 = 1$ $\Rightarrow m\omega^2 = \frac{1}{m}$

energy $E_1 = \frac{1}{2}m\omega^2(A)^2$

So energy $E_1 = \frac{1}{2}m\omega^2(2a)^2$

$= \frac{1}{2}\frac{1}{m}\times(4a^2) = \frac{2a^2}{m}$

Comparing (i) and (iii)

$A = a$

$(m\omega)^2 = 1 \Rightarrow m\omega^2 = \frac{1}{m}$

So $E_2 = \frac{1}{2}m\omega^2 A^2 = \frac{1}{2}\times\frac{1}{m}a^2 = \frac{1}{2}\frac{a^2}{m^2}\ \frac{1}{2}\frac{a^2}{m}$

So $\frac{E_1}{E_2} = 4 \Rightarrow E_1 = 4E_2$

# CHARGES AND ELECTROSTATIC FIELD

### Single Option Correct Type Questions (01 to 60)

**1.** **(1)**

By drawing a symmetrical surface,

$E \parallel dA$

and $E.\,dA = EdA$

This leads to $E\oint dA = \frac{q_{\text{enclosed}}}{\varepsilon_0}$

Which is easier to evaluate

**2.** **(1)**

**Sol:** $0.144 = \frac{9\times10^9 q^2}{(0.05)^2}$

$q^2 = \frac{0.144}{9\times10^9\times400}$

**3.** **(1)**

**Sol:** Coulomb's law follows Newtons third law.

**4.** **(2)**

**5.** **(3)**

**Sol:** According to principle of superposition force acting between the two charges does'nt depend on the presence of other.

**6.** **(1)**

**7.** **(3)**

**Sol:** $F = \frac{k\,q_1q_2}{r^2}$ ....(1)

$4F = \frac{k\,q_1q_2}{16R^2}$ ...(2)

$\Rightarrow R = \frac{r}{8}$

**8.** **(2)**

**Sol:** $E = \frac{F}{Q}$

**9.** **(3)**

**Sol:** $\frac{Q}{4\pi\epsilon_0 r_0^2} = \frac{\lambda}{2\pi\epsilon_0 r_0} = \frac{\sigma}{2\epsilon_0}$

$Q = 2\pi\sigma r_0^2$ (1) incorrect

$r_0 = \frac{\lambda}{\pi\sigma}$ (2) incorrect

$E_1\left(\frac{r_0}{2}\right) = \frac{4E_1(r_0)}{1}$

$E_2\left(\frac{r_0}{2}\right) = 2E_2(r_0) \Rightarrow$ (3) correct

$E_3\left(\frac{r_0}{2}\right) = E_3(r_0) = E_2(r_0)$ (4) incorrect

**10.** **(3)**

**Sol:** $E = \frac{2K\lambda}{r}$

**11.** **(3)**

**12.** **(4)**

Unit positive charge at $O$ will be repelled equally by three charges at the three corners of triangle. By symmetry, resultant $\vec{E}$ at O would be zero.

**13.** **(3)**

**Sol:** Maximum electric field will be at the surface

$E = \frac{kq}{r^2} = \frac{9\times10^9\times1\times10^{-6}}{(0.1)^2}$

**14.** **(3)**

**Sol:** mg = qE $\quad m = \left(\rho.\frac{4}{3}\pi r^3\right)$

$q = 1.6 \times 10^{-19}C$

**15.** **(3)**

**Sol:** As +q is displaced towards right, the repulsion of right side wire will dominate and the net force on +q will be towards left, and vice versa

$$F_{restoring} = q\left(\frac{2k\lambda}{d-x} - \frac{2k\lambda}{d+x}\right)$$

$$\Rightarrow F_{restoring} = \frac{2k\lambda(2x)q}{d^2-x^2} \approx \left(\frac{4k\lambda q}{d^2}\right)x$$

Hence SHM

For –q, as it is displaced towards right the attraction of right side wire will dominate, which forces the –q charge to move in the same direction of displacement.

Hence it is not SHM.

**16.** **(4)**

**Sol:** $T = 2\pi\sqrt{\frac{\ell}{g_{eff}}}$

where $= g_{eff} = \frac{\sqrt{m^2g^2+q^2E^2}}{m}$

$$= \sqrt{g+\left(\frac{qE}{m}\right)^2}$$

**17.** **(2)**

**18.** **(3)**

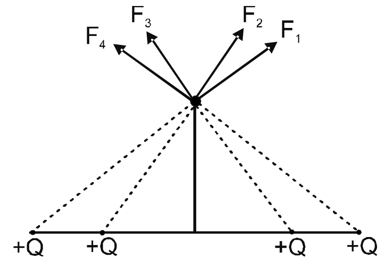
**Sol:** $E = \frac{kqx}{(R^2+x^2)^{3/2}}$, for max E, $\frac{dE}{dx} = 0$

$$\Rightarrow x = \pm\frac{R}{\sqrt{2}}$$

$$\Rightarrow E_{max} = \frac{2kq}{3\sqrt{3}R^2}$$

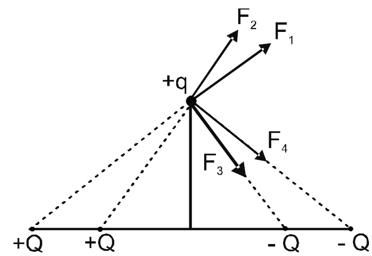
**19.** **(1)**

**Sol:** (I)



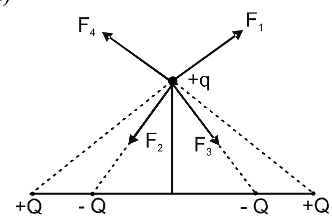

Component of forces along x-axis will vanish.
Net force along +ve y-axis

(II)



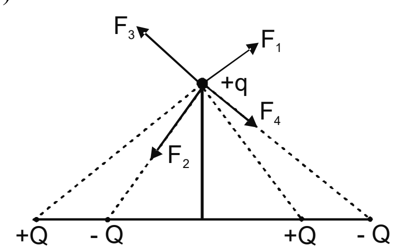

Component of forces along y-axis will vanish.
Net force along +ve x-axis

(III)




Component of forces along x-axis will vanish.
Net force along -ve y-axis.

(IV)




Component of forces along y-axis will vanish.
Net force along -ve x-axis.

**Ans.** **(A)** I-R, II-P, III-S, IV-Q

**20.** **(2)**

**21.** **(3)**

**Sol:** $E_{axis} = \frac{2KP}{r^3}$ and $E_{equator} = \frac{KP}{r^3}$

**22.** **(3)**

**Sol:** max PE $\Rightarrow$ position of unstable equilibrium

$\Rightarrow \quad \theta = \pi$

**23.** **(2)**

**Sol:** $\phi = \frac{q_2 + q_3}{\epsilon_0}$

**24.** **(3)**

**Sol:** $\phi_{closed} = \frac{q_{in}}{\epsilon_0}$

**25.** **(4)**

**Sol:** Total incoming flux = Total outgoing flux.

**26.** **(4)**

The charge inside the closed surface is given by $q$ = net electric flux pass through the surface × $\varepsilon_0$ $q = (4 \times 10^3 - 8 \times 10^3\,\varepsilon_0$

Therefore, $q = -4 \times 10^3\ \varepsilon_0$ C

**27.** **(3)**

**28.** **(4)**

**Sol:** $\vec{E}$ inside conductor is zero.

**29.** **(3)**

**Sol:** $T_0 = 2\pi\sqrt{\frac{L}{g}}$

When the plates are charged, the net acceleration is,

$g' = g + a$

$$g' = g + \frac{qE}{m}\left(a = \frac{qE}{m}\right)$$

$$\therefore T = 2\pi\sqrt{\frac{L}{g + \frac{qE}{m}}}$$

$$\therefore \frac{T}{T_0} = \left(\frac{g}{g + \frac{qE}{m}}\right)^{1/2}$$

**30.** **(2)**

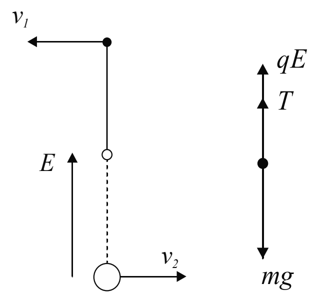
**Sol:** By using $\int \vec{E}.\overrightarrow{dA} = \frac{1}{\varepsilon_0}(Q_{\text{enc}})$

**31.** **(3)**

**Sol:** Gain in $KE$ = Work done by external forces

$= W_{\text{gravity}} + W_{\text{electrical}}$

$$\Rightarrow \frac{1}{2}m\left(v_2^2 - v_1^2\right) = mg(2l) + (-q\ E2l) \qquad ...(i)$$




For ball at lower most position,

$$qE + T - mg = \frac{mv_2^2}{l}$$

Given, $T$=15mg

From Eqs. (i) and (ii), we have

$$v_1 = \sqrt{\frac{l}{m}(10mg + 5qE)}$$

**32.** **(2)**

**Sol:** $As,\ E = \lim_{q_0 \to 0} \frac{F}{q_0}$

i.e. test charge $q_0$ is very small, so that it does not modify the field of charge $q$.

Hence, when we measure a field by putting a test charge $q_0$ at a point, measured value of field is smaller than true value of field.

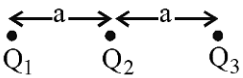
**33.** **(3)**

**Sol:** Electric field intensity will be more where electric field lines are closed

**34.** **(4)**

**Sol:** There is no point near electric dipole having $E = 0$.

**35.** **(1)**




$Q_2 = -Q_3 = Q$

Force on $Q_3$ due to $Q_2$ + Force on $Q_3$ due to $Q_1 = 0$.

$$\frac{1}{4\pi\epsilon_0}\left(\frac{-Q^2}{a^2}\right)+\frac{1}{4\pi\epsilon_0}\frac{Q_1Q}{4a^2}=0 \Rightarrow Q_1 = 4Q_3$$

**36.** **(3)**

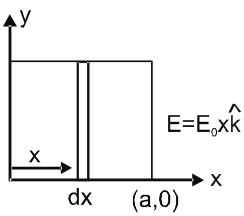
**37.** **(4)**

**Sol:** $\frac{1}{2}mv^2 = \frac{KqQ}{r} \Rightarrow r \,\alpha\, \frac{1}{v^2}$

**38.** **(1)**

**39.** **(2)**

**Sol:**



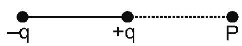

flux through differential element $d\phi$

$= E_0 \times a\, dx$.

$$\phi = E_0 a \int_0^a x.\,dx = \frac{E_0a^3}{2}$$

**40.** **(3)**

**Sol:** $\phi = \int Eds = \frac{Kq}{r^2}4\pi r^2 = \frac{q}{\varepsilon_0}$




$W_{ext} = q(V_B - V_A)$

Comment : (D) is not correct answer because it is not given that charge is moving slowly.

**41.** **(1)**

**Sol:** The frequency will be same $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ but due to the constant qE force, the equilibrium position gets shifted by $\frac{qE}{K}$ in forward direction. So Ans. will be (1)

**42.** **(1)**

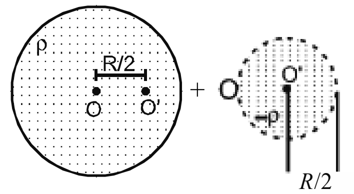
**Sol:** Nearby the plate, field is uniform. Equal and opposite forces are experienced by upper half and lower half

**43.** **(3)**

**Sol:** Case (i) : (with cavity) :

Let charge density be ρ.

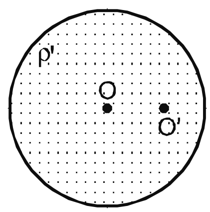
Consider as superposition of the bodies shown below:




At O′ $E = \frac{1}{4\pi\varepsilon_0}\cdot\frac{4}{3}\pi\left(\frac{R}{2}\right)\rho + 0$

Case (ii)

At O′, $E' = \frac{1}{4\pi\varepsilon_0}\cdot\frac{4}{3}\pi\left(\frac{R}{2}\right)\rho'$




$$\therefore \frac{E'}{E} = \frac{\rho'}{\rho} = \frac{q/V'}{q/V} = \frac{V}{V'} = \frac{7}{8}$$

$$\left(V = \frac{4}{3}\pi R^3 - \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 \text{ and } V' = \frac{4}{3}\pi R^3\right)$$

**44.** **(4)**

**Sol:** Electric field in cavity

$$\vec{E} = \frac{\rho\overrightarrow{OP}}{3\epsilon_0}$$

$$OP = R_1 - R_2 = \frac{\rho\vec{a}}{3\epsilon_0}$$

**45. (3)**

**Sol:** $E_1 = \dfrac{KQ}{R^2}$

$E_2 = \dfrac{k(2Q)}{R^2} \Rightarrow E_2 = \dfrac{2kQ}{R^2}$

$E_3 = \dfrac{k(4Q)R}{(2R)^3} \Rightarrow E_3 = \dfrac{kQ}{2R^2}$

$E_3 < E_1 < E_2$

**46. (3)**

Electric flux, $\phi = E.S$

or $\phi = E.S\cos\theta$

Here, $\theta$ is the angle between $E$ and $S$. In this question $\theta = 45^o$, because $S$ is perpendicular to surface.

$E = E_0$

$S = \left(\sqrt{2}a\right)(a) = \sqrt{2}a^2$

$\therefore\ \phi = (E_0)\left(\sqrt{2}a^2\right)\cos 45^o = E_0 a^2$

**47. (2)**

**Sol:** The density of electric field line is directly proportional to magnitude of electric field intensity

**48. (2)**

**Sol:** Electric field intensity due to infinite line charge is $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

Given,

$E = 7.182 \times 10^8\ NC^{-1}$

$r = 2\ cm = 2 \times 10^{-2}\ m$

$\lambda = ?$

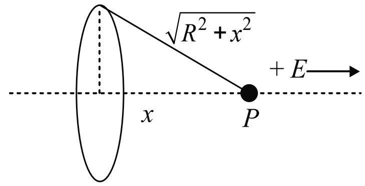
$\Rightarrow \lambda = 2\pi\varepsilon_0 rE = \dfrac{2\times 2\pi\varepsilon_0 rE}{2}$

$= \dfrac{1\times 2\times 10^{-2}\times 7.182\times 10^8}{2\times 9\times 10^9}$

$= 7.98 \times 10^{-4}\ Cm^{-1}$

**49. (3)**

**Sol:** At point $P$ in axis, $E = \dfrac{kqx}{\left(R^2+x^2\right)^{3/2}}$




For max $E$, $\dfrac{dE}{dx} = 0 \Rightarrow or\ x = \dfrac{R}{\sqrt{2}}$

$\therefore$ Putting $x$ in $(i)$ $E_{max} = \dfrac{2kq}{3\sqrt{3}R^2}$

**50. (1)**

**51. (1)**

**Sol:** Torque about Q of charge –q is zero, so angular momentum of charge –q is constant, but distance between charges is changing, so force is changing, so speed and velocity are changing.

**52. (2)**

**Sol:** $\vec{F}_{12(x)} = \dfrac{q_1 q_2}{4\pi \in_0 b^2}(+\hat{i})$

$\vec{F}_{13(x)} = \dfrac{q_1 q_3}{4\pi\varepsilon_0 a^2}(+\sin\theta\hat{i})$

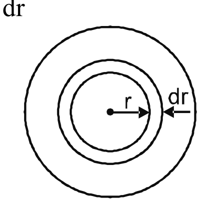
$\therefore$ Net $\vec{F}_x = \dfrac{Kq_1q_2}{b^2}(+\hat{i}) + \dfrac{kq_1q_3}{a^2}\sin\theta(+\hat{i})$

or $F_x = Kq_1\left[\dfrac{q_2}{b^2} + \dfrac{q_3}{a^2}\sin\theta\right]$

$\therefore$ $F_x \propto \dfrac{q_2}{b^2} + \dfrac{q_3}{a^2}\sin\theta$

**53. (2)**

**Sol:** Consider a spherical shell having radius r and thickness dr




$dq = \dfrac{Q}{\pi R^4}\ r \times 4\pi r^2 dr$

or $q = \frac{4Q}{R^4}\int_0^{r_1} r^3 dr$

so, $q = \frac{Q.r_1^4}{R^4}$

Electric field at a distance $r_1$ from the center (inside)

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_1^2}$$

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q.\, r_1^2}{R^4}$$

**54. (3)**

**Sol:** $\vec{E} = \left(\frac{2k\lambda}{r}\right)(-\hat{j}) \Rightarrow \vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}(-\hat{j})$

$$\lambda = \frac{q}{\pi r} \quad \Rightarrow \vec{E} = \frac{q}{2\pi^2\varepsilon_0 r^2}(-\hat{j})$$

**55. (3)**

**Sol:** At equilibrium

$$\tan\theta/2 = \frac{F_e}{mg}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{q^2}{[2\ell\sin(\theta/2)]^2} \cdot \frac{1}{mg} \qquad \ldots(i)$$

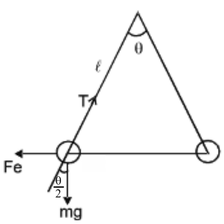
When suspended in liquid

$$\tan\frac{\theta}{2} = \frac{1}{4\pi\epsilon_0 K}\frac{q^2}{[2\ell\sin(\theta/2)]^2}\frac{1}{(mg - F_B)}$$

$$= \frac{1}{4\pi\epsilon_0 K}\frac{q^2}{[2\ell\sin(\theta/2)]^2} \cdot \frac{1}{(mg - \frac{m}{1.6}\times 0.8\, g)} \qquad \ldots(ii)$$

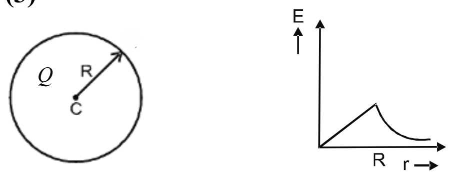
on comparing the two equation we get

$$K\left(1 - \frac{0.8}{1.6}\right) = 1 \Rightarrow K = 2$$

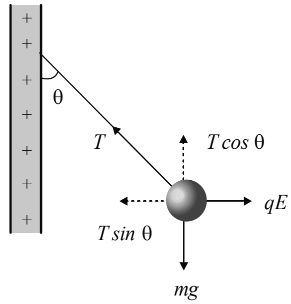



**56. (3)**

**Sol:**




**57. (2)**



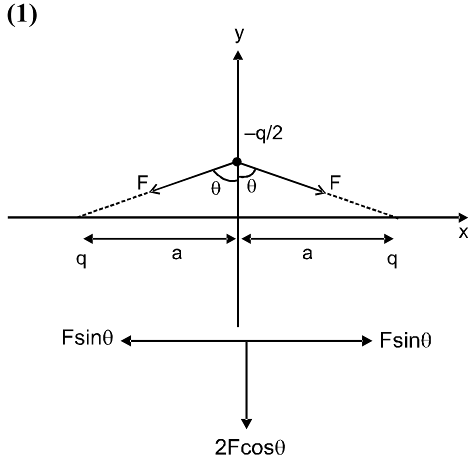

$T\sin\theta = qE$ and $T\cos\theta = mg$

$$\Rightarrow \tan\theta = \frac{qE}{mg} = \frac{q}{mg}\left(\frac{\sigma}{2\varepsilon_0}\right)$$

$\Rightarrow \sigma \propto \tan\theta.$

**58. (1)**

**Sol:**




$\Rightarrow F_{net} = 2F\cos\theta$

$$F_{net} = \frac{2kq\left(\frac{q}{2}\right)}{\left(\sqrt{y^2 + a^2}\right)^2} \cdot \frac{y}{\sqrt{y^2 + a^2}}$$

$$F_{net} = \frac{2kq\left(\frac{q}{2}\right)y}{(y^2 + a^2)^{3/2}} \quad \Rightarrow \quad \frac{kq^2 y}{a^3} \propto y$$

**59. (1)**

**Sol:** (2) and (3) is not possible since field lines should originate from positive and terminate to negative charge.

(4) is not possible since field lines must be smooth.

(1) satisfies all required condition.

**60. (3)**

Net downward force on the drop

$$= \frac{4}{3}\pi r^3 (\rho - \rho_0) g$$

For equilibrium, electric force must be upwards i.e. charge on the drop is positive.

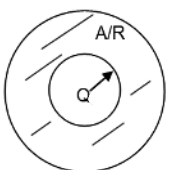
$$neE = \frac{4}{3}\pi r^3 (\rho - \rho_0) g$$

$$\text{i.e. } n = \frac{4\pi r^3 (\rho - \rho_0) g}{3eE}$$

## Integer Type Questions (61 to 75)

**61. (2)**

**Sol:**




$$(E)(4\pi r^2) = \frac{Q + \int_a^r \frac{A}{r} 4\pi r^2 dr}{\varepsilon_0}$$

$$\Rightarrow (E)\,4\pi r^2 = \frac{Q + \frac{4\pi A}{2}(r^2 - a^2)}{\varepsilon_0}$$

$$\Rightarrow E = \frac{Q}{4\pi\varepsilon_0 r^2} + \frac{A}{\varepsilon_0 2r^2}(r^2 - a^2)$$

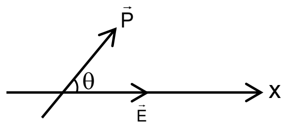
$$= \frac{Q}{4\pi\varepsilon_0 r^2} + \frac{A}{2\varepsilon_0} - \frac{Aa^2}{2\varepsilon_0 r^2}$$

$$\frac{Q}{4\pi\varepsilon_0} = \frac{Aa^2}{2\varepsilon_0}$$

$$A = \frac{Q}{2\pi a^2}$$

**62. (60)**

**Sol:**




$$PE\sin\theta = P(\sqrt{3}E)\sin(90° - \theta)$$

$$\tan\theta = \sqrt{3}$$

$$\theta = 60°$$

**63. (2)**

By Gauss' theorem, $E \propto \frac{q_{net}}{r^2}$

$$\Rightarrow 8 = \frac{\int_0^R 4\pi r^2 kr^a dr}{\int_0^{R/2} 4\pi r^2 kr^a dr} \times \frac{(R/2)^2}{R^2}$$

$$\Rightarrow 8 = \frac{\left[\frac{k4\pi r^{2+a+1}}{2+a+1}\right]_0^R}{\left[\frac{k4\pi r^{2+a+1}}{2+a+1}\right]_0^{R/2}} \times \frac{1}{4}$$

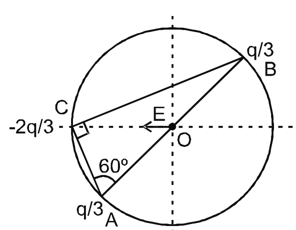
$$\Rightarrow 8 \times 4 = \frac{\left(r^{2+a+1}\right)_0^R}{\left(r^{2+a+1}\right)_0^{R/2}} = 2^{2+a+1}$$

$$\Rightarrow 2 + a + 1 = 5$$

$$\Rightarrow a = 2$$

**64. (54)**

**Sol:**



Force between B and C

$$F = \frac{K\left(\frac{2q}{3}\right)\left(\frac{q}{3}\right)}{(2R\sin 60°)^2}$$

$$= \frac{4\times 2\,Kq^2}{9\times 4\times 3\,R^2} = \frac{2q^2}{9\times 3\times 4\pi\varepsilon_0 R^2} \text{ (attractive)}$$

$$= \frac{1}{54}\frac{q^2}{\pi \in_0 R^2}$$

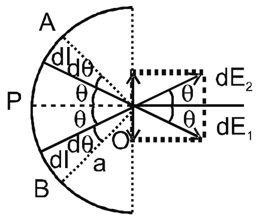
**65. (2)**

**Sol:** From Gauss's law

$$\frac{\Sigma Q_{in}}{\varepsilon_0} = \frac{(8C/4)-7C+(6C/2)}{\varepsilon_0} = -\frac{2C}{\varepsilon_0}$$

**66. (2)**

**Sol:** Considering symmetric elements each of length $d\ell$ at A and B, we note that electric fields perpendicular to PO are cancelled and those along PO are added. The electric field due to an element of length $d\ell$ (ad$\theta$) along PO.




$$dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{a^2}\cos\theta$$

$(\because\ d\ell = \text{a}d\theta)$

$$= \frac{1}{4\pi\varepsilon_0}\frac{\lambda dI}{a^2}\cos\theta$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{\lambda(a\,d\theta)}{a^2}\cos\theta$$

Net electric field at O

$$E = \int_{-\pi/2}^{\pi/2} dE$$

$$= 2\int_0^{\pi/2}\frac{1}{4\pi\varepsilon_0}\frac{\lambda\, a\cos\theta\, d\theta}{a^2}$$

$$= 2.\ \frac{1}{4\pi\varepsilon_0}\ \frac{\lambda}{a}\ [\sin\theta]_0^{\pi/2}$$

$$= 2.\ \frac{1}{4\pi\varepsilon_0}\ .\ \frac{\lambda}{a}\ .1 = \frac{\lambda}{2\pi\varepsilon_0\, a}$$

**67. (6)**

**Sol:** Each charge has its 1/8th part inside cube since there are 8 charges.

net enclosed charge $= \frac{q}{8}\times 8 = q$

net flux $= \frac{q_{in}}{\varepsilon_0} = \frac{q}{\varepsilon_0}$.

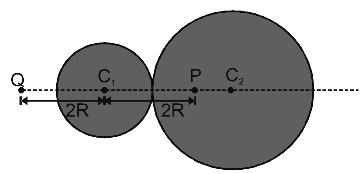
flux through one surface $= \frac{1}{6}\times\frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$

**68. (4)**

**Sol:** $\sigma = \frac{q}{4\pi r^2} \Rightarrow \frac{\sigma_1}{\sigma_2} = \left(\frac{r_2}{r_1}\right)^2$

**69. (4)**

**Sol:**




At point P

If resultant electric field is zero

then

$$\frac{KQ_1}{4R^2} = \frac{KQ_2}{8R^3}R$$

$$\frac{\rho_1}{\rho_2} = 4$$

**70. (54)**

**Sol:** $\phi = \int \vec{E}.d\vec{s}$

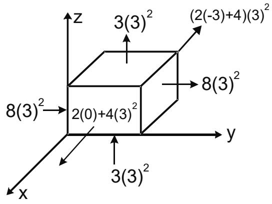
Direction of field at $x = -3$m is along negative x axis. Area vector is also along same direction.

x = – 3

$\phi = 6 \times 9 = \dfrac{Q}{\varepsilon_0}$

Components of electric field which are constant,
do not contribute in net flux in or out.

$\dfrac{q_{in}}{\epsilon_0} = 54 \Rightarrow q_{in} = 54\ \epsilon_0$




**71. (9)**

**Sol:** Electric field due to one line charge at a distance r is $E = \dfrac{2k\lambda}{r}$

$F = qE = \dfrac{(\lambda \times 1)2k\lambda}{r} = \dfrac{2k\lambda^2}{r}$

**72. (8)**

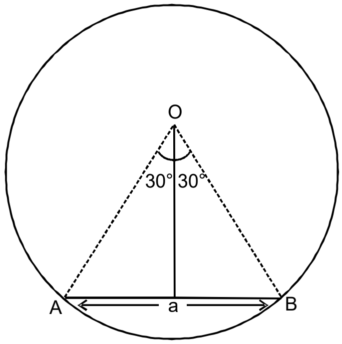
**Sol:** $E \propto \dfrac{1}{r^3}$

**73. (6)**

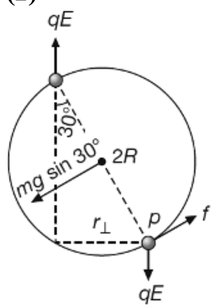
**Sol:** Flux from total cylindrical surface (angle = $2\pi$)

$= \dfrac{Q_{in}}{\varepsilon_0}$

Flux from cylindrical surface AB = flux from the given surface $= \dfrac{Q_{in}}{6\varepsilon_0} = \dfrac{\lambda\ell}{6\varepsilon_0} = n = 6$




**74. (2)**




For system to be in equilibrium, $\tau = 0$
Let us take the torque about the point *P*, so

$qE[2R\sin(30°)] = [mg\sin(30°)]R$

$\Rightarrow E = \dfrac{mg}{2q}$

**75. (2)**

**Sol:** $-4(1) + 6(1) = \dfrac{q}{\varepsilon_o} \Rightarrow q = 2\varepsilon_o$

# ELECTROSTATIC POTENTIAL AND CAPACITANCE

*Single Option Correct Type Questions (01 to 59)*

**1.** **(1)**

**Sol:** $E = \frac{F}{q} = \frac{3000}{3} = \frac{V}{d}$

$V = \frac{1000 \times 1}{100} = 10\text{ V}$

**2.** **(2)**

**Sol:** Conceptual

**3.** **(2)**

**Sol:** $E = \frac{V}{d}$, $E = \frac{10}{2} \times 100 = 500\text{ N/C}$

**4.** **(1)**

**Sol:** $V_c - V_s = \frac{3}{2}\frac{KQ}{R} - \frac{KQ}{R}$

$= \frac{KQ}{2R} = \frac{1}{8\pi \in_0 R}\left(\frac{4}{3}\right)\pi R^3 \rho = \frac{R^2 \rho}{6 \in_0}$

**5.** **(3)**

**Sol:**

**6.** **(3)**

**Sol:** Potential at origin is

$V = kq\left[1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} .......\infty\right]$

$V = kq\left[\frac{1}{1+\frac{1}{2}}\right]$

**7.** **(4)**

**Sol:** $W = \vec{F}.\vec{r} = 0\ (\vec{F} \perp \vec{r})$

**8.** **(4)**

**Sol:** PE may increase or may decrease depending on sign of charges.

**9.** **(1)**

**Sol:** $\text{PE} = \frac{2Kq^2}{a} + \frac{2xkq^2}{a} + \frac{xkq^2}{a} = 0$

where $a$ is distance between charges.

$2 + 3x = 0 \qquad x = -\frac{2}{3}$

**10.** **(4)**

**Sol:** Electric field is always perpendicular to equipotential surface. Opposite to electric field potential increases.

**11.** **(3)**

**Sol:** $E = \frac{10}{0.1 \sin 30°} = 200\ V/m$

**12.** **(3)**

**Sol:** max $PE \Rightarrow$ position of unstable equilibrium $\Rightarrow \theta = \pi$.

**13.** **(3)**

**Sol:** $V_{\text{inside}} = V_{\text{surface}} = \frac{kq}{R} = \frac{9 \times 10^9 \times 3.2 \times 10^{-19}}{0.1}$

**14.** **(2)**

**Sol:** $\frac{Q_1}{Q_2} = \frac{r_1}{r_2}$, $\frac{\sigma_1}{\sigma_2} = \frac{Q_1}{4\pi r_1^2}\frac{4\pi r_2^2}{Q_2} = \frac{r_1}{r_2}\left(\frac{r_2^2}{r_1^2}\right) = \frac{r_2}{r_1}$

**15.** **(1)**

**Sol:** Positive charge flows from higher potential to lower potential.

**16.** **(1)**

**Sol:** Potential difference between two points in a electric field is,

$V_A - V_B = \frac{W}{q_0}$

where, $W$ is work done by moving charge $q_0$ from point $A$ to $B$.

So, $V_A - V_B = \dfrac{2}{20} = 0.1$ V

(Here : $W = 2\ J$, $q_0 = 20C$)

**17.** **(4)**

**Sol:** $V(x) = \dfrac{20}{x^2 - 4}$,

$$E = -\frac{dV}{dx} = -\frac{d}{dx}\left(\frac{20}{x^2-4}\right)$$

$$= \frac{20}{(x^2-4)^2}(2x)$$

$E$ at $x = 4\ \mu m$ is $\dfrac{(20)(2\times4)}{144} = \dfrac{10}{9}$ volt/$\mu m$

Also as $x$ increases, $V$ decreases. So, $E$ is along +ve $x$-axis.

**18.** **(3)**

**Sol:** $\left(W_{P\to Q}\right)_{ext} = q\,(V_Q - V_P)$

$= -1.6 \times 10^{-19} \times 100\,(-4-10)$

$= 2.24 \times 10^{-16}\ J$

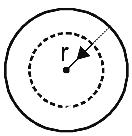
**19.** **(1)**

**Sol:** Statement–1: Correct as the field is conservative

Statement :2: Correct Explanation

**20.** **(4)**

**Sol:**




$\phi = ar^2 + b$

$$E = -\frac{d\phi}{dr} = -2ar$$

$$\Rightarrow \oint \vec{E}.\vec{dS} = \frac{q}{\varepsilon_0}$$

$$-2ar \,.\, 4\pi r^2 = \frac{q}{\varepsilon_0}$$

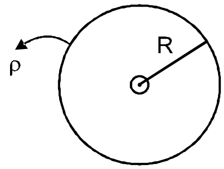
$q = -8\,\varepsilon_0 a\pi r^3$

$$\rho = \frac{q}{\frac{4}{3}\pi r^3}$$

$\rho = -6a\varepsilon_0$

**21.** **(3)**

**Sol:**




$$U_c = \frac{3}{2}\frac{KQ}{R}q$$

$$U_S = \frac{KQ}{R}q$$

$$\therefore\quad \Delta U = \frac{KQ}{2R}q$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{1}{2R}\rho\frac{4\pi R^3}{3}q = \frac{\rho R^2 q}{6\varepsilon_0}$$

**22.** **(3)**

**Sol:** $V_A - V_O = -\int_0^2 E_x dx$

$$V_A - V_O = -\int_0^2 30x^2 dx = -30\,\frac{2^3}{3} = -80\text{V}$$

**23.** **(4)**

**Sol:** Capacitance of small sphere = $4\pi\varepsilon_0 r = C$

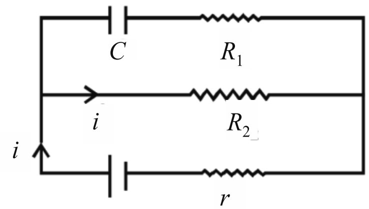
$$\frac{4}{3}\pi R^3 = 8\times\frac{4\pi r^3}{3} \quad\Rightarrow\ R = 2r$$

Capacitance of big sphere = $4\pi\varepsilon_0 R = 2\text{C}$

**24.** **(3)**

**Sol:** Charge on capacitor = $CV$ = capacitance × (voltage across it)

In steady state, there will be no current through capacitor.




voltage across $C = iR_2 = \dfrac{ER_2}{R_2 + r}$

Charge on capacitor = $CiR_2 = \dfrac{CER_2}{R_2 + r}$

**25. (1)**

**Sol:** $Q = CV \Rightarrow \frac{dQ}{dt} = C\frac{dV}{dt}$

$\Rightarrow 100\mu C/sec = 500 \times \frac{20}{t}$

$t = 100\,sec$

**26. (1)**

**Sol:** $4\pi\varepsilon_0 R = \frac{\varepsilon_0 A}{d}$

$d = \frac{\varepsilon_0 A}{4\pi\varepsilon_0 R} = \frac{\varepsilon_0 \pi R^2}{4\pi\varepsilon_0 R} = \frac{R}{4}$

**27. (4)**

**Sol:** Charge on each capacitor will be same. In steady state current through capacitor will be zero

current in steady state = $i = \frac{10}{5} = 2$ A

potential across middle 4Ω resistor

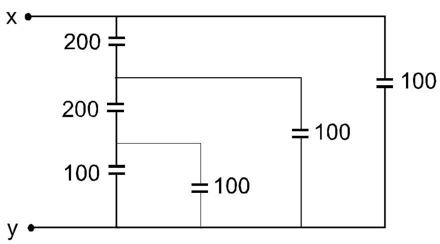
$= iR = 2 \times 4 = 8\ V.$

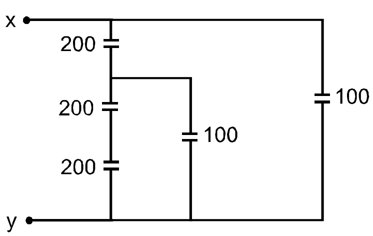
Potential across each capacitor = 4 V

Charge on each plate $Q = C\,V = 3 \times 4 = 12\ \mu C$

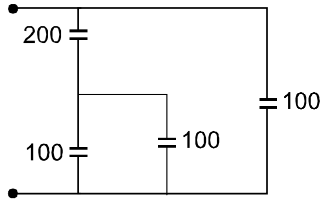
**28. (2)**

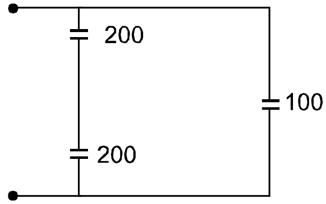
**Sol:**

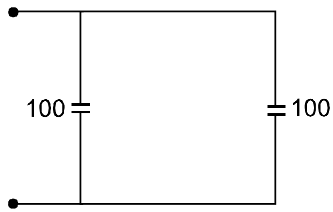


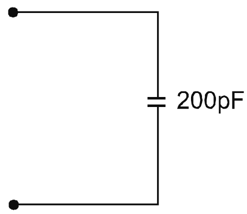

⇒ 


Solving by parallel series combinations,

⇒ 


⇒ 


⇒ 


⇒ 


$C_{eq} = 200$ pF

**29. (4)**

**Sol:** Let the electric field in region I and II be $E_1$ and $E_2$. The potential difference across left half capacitor and right half capacitor is same. Therefore $E_1 d = E_2 d$ where $d$ = inter planar gap.

$\therefore E_1 = E_2$

Hence statement 1 is false, statement 2 is correct by definition.

**30. (1)**

**Sol:** (1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

**31.** **(1)**

**Sol:** The initial charge on capacitor

$= CV_i = 2 \times 1\ \mu C = 2\ \mu C$

The final charge on capacitor

$= CV_f = 4 \times 1\ \mu C = 4\ \mu C$

$\therefore$ Net charge crossing the cell of emf 4V is

$q_f - q_i = 4 - 2 = 2\ \mu C$

The magnitude of work done by cell of emf 4V is

$W = (q_f - q_i)\, 4 = 8\ \mu J$

The gain in potential energy of capacitor is

$\Delta U = \frac{1}{2}C(V_f^2 - V_i^2)$

$= \frac{1}{2}\ 1 \times [4^2 - 2^2]\ \mu J = 6\ \mu J$

Net heat produced in circuit is

$\Delta H = W - \Delta U = 8 - 6 = 2\ \mu J$

**32.** **(2)**

**Sol:** Energy stored by any system of capacitors is

$E_{net} = \frac{1}{2}\ C_{net}\ V^2$

where $V$ is source voltage

Thus, $n$ capacitors are connected in parallel,

Therefore, $C_{net} = nC$

$\therefore E_{net} = \frac{1}{2}nCV^2$

**33.** **(1)**

**Sol:** Capacitance of spherical conductor $= 4\pi\epsilon_0 a$

where $a$ is radius of conductor

Therefore, $C = \frac{1}{9\times10^9} = \frac{1}{9}\times10^{-9}$

$= 0.11 \times 10^{-9}$ F $= 1.1\times 10^{-10}$ F

**34.** **(4)**

**Sol:** $E = (1/2)\, CV^2$ ............ (i)

The energy stored in capacitor is lost in form of heat energy.

$H = ms\,\Delta T$ ............ (ii)

From Eq. (i) and (ii), we have

$ms\Delta T = (1/2)\, CV^2$

$V = \sqrt{\frac{2ms\Delta T}{C}}$

**35.** **(3)**

**Sol:** $U_0 = \frac{q_0^2}{2C}\quad U = \frac{q_0^2 e^{-2t_1/\tau}}{2C} = \frac{U_0}{2} = \frac{q_0^2}{4C}$

$\Rightarrow\quad e^{-2t_1/\tau} = \frac{1}{2}$

$t_1 = \frac{\tau}{2}\ \ell n2$ ....(1)

$q = q_0 e^{-t_2/\tau}$

$\frac{q_0}{4} = q_0 e^{-t_2/\tau}$,

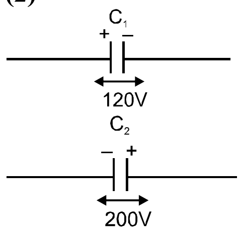
$e^{-t_2/\tau} = \frac{1}{4}$

$t_2 = 2\tau \ln 2$ ....(2)

$\frac{t_1}{t_2} = \frac{1}{4}$

**36.** **(2)**

**Sol:**




For potential to be made zero, after connection

Initially charge should be same

$120C_1 = 200\ C_2$

$\Rightarrow\quad 3C_1 = 5C_2$

**37.** **(1)**

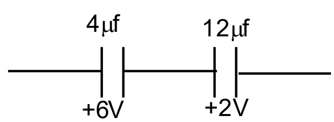
**Sol:** Electric field inside dielectric $= \frac{\sigma}{K\varepsilon_0} = 3 \times 10^4$

$\Rightarrow \sigma = 2.2 \times 8.85 \times 10^{-12} \times 3 \times 10^4$

$= 5.8 \times 10^{-7}\ C/m^2$

**38.** **(2)**

**Sol:**




$Q_1 = 24\mu c$

$Q_2 = 18\mu C$

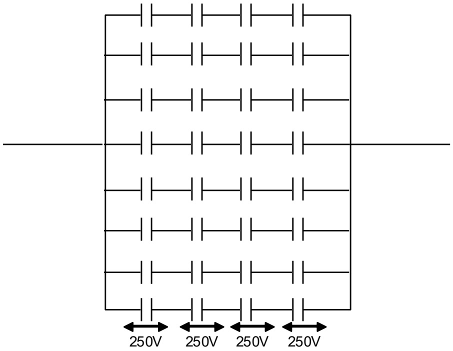
$Q = 42\mu c$

$E = 10^7 \times 42 \times 10^{-6}$

$E = 420$ N/C

**39.** **(1)**

**Sol:**




Minimum no. of capacitors required = 32

**40.** **(3)**

**Sol:** $q_3 = \frac{C_3}{C_2 + C_3}$ .Q

$q_3 = \frac{3}{3+2} \times 80 = \frac{3}{5} \times 80 = 48\ \mu C$

**41.** **(1)**

**Sol:** $Q_t = Q_1 + Q_2 = 150\ \mu C$

$\frac{kQ_1}{r_1} = \frac{kQ_2}{r_2} \Rightarrow 2Q_1 = Q_2 \qquad \Rightarrow Q_1 = 50\ \mu\text{C}$

$Q_2 = 100\ \mu\text{C}$

Hence, 25μC charge will flow from smaller to bigger sphere.

**42.** **(2)**

**Sol:** Isolated capacitor $\Rightarrow Q$ = constant

separation d increases $\Rightarrow C$ = decreases

$Q = CV \Rightarrow V$ = increases

**43.** **(3)**

**Sol:** $C = 4\pi\varepsilon_0 R$

**44.** **(2)**

**Sol:** $U = \frac{CV^2}{2}$

$V$ = 400 volt

**45.** **(3)**

**Sol:** Conceptual

**46.** **(2)**

**Sol:** $W = U_f - U_i = \frac{1}{2}CV_f^2 - \frac{1}{2}CV_i^2$

$= \frac{1}{2}C(40^2 - 20^2) = 600C$

$W_1 = \frac{1}{2}C(50^2 - 40^2) = \frac{900}{2}C$

$W_1 = \frac{900}{2} \times \frac{W}{600} = \frac{3}{4}W$

**47.** **(4)**

**Sol:** $V = \frac{V_1C_1 + V_2C_2}{C_1 + C_2}$

$40 = \frac{100 \times 10 + 0}{C_1 + C_2}$

$C_1 + C_2 = 25\ \mu F$

$C_2 = 25 - 10 = 15\ \mu F$

**48.** **(4)**

**Sol:** $C = \frac{\varepsilon_0 A}{d}$

$C1 = \frac{\varepsilon_0(2A)}{d/2} = 4\left(\frac{\varepsilon_0 A}{d}\right) = 4C = 48\ \mu\text{F}$

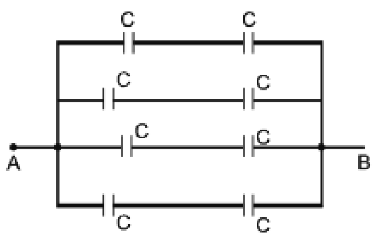
**49.** **(2)**

**Sol:** $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{(900 + 2500)\mu\text{F volt}}{(3+5)\mu\text{F}}$

$= \frac{3400\ \text{Volt}}{8} = 425\ V$

**50.** **(2)**

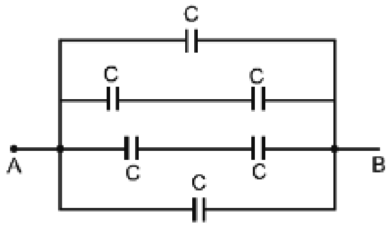
**Sol:**




$\text{Ceq} = \frac{4C}{2} = 2\text{C}$

**51.** **(3)**

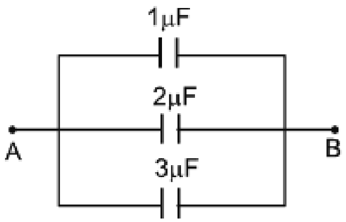
**Sol:**




$$\text{Ceq} = \text{C} + \frac{2\text{C}}{2} + \text{C} = 3\text{C}$$

**52.** **(4)**

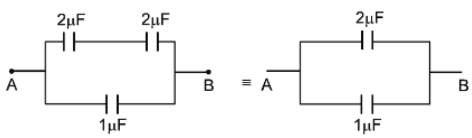
**Sol:** Equivalent figure




$C_{eq} = C_1 + C_2 + C_3 = 1 + 2 + 3 = 6\ \mu F$

**53.** **(2)**

**Sol:**




$C_{AB} = \text{Ceq} = 2\mu\text{F}$

**54.** **(3)**

**Sol:** $C_{eq} = 4\frac{C}{2} = 2C$

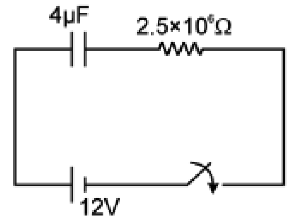
**55.** **(2)**

**Sol:** Charge will be same at $t = 0$

**56.** **(2)**

**Sol:** $Vc + V_R = 12$

$$V_C + \frac{V_C}{3} = 12 \Rightarrow V_C = 9 \text{ volt}$$




$$Vc = \frac{q}{C} = \frac{CE(1-e^{-t/RC})}{C} = E\left(1 - e^{\frac{-t}{RC}}\right)$$

$\Rightarrow (E = 12\ V)$

$$\Rightarrow 9 = 12\left(1 - e^{-\frac{t}{4\times 2.5}}\right)$$

$$e^{-\frac{t}{10}} = \frac{1}{4}$$

$t = 20 \ln 2$

$= 20 \times 0.693$

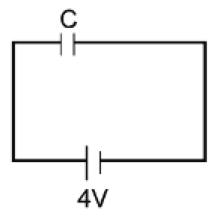
$t = 13.86$ sec

**57.** **(2)**

**Sol:** $C' = \frac{\epsilon_0 A}{d/2} = \frac{2\epsilon_0 A}{d} = 2C.$

**58.** **(3)**

**Sol:**




Here, Potential difference on the capacitor will depend on emf of battery i.e., 4V

**59.** **(1)**

**Sol:** Charge or battery = $Q = CV = 4C$

Now charge remains same, as battery is disconnected new capacitance

$C' = KC = 8C$

$C'V' = Q = 4C$

$$\Rightarrow V' = \frac{Q}{C} = \frac{4C}{8C} = \frac{1}{2}V \qquad \ldots(1)$$

## Integer Type Questions (60 to 71)

**60.** **(4)**

**Sol:** Battery is connected while dielectric is inserted so potential difference will be remains same

$$U_i = \frac{1}{2}CV^2$$

$$U_f = \frac{1}{2}KCV^2$$

$$\Rightarrow \Delta U = \frac{1}{2}(K-1)CV^2 = \frac{1}{2}\times 1\times 200\times 10^{-6}\times (200)^2 = 4$$

**61.** **(0)**

**Sol:** $V_B = V_C$

**62.** **(0)**

**Sol:** Potential at origin is $V = \frac{-kq}{a} + \frac{kq}{a} = 0$

**63.** **(16)**

**Sol:** Potential of single drop, $V = \frac{kq}{r}$

Radius of bigger drop $R = 4r$

$V'$ (potential of bigger drop) = $\frac{k64q}{4r} = \frac{16kq}{r}$

**64.** **(6)**

**Sol:** $\Delta V = Er$ $\quad r = \frac{\Delta V}{E} = 6\text{m}.$

**65.** **(27)**

**Sol:** $V = \frac{9\times 10^9 \times 1.5\times 10^{-9}}{(0.5)} = 27$ V.

**66.** **(18)**

**Sol:** The work done in rotating the electric dipole

$\Delta U = U_f - U_i$

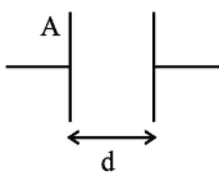
$\Delta U = (-pE\cos(180°)) - (-pE\cos(0°)) = 2pE$

$\Delta U = 2\times 6\times 10^{-6}\times 1.5\times 10^3 = 18$ mJ

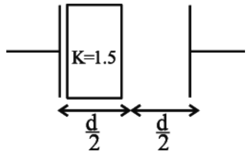
**67.** **(6)**

**Sol:** For the capacitor having air between the plates

$$C = \frac{\epsilon_0 A}{d} = 5\mu\text{F}$$




When a dielectric slab is inserted inside the capacitor




$$C_{new} = \frac{\epsilon_0 A}{\frac{\left(\frac{d}{2}\right)}{1.5} + \frac{\left(\frac{d}{2}\right)}{1}}$$

$$= \frac{6\epsilon_0 A}{5d} = \frac{6}{5}\times 5\mu F = 6\mu F$$

**68.** **(6)**

**Sol:** Let the final p.d across the combination of capacitor be $V'$

$\therefore$ From the conservation of charge

$$C\times 18 + 3C\times 18 = 9C\times V' + 3C\times V' \left(\because K = 9\right)$$

$$72CV = 12CV' \Rightarrow V' = 6\text{ V}$$

**69.** **(200)**

**Sol:** Equivalent capacitance of the system

$C_{eq} = C_1 + C_2 + C_3 + C_4$

$= 1 + 2 + 4 + 3 = 10\mu$F

Charge,

$Q = C_{eq} V$

$= (10\times 20)\mu$C

Q = 200 μC

**70.** **(161)**

**Sol:** $\frac{1}{C} = \frac{5}{\varepsilon_0\times 100} + \frac{5}{10\times\varepsilon_0\times 100}$

$$\Rightarrow C = \frac{8.85\times 10^{-12}\times 1000}{55} = 161\text{pF}$$

**71.** **(125)**

**Sol:** Electrostatic Energy loss,

$$= \frac{1}{2}\frac{C_1\cdot C_2}{C_1 + C_2}(V_1 - V_2)^2$$

$$= \frac{1}{2}\times\frac{50\times 10^{-12}\times 50\times 10^{-12}}{50\times 10^{-12} + 50\times 10^{-12}}\times(100-0)^2$$

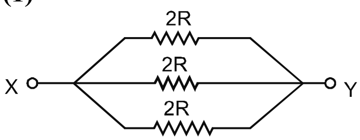
$$= 125\times 10^{-9}\text{ J} = 125n\text{J}$$

# CURRENT ELECTRICITY

## Single Option Correct Type Questions (01 to 60)

**1.** **(2)**
Specific resistance depends only on the material of the wire.

**2.** **(1)**

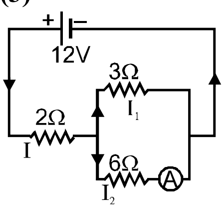



$$R_{eq.} = \frac{2R}{3}$$

**3.** **(3)**

$$E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} \quad r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

**4.** **(3)**




$$R_{xy} = 2 + \frac{3 \times 6}{9} = 2 + 2 = 4$$

$$I = \frac{12}{4} = 3$$

$$I_1 : I_2 = 6 : 3 = 2 : 1 \Rightarrow I_2 = \frac{1}{3} \times 3 = 1$$

**5.** **(1)**

$$R_{eq} = 2 + \frac{4}{2} + \frac{15}{3} + R_A = 9 + R_A$$

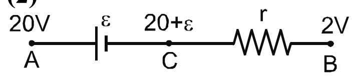
$$I = \frac{V}{R_{eq}} \Rightarrow 1 = \frac{10}{9 + R_A} \Rightarrow R_A = 1\Omega$$

if $4\Omega$ replace by $2\Omega$ resistance then

$$R_{eq} = 2 + \frac{2}{2} + \frac{15}{3} + 1 = 9\Omega$$

$$I = \frac{10}{9}\, amp$$

**6.** **(2)**

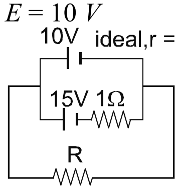



Potential at $C$ point is greater than potential at point $B$. Therefore current flow in resistance from $B$ to $A$.

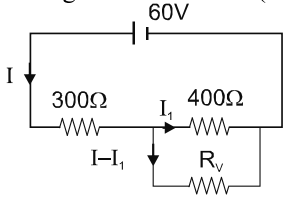
**7.** **(4)**
For ideal $r \to 0$

$$E = \frac{\frac{10}{r} + \frac{15}{1}}{\frac{1}{r} + \frac{1}{1}} = \frac{10 + 15\ r}{1 + r}$$

$E = 10\ V$




**8.** **(3)**
**case – I**
Voltage across $300\Omega = (60 - 30)\ V = 30\ V$

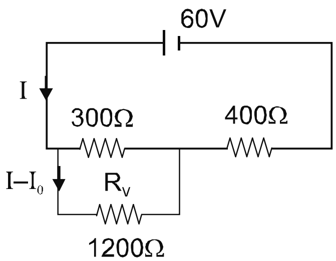


current $I = \frac{30}{300} = \frac{1}{10}$ *amp*

$I_1 = \frac{30}{400} = \frac{3}{40}$ *amp.*

$30 = (I - I_1) R_V \Rightarrow R_V = \frac{30}{\frac{1}{10} - \frac{3}{40}} = 1200\Omega$

**Case – II**




$$I = \frac{60}{400 + \frac{300 \times 1200}{1200 + 300}} = \frac{3}{32} \text{ amp.}$$

$I_0\ 300 = (I - I_0)\ 1200$

$\Rightarrow I_0 = \frac{1200}{1500} I$

$= \frac{4}{5} \times \frac{3}{32} = \frac{3}{40}$ *amp* $\left( as\ I = \frac{3}{32} amp \right)$

Reading of voltmeter

$= \frac{3}{40} \times 300 = \frac{900}{40} = 22.5\ V$

**9.** **(3)**

From relation $\vec{J} = \sigma \vec{E}$, the current density $\vec{J}$ at any point in ohmic resistor is in direction of electric field at that point. In space having non-uniform electric field, charges released from rest may not move along ELOF. Hence statement 1 is true while statement 2 is false.

**10.** **(1)**

$R = \rho \frac{\ell}{A} = \rho \frac{\ell^2}{V} \qquad \Rightarrow R \propto \ell^2$

as $\ell \longrightarrow 2\ell$

$\Rightarrow R \longrightarrow 4R$

$\Rightarrow$ % change in $R$ = 300 %

**11.** **(4)**

$x = \frac{\rho \times 4a}{a \times 2a} = 2\frac{\rho}{a}$

$y = \frac{\rho \times a}{4a \times 2a} = \frac{1}{8}\frac{\rho}{a}$

$z = \frac{\rho \times 2a}{4a \times a} = \frac{1}{2}\frac{\rho}{a}$

so, $x > z > y$

**12.** **(2)**

$R_{eq} = \frac{R/2 \times 2R}{R/2 + 2R} = \frac{2R}{5}$

**13.** **(2)**

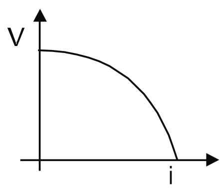
$\rho_{eq} \frac{2\ell}{A} = \rho_1 \frac{\ell}{A} + \rho_2 \frac{\ell}{A}$

$\rho_{eq} = 1/2\ (\rho_1 + \rho_2)$

**14.** **(4)**

Given $r \propto i$

$\Rightarrow r = ki\ V = E - ir = E - i(ki)\ V = -i^2 k + E$

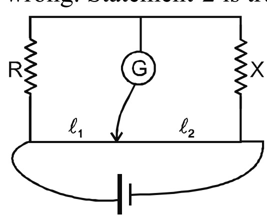



**15.** **(4)**

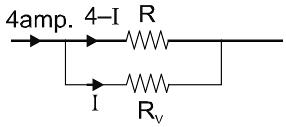
$Rl_2 = l_1 X$

$X = \frac{\ell_2 R}{\ell_1}$

To keep same null point, means $l_1$ and $l_2$ are same. As temperature increases value of unknown resistance increases. To get same null point, $R$ must be increased. So statement 1 is wrong. Statement-2 is true.



**16.** **(3)**




$(4 - I) R = IR_V = 20$

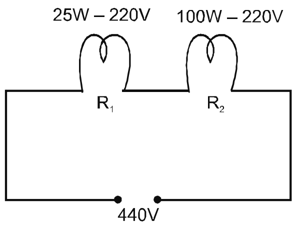
$(4 - I) R = 20$

$4 - I$ is less than 4

$4 - I , 4$

So that, $R$ is greater than $5\Omega$

**17.** **(3)**

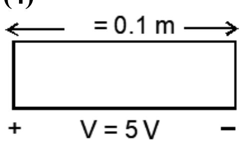



As $R_1 = \frac{220}{25} \times 220$ and $R_2 = \frac{220}{100} \times 220$

Hence $R_1 : R_2 = 4 : 1$

When connected in series, the voltage divides in the ratio of their resistance. The voltage of 440V divides in such a way that voltage across 25W bulb will be more than 220 V. Hence 25 W bulb will fuse.

**18.** **(4)**




$v_d = 2.5 \times 10^{-4}\ m/s$

$n = 8 \times 10^{28}\ /m^3$

$I = ne\ A\ v_d$

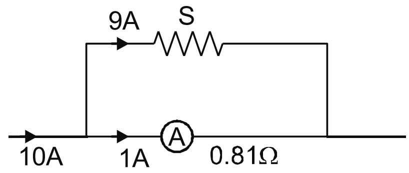
$\frac{VA}{\rho \ell} = ne\ A\ v_d$

$\rho = \frac{V}{nev_d \ell}$

$= \frac{5}{8 \times 10^{28} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-4} \times 0.1}$

$= 1.6 \times 10^{-5}\ \Omega\ m$

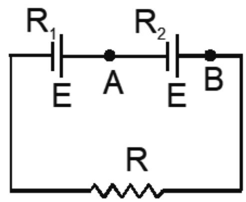
**19.** **(1)**




$0.8 \times 1 = 9\ S$

$\Rightarrow S = 0.09\Omega$

**20.** **(2)**




$R_{eq} = R_1 + R_1 + R$

$\therefore\ I = \frac{2E}{R_1 + R_2 + R}$

According to the questions, $V_A - V_B = E - IR_2$

$0 = E - IR_2$

$E = IR_2$

$E = \frac{2E}{R_1 + R_2 + R} . R_2$

$R_1 + R_2 + R = 2R_2$

$\therefore\ R = R_2 - R_1$

**21.** **(3)**

Total power $(P) = (15 \times 40) + (5 \times 100)$
$+ (5 \times 80) + (1 \times 1000) = 2500\ W$

$P = VI$

$\Rightarrow I = \frac{2500}{220} A = \frac{125}{11} = 11.3\ A$

Minimum capacity should be 12 $A$

**22.** **(3)**

The drift velocity of electrons in a conducting wire is of the order of 1 $mm/s$. But electric field is set up in the wire very quickly, producing a current through each cross section, almost intantaneousty.

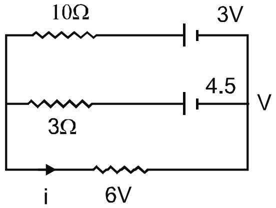
**23.** **(4)**

$$S = \frac{i_g G}{I - i_g}$$

here $i_g = 10^{-3}\ A\ G = 10^2\Omega,\ I = 10A$

$S \simeq 10^{-2}\Omega$

**24.** **(1)**




$$E_{eq} = \frac{\frac{4.5}{3} + \frac{3}{10}}{\frac{1}{3} + \frac{1}{10}} = \frac{54}{13} = V$$

$$r_{eq} = \frac{3 \times 10}{13} = \frac{30}{13}\Omega$$

$$i = \frac{54/13}{6 + \frac{30}{13}} = \frac{54}{108} = \frac{1}{2}\ amp.$$

$$\Rightarrow V_{6\Omega} = i.R = \frac{1}{2} \times 6 = 3V$$

Therefore current in 10Ω is zero.

**25.** **(3)**

Let $R = R_0$ at 0ºC

$5 = R_0\,(1 + \alpha \times 50)$ .......(i)

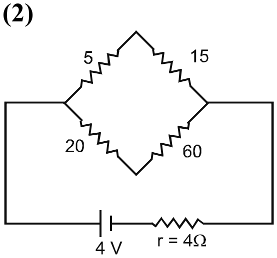
$\Rightarrow 6 = R_0\,(1 + \alpha \times 100)$ ........(ii)

Solving (i) and (ii) $\Rightarrow$ $R_0 = 4\Omega$

**26.** **(2)**

The ratio $\frac{AC}{CB}$ will remain unchanged.

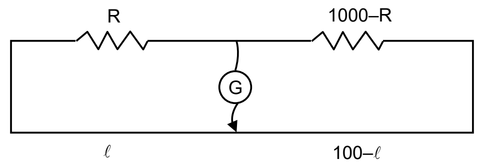
**27.** **(2)**




$$\Rightarrow R_{eq} = \frac{80 \times 20}{80 + 20} + 4 = 20\Omega$$

$$\Rightarrow I = \frac{V}{R} = \frac{4}{20} = \frac{1}{5}A$$

**28.** **(1)**




Say resistances are $R$ and $1000 - R$

For case-I $\frac{R}{\ell} = \frac{1000 - R}{100 - \ell}$

For case-II $\frac{1000 - R}{\ell - 10} = \frac{R}{110 - \ell}$

Multiplying both equation

$$\frac{R(1000 - R)}{\ell(\ell - 10)} = \frac{(1000 - R)R}{(100 - \ell)(110 - \ell)}$$

$\Rightarrow l^2 - 10l = 11000 + l^2 - 210\,l$

$\Rightarrow 200\,l = 11000$

$\Rightarrow l = 55\ cm$

putting in first equation

$$\frac{R}{55} = \frac{1000 - R}{45}$$

$45R = 55000 - 55R$

$R = 550\ \Omega$

**29.** **(1)**

Let each resistance value is r

$R_{PR} = \frac{5}{11}r,\ R_{PQ} = \frac{4}{11}r$ and $R_{RQ} = \frac{3}{11}r$

$\therefore R_{PR}$ is maximum

**30.** **(2)**

In an electric circuit containing a battery, the positive charge inside the battery may go from the positive terminal to the negative terminal

**31.** **(3)**

For balanced meter bridge

$$\frac{X}{R} = \frac{\ell}{(100-\ell)}$$

$$\Rightarrow \frac{X}{l} = \frac{R}{100-l}$$

$$\frac{X}{40} = \frac{90}{60} \quad \Rightarrow X = 60\Omega$$

$$X = R\frac{\ell}{(100-\ell)}$$

$$\frac{\Delta X}{X} = \frac{\Delta\ell}{\ell} + \frac{\Delta\ell}{100-\ell} = \frac{0.1}{40} + \frac{0.1}{60}$$

$\Delta X = 0.25$

so $X = (60 \pm 0.25)\ \Omega$

**32.** **(4)**

Let $R$ be their individual resistance at 0ºC. Their resistance at any other temperature t is $R_1 = R(1 + \alpha_1 t)$ and $R_2 = R(1 + \alpha_2 t)$.

In series

$R_{\text{series}} = R_1 + R_2 = R[2 + (\alpha_1 + \alpha_2).t]$

$$= 2R\left[1 + \frac{\alpha_1 + \alpha_2}{2}t\right].$$

$$\alpha_{\text{Series}} = \frac{\alpha_1 + \alpha_2}{2}$$

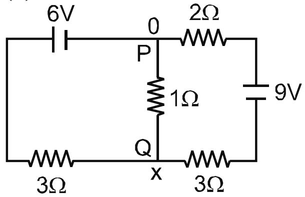
In Parallel

$$R_{\text{Parallel}} = \frac{R_1 + R_2}{R_1 + R_2} = \frac{R(1+\alpha_1 t)R(1+\alpha_2 t)}{R(2+\alpha_1+\alpha_2)t)}$$

$$\approx \frac{R^2(1+\alpha_1+\alpha_2)t)}{2R(1+\frac{\alpha_1+\alpha_2}{2}t)} \approx \frac{R}{2}\left(1+\frac{\alpha_1+\alpha_2}{2}t\right)$$

$$\alpha_{\text{Parallel}} = \frac{\alpha_1 + \alpha_2}{2}.$$

**33.** **(3)**




$$\frac{x-6}{3} + \frac{x-0}{1} + \frac{x+9}{5} = \mathbf{0}$$

$$x = \frac{3}{23}$$

$$i = \frac{x-0}{1} = \frac{3}{23} = 0.13\ A$$

from $Q$ to $P$

**34.** **(2)**

From Kirchoff's junction law, current in 2Ω is zero, because 2Ω resistance is not a part of closed circuit.

**35.** **(3)**

$\rho_B = 2\rho_A \quad r_B = 2r_A$

$$R_A = R_B \quad \Rightarrow \rho_A\left(\frac{\ell_A}{\pi r_A^2}\right) = \rho_B\left(\frac{\ell_B}{\pi r_B^2}\right)$$

$$\Rightarrow \frac{\ell_A}{\ell_B} = \frac{1}{2}$$

**36.** **(2)**

$V = Al$

By differentiation $0 = ldA + Adl$ ....(1)

$$R = \frac{\rho\ell}{A} \qquad (\because V = Al \text{ const.})$$

By differentiation $dR$

$$= \frac{\rho(Ad\ell - \ell dA)}{A^2} \qquad ....(2)$$

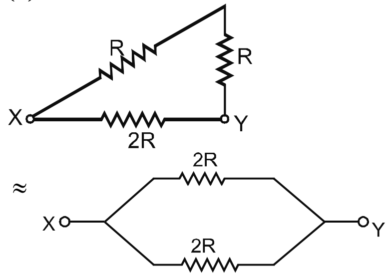
$$dR = \rho\frac{2Ad\ell}{A^2}$$

$$dR = \frac{2\rho d\ell}{A} \text{ or } \frac{dR}{R} = 2.\frac{d\ell}{\ell}$$

$$\text{So } \frac{dR}{R}\% = 2.\frac{d\ell}{\ell}\% = 2 \times 0.1\%$$

$$\frac{dR}{R}\% = 0.2\%$$

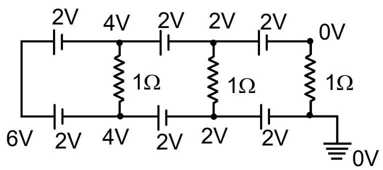
**37.** **(1)**




$R_{eq} = R$

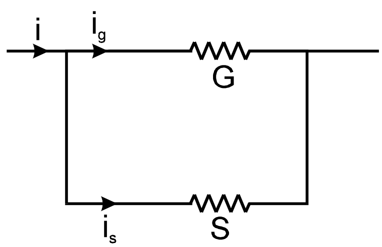
**38.** **(3)**
In semiconductor resistance decrease with increase in the temperature. Therefore resistivity also decrease. In conducting solid resistance increase with increase the temperature because the rate of collisions between free electron and ions increases with increase of temperature both the statements are true.

**39.** **(1)**




p.d. across each resistance is zero so current is also zero.

**40.** **(4)**




$i = i_g + i_s$ .........(1)

$i_g G = i_s S$ .........(2)

from (1) & (2) (putting $i_g = 0.1$ mA, $G = 100\Omega$) we have

$i = 100.1$ mA

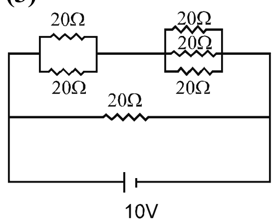
**41.** **(4)**

$$\frac{R_1}{R_2} = \frac{A_2}{A_1} = \frac{\pi r^2}{4\pi r^2} = \frac{1}{4}$$

$$\therefore \frac{V_1}{V_2} = \frac{R_1}{R_2} = \frac{1}{4}$$

$V_{BC} = 4V_{AB}$

**42.** **(3)**




$$R_{eq} = \frac{\left(\frac{20}{2} + \frac{20}{3}\right) \times 20}{\frac{20}{2} + \frac{20}{3} + 20} = \frac{50 \times 20}{110}$$

$$\Rightarrow R_{eq} = \frac{100}{11}\Omega$$

$$P = \frac{V^2}{R} = \frac{(10)^2}{100/11} = 11\ W.$$

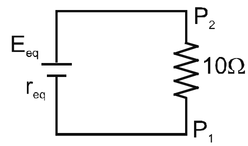
**43.** **(1)**

$$\frac{1}{2} mA\ (30) = S\ [10 - \frac{1}{2} mA]$$

$$S = \frac{30}{20000 - 1} \cong \frac{30}{20000} \cong 1.5\ m\Omega$$

**44.** **(2)**

$$E_{eq} = \left(\frac{\frac{5}{2} - \frac{2}{1}}{\frac{1}{2} + 1}\right) V \qquad r_{eq} = \frac{2 \times 1}{2 + 1} = \frac{2}{3}\ \Omega$$




$$i = \frac{E_{eq}}{10 + r_{eq}} = 0.03\ A \text{ from } P_2 \text{ to } P_1$$

**45.** **(4)**
In the presence of an applied electric field ($\vec{E}$) in a metallic conductor. The electrons also move randomly but slowly drift in a direction opposite to $\vec{E}$.

**46.** **(3)**
For $P_{max} \Rightarrow r = R_{eq}$, $R_{eq} = R/3$

$$0.1 = \frac{R}{3} \Rightarrow R = 0.3\ \Omega$$

**47.** **(2)**

$$\frac{15^2}{R_{eq}} = 150 \qquad .....(i)$$

$$R_{eq} = \frac{2R}{2+R} \qquad .....(ii)$$

Solving (i) and (ii) $R = 6\ \Omega$

**48.** **(1)**

$R_1 + R_2 = S \quad \frac{R_1 R_2}{R_1 + R_2} = P$

$S = nP \Rightarrow (R_1 + R_2)^2 = nR_1R_2$

$\Rightarrow n = \left(\frac{R_1}{R_2} + \frac{R_2}{R_1} + 2\right)$

$\Rightarrow n_{\min} = 2 + 2 = 4$

$\because \left(x + \frac{1}{x}\right)_{\min} = 2$ for $x > 0$

**49.** **(1)**

$P = \frac{V^2}{R}$

$\therefore R_{hot} = \frac{V^2}{P} = \frac{200 \times 200}{100} = 400\ \Omega$

$\Rightarrow R_{cold} = \frac{400}{10} = 40\ \Omega$

**50.** **(2)**

**51.** **(1)**

$R = \frac{20 \times 20}{20 + 20} = 10\Omega$

**52.** **(1)**

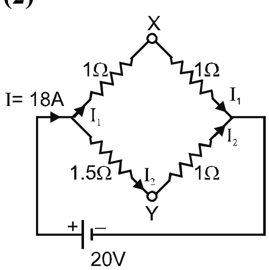
$P = V^2/R$, putting values we get $R = (22)^2$ *ohm*

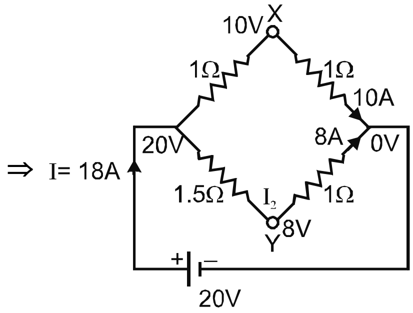
When operated at 110 $V, P' = (110)^2/R = 25$ *watt*

**53.** **(2)**

$V_R = 2V = \left(\frac{R}{500 + R}\right) \times 12 \Rightarrow R = 100\ \Omega$

**54.** **(2)**




$R_{eq} = \frac{2 \times 2.5}{2 + 2.5} = \frac{10}{9}$

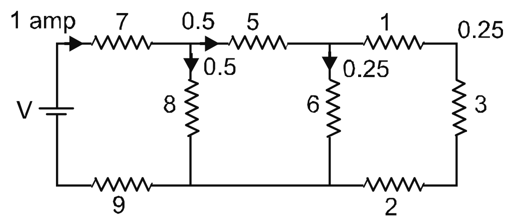
Net current $I = \frac{20}{10/9} = 18$ Amp.

$I_1 = \frac{2.5}{4.5} \times 18 = 10$ Amp.

$I_2 = 18 - 10 = 8$ Amp.

$\Rightarrow V_x - V_y = 2V$

**55.** **(2)**




$R_{eq} = 7 + 4 + 9 = 20\Omega$

$V = IR_{eq} = 1 \times 20 = 20\ V$

**56.** **(4)**

Let resistance of bulb filament is $R_0$ at 0ºC, then from expression

$R = R_0 (1 + \alpha\Delta T)$

$\therefore 100 = R_0 (1 + 0.005 \times 100)$

$200 = R_0 (1 + 0.005 \times x)$

where $x$ is temperature in ºC at which resistance become 200 Ω.

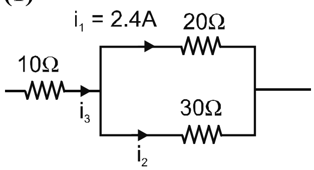
Dividing the above two equation

$\frac{200}{100} = \frac{1 + 0.005x}{1 + 0.005 \times 100} \Rightarrow x = 400$ ºC

**57.** **(1)**

$R = \frac{V}{I} \quad \Rightarrow \quad \pm\frac{\Delta R}{R} = \pm\frac{\Delta V}{V} \pm \frac{\Delta I}{I} = 3 + 3 = 6\%$

**58.** **(1)**




In parallel $2.4 \times 20 = 30\, i_2$

$\Rightarrow i_2 = \frac{2.4 \times 20}{30} = 1.6\ amp$

**59.** **(1)**

In series current remain same

$I = neAv_d$, $J = I/A$, for constant current

$v_d \propto \frac{1}{A}$ and $J \propto \frac{1}{A}$ .

**60.** **(1)**

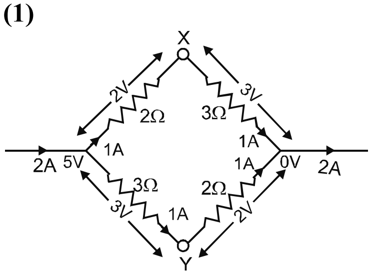
$IR = V = El \quad \Rightarrow \quad I\frac{\rho\ell}{A} = E\ell$

$\Rightarrow \quad \rho = \frac{EA}{I} = \frac{E}{J} = \frac{5 \times 10^{-2}}{10}$

$= 5 \times 10^{-3}\ \Omega\text{–}m$

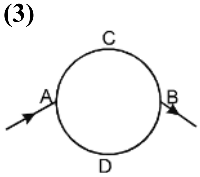
## *Integer Type Questions (61 to 75)*

**61.** **(1)**




$\Rightarrow V_x - V_y = 3 - 2 = 1V$

**62.** **(3)**




$\frac{1}{R_{eq.}} = \frac{1}{R_{ACB}} + \frac{1}{R_{ADB}}$

$2\pi r = L$

$ACB = \pi r$

$\pi r = \frac{L}{2} = \frac{12}{2} = 6$

$\frac{1}{R_{eq.}} = \frac{1}{6} + \frac{1}{6} \Rightarrow R_{eq} = 3$

**63.** **(40)**

$R_{eq} = 200 + \frac{300 \times 600}{300 + 600} + 100 = 500\ \Omega$

$I = \frac{100}{500} = \frac{1}{5}\ amp$

$I_{600} = \frac{\frac{1}{600}}{\frac{1}{300} + \frac{1}{600}} \times \frac{1}{5} = \frac{1}{15}\ amp$

Reading of volt meter $= I R_{600}$

$= \frac{1}{15} \times 600 = 40\ V$

**64.** **(4)**

Using the formula $P = \frac{V^2}{R}$ ......(i)

Where $R$ is resistance of wire, $V$ is voltage across wire and $P$ is power dissipation in wire and

$R = \frac{\rho\ell}{A}$ ......(ii)

From Eqs. (i) and (ii)

$P_1 = \frac{V^2}{\rho\ell / A} = \frac{V^2}{\rho\ell} . A$

$P_1 = \frac{V^2}{\rho\ell} . A$ ......(iii)

In 2nd case

Let $R_2$ is net resistance.

$R_2 = \frac{R \times R}{R + R} = \frac{R}{2}$

Where, $R$ is the resistance of half wire.

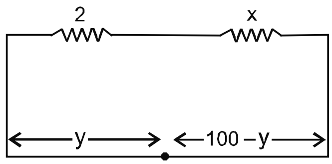
$$\therefore R_2 = \frac{\rho.\left(\frac{\ell}{2}\right)}{A.2} = \frac{\rho\ell}{4A}$$

$$\therefore P_2 = \frac{V^2}{\rho\ell}.4A \qquad .....(iv)$$

Hence, from Eqs. (iii) and (iv)

$$\frac{P_1}{P_2} = \frac{1}{4} \Rightarrow \frac{P_2}{P_1} = \frac{4}{1}$$

**65.** **(3)**



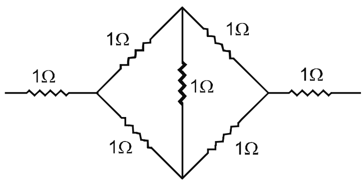

$2(100 - y) = xy$

Also $(100 - y) - y = 20$

on solving $y = 40$ cm, $x = 3\ \Omega$

**66.** **(2)**

initial $R_{eq} = 5\Omega$




final $R_{eq} = 3\ \Omega$

change in resistance = 5 – 3 = 2Ω

**67.** **(4)**

$$\frac{6}{R} = \frac{\ell}{x - \ell}$$

$$\frac{6}{R} = \frac{30}{20} \Rightarrow R = 4\Omega$$

**68.** **(4)**

$\therefore$ 2Ω and 6Ω are in parallel

$$\Rightarrow R_{eq} = \frac{3 \times (1.5 + 1.5)}{3 + (1.5 + 1.5)} = \frac{3}{2}\Omega$$

$$i = \frac{6}{R_{eq}} = 4A$$

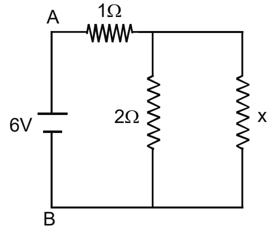
**69.** **(8)**

$$\varepsilon_{eq} = 4 + \frac{\frac{4}{1} + \frac{4}{0.5}}{\frac{1}{1} + \frac{1}{0.5}} = 4 + \frac{12}{3} = 8\ V.$$

**70.** **(2)**

Let $R_{AB} = x$. Then, we can break one chain and connect a resistance of magnitude $x$ in place of it.

Thus, the circuit remains as shown in figure.




Now, 2Ω and $x$ are in parallel. So, their combined resistance is $\frac{2x}{2 + x}$

or $R_{AB} = 1 + \frac{2x}{2 + x}$

But $R_{AB}$ is a assumed to $x$. Therefore,

$$x = 1 + \frac{2x}{2 + x}$$

Solving this equation, we get

$x = 2\ \Omega$

**71.** **(220)**

$$\frac{55}{20} = \frac{R}{80} \Rightarrow R = 220\ \Omega \ \textbf{Ans.}$$

**72.** **(5)**

$$R_{xy} = \frac{10 \times 10}{10 + 10} = 5\Omega$$

**73.** **(4)**

Formula of resistance, $R = \frac{\rho\ell}{A}$

Equivalent resistance of eight wire in parallel is R/8

According to questions,

$$R = \frac{\rho\ell}{\pi\left(\frac{d}{2}\right)^2} \Rightarrow R \propto \frac{\ell}{d^2}$$

$$\frac{R_1}{R_2} = \frac{\ell_1}{\ell_2} \times \frac{d_2^2}{d_1^2}$$

$$\Rightarrow d_2 = 4d$$

**74.** **(2)**

$$\frac{2}{3} = \frac{\frac{x}{x+1}}{x}$$

$$\Rightarrow \frac{2}{3} = \frac{1}{x+1}$$

$$\Rightarrow x = 0.5 = \frac{1}{2}$$

$n = 2$

**75.** **(100)**

Series combination gives maximum resistance whereas parallel combination gives minimum resistance.

$$R_{\max} = 10R, R_{\min} = \frac{R}{10}$$

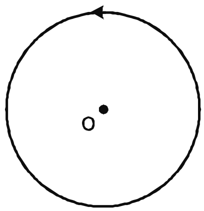
$$\therefore \frac{R_{\max}}{R_{\min}} = \frac{10R}{R/10} = 100$$

# MAGNETIC EFFECTS OF CURRENT & MAGNETISM

## Single Option Correct Type Questions (01 to 55)

**1.** **(4)**

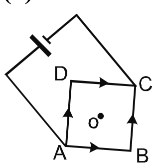
**Sol:** $B = \frac{\mu_0 i}{2r}$




$$B_0 = 10^{-7} \times \frac{q\omega}{r}$$

**2.** **(1)**

**Sol:**



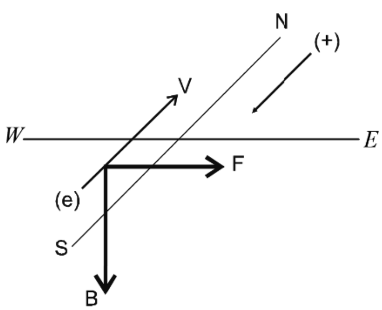

$B_0 = B_{AB} + B_{BC} + B_{AD} + B_{DC}$

Now $B_{AB} = -B_{DC}$ and $B_{AD} = -B_{BC}$

then $B_0$ = zero

**3.** **(1)**

**Sol:**




Electron beam will experience force towards east that is towards proton beam.

**4.** **(2)**

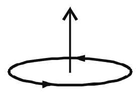
**Sol:** Magnetic field won't change speed.

**5.** **(3)**

**Sol:** The path will be helical due to the additional parallel component.

**6.** **(3)**

**Sol:**



In uniform magnetic filed force acting on a closed loop = 0.

**7.** **(1)**

**Sol:** Since, electron and proton have same momenta so, the same force will act on them by the magnetic field.

$F = qvB \sin\theta$

$= qvB$ ($\because \theta = 90^\circ$)

Hence, both will move on same trajectory (curved path)

**8.** **(3)**

**Sol:** Charge the rest produces only electric field but charge in motion produces both electric and magnetic field.

**9.** **(2)**

**Sol:** $U_i = -MB$

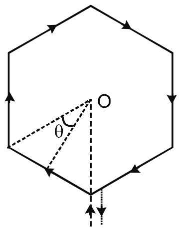
$U_f = MB$

$W = \Delta U = 2\,MB$

$= 2 \times 2.5 \times 0.2 = 1\text{J}$

**10.** **(4)**

**Sol:**




Perpendicular distance from side of "*O*" is *a* cos 30º

$r = \frac{\sqrt{3}a}{2}$

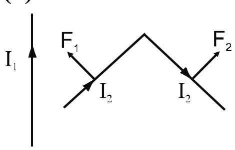
$B_{net} = 6.B,$

$= 6 \times \frac{\mu_0 i}{4\pi r}$ (sin 30º + sin 30º)

$= \frac{6 \times \mu_0 i \times 2}{4\pi.\sqrt{3}a} \times \frac{2 \times 1}{2} = \frac{\sqrt{3}\mu_0 i}{\pi a}$

**11.** **(4)**

**Sol:**




Resulted force will be at an angle with *x* as well as *y* axis due to $F_1 > F_2$

**12.** **(1)**

**Sol:** $B_0 = B_1 \odot$ and $B_2 \otimes$

as *B* due to *QP* and *RS* at "*O*" is zero

$= \frac{\mu_0 i}{4}\left(\frac{1}{r_1}\right) - \frac{\mu_0 i}{4}\left(\frac{1}{r_2}\right)$

$= \frac{\mu_0 i}{4}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

**13.** **(4)**

**Sol:** $F = qVB$

$F_{Max} = q_{Max}VB$

**14.** **(2)**

**Sol:** $F = \frac{\mu_0 I_1 I_2}{2\pi r} \times l_1 = \frac{\mu_0 1 \times 1}{2\pi \times 2} \times 1 = 10^{-7}$ N

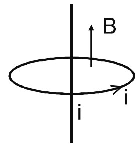
**15.** **(1)**

**Sol:** $B = \frac{\mu_0 i}{4\pi r} + \frac{\mu_0 i}{4r}$

**16.** **(3)**

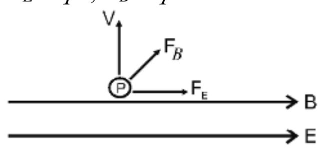
**Sol:** Field produced by loop at the centre will be along the axis of the loop i.e. || to straight wire.

So, $F = i(\vec{i} \times \vec{B}) = 0$




**17.** **(4)**

**Sol:** $F_E = qE$, $F_B = qvB$




$R = \frac{mv}{qB}$

Pitch, $p = V_{||}T$

$T = \frac{2\pi R}{v}$

$V_{||} = 0 + \frac{qE\,t}{m}$

**18.** **(4)**

**Sol:** $B = \mu_0\mu_r ni$

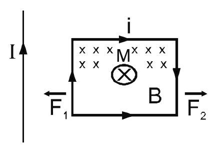
$= 10^{-7} \times 4\pi \times 4000 \times 1000 \times 5$

$= 8\pi T$

$= 25.12$ T

**19.** **(3)**

**Sol:** $\vec{M} \times \vec{B} = 0$




$\tau = 0$

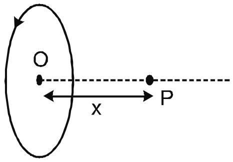
Loop will not rotate

$F_1 > F_2$

So loop move towards the wire

**20.** **(2)**

**Sol:**




$B_P = \frac{B_0}{8}$

$\frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}} = \frac{\mu_0 i}{2R\times 8}$, $R = a$ (given)

$8R^3 = (R^2+x^2)^{3/2}$

$2R = (R^2+x^2)^{1/2}$

$x^2 = 3R^2$

$x = \sqrt{3}\,R = \sqrt{3}\,a$

**21.** **(1)**

**Sol:** The magnetic field at a point on the axis of a circular loop at distance $x$ from the centre is

$$B = \frac{\mu_0 i R^2}{2\left(R^2+x^2\right)^{3/2}}$$

Given: $B = 54\ \mu T$, $x = 4$ cm, $R = 3$cm

Putting the given values we get

$$\therefore \quad 54 = \frac{\mu_0 i\times(3)^2}{2\left(3^2+4^2\right)^{3/2}}$$

$$\Rightarrow \quad 54 = \frac{9\mu_0 i}{2(25)^{3/2}} = \frac{9\mu_0 i}{2\times(5)^3}$$

$$\therefore \quad \mu_0 i = \frac{54\times 2\times 125}{9}$$

$\mu_0 i = 1500$

Now, putting $x = 0$ in equation (i), magnetic field at the centre of loop is

$$B = \frac{\mu_0 i}{2R}$$

$$= \frac{1500}{2\times 3} = 250\ \mu T$$

**22.** **(1)**

**Sol:** The force per unit length between the two wires is

$$\frac{F}{l} = \frac{\mu_0 i^2}{2\pi d}$$

The force will be attractive as current directions in both are same.

**23.** **(1)**

**Sol:** $\Rightarrow \quad W = MB\,(1-\cos\theta)$

$\Rightarrow \quad W = \frac{MB}{2}$

$\therefore \quad MB = 2W$

Torque, $\tau = MB\sin 60^\circ$

$= \frac{MB\sqrt{3}}{2} = \frac{2W\sqrt{3}}{2}$

$= W\sqrt{3}$

**24.** **(4)**

**Sol:** Magnetic force $F = qvB$ ........ (i)

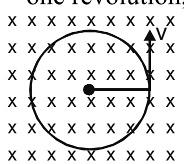
Centripetal force

$F = \frac{mv^2}{r}$ ....... (ii)

From Eq. (i) and (ii),

$$\frac{mv^2}{r} = qvB \Rightarrow r = \frac{mv}{qB}$$

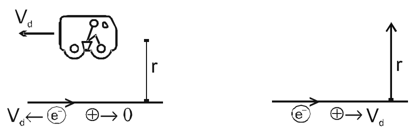
The time taken by the particle to complete one revolution,




$$T = \frac{2\pi r}{v} = \frac{2\pi mv}{qB} = \frac{2\pi m}{qB}$$

**25.** **(1)**

**Sol:** In observer frame of reference



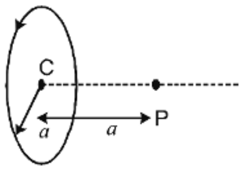

$$B = \frac{\mu_0 i}{2\pi r}$$

**26. (1)**

**Sol:** When electron is projected in an electric field, then velocity of electron will decrease.

**27. (3)**

**Sol:**




$$\frac{B_C}{B_P} = \frac{\mu_0 i/2a}{\mu_0 i a^2/2(a^2+a^2)^{3/2}} = \frac{2\sqrt{2}}{1}$$

**28. (2)**

**Sol:** Due to flow of current in same direction in two adjacent sides, an attractive magnetic force will be produced due to which spring will get compressed.

**29. (1)**

**Sol:** $dB = \frac{\mu_0(dq)}{2r}\left(\frac{\omega}{2\pi}\right)$

$B = \int dB = \frac{\mu_0\omega}{4\pi}.\frac{Q}{\pi R^2}2\pi\int_0^R \frac{rdr}{r}$

$B = \frac{\mu_0\omega Q}{2\pi R^2}.R$

$B = \frac{\mu_0\omega Q}{2\pi R}$

$B \propto \frac{1}{R}$

**30. (3)**

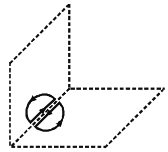
**Sol:** For stable equilibrium angle should be zero and for unstable equilibrium angle between $\vec{M}$ and $\vec{B}$ should be $\pi$.

**31. (4)**

**Sol:** $\oint_{ABCDA} \vec{B}.\vec{dl} = \oint_{ABCA} \vec{B}.\vec{dl} + \oint_{CDAC} \vec{B}.\vec{dl}$

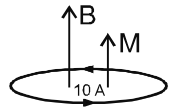
$= \mu_0(i_1 + i_3) + \mu_0(i_2 - i_3)$

$= \mu_0(i_1 + i_2)$



**32. (1)**

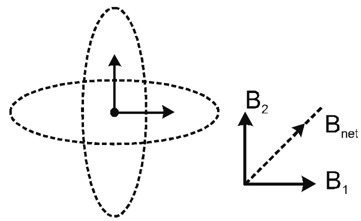
**Sol:**




$\vec{\tau} = \vec{M}\times\vec{B} = 0$

**33. (2)**

**Sol:**




$B_1 = \frac{\mu_0 I N}{2R}$

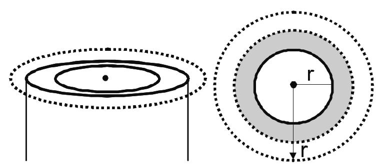
$B_2 = \frac{\mu_0\sqrt{3}IN}{2R}$

$B_{net} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0 IN}{2R}(1+3)^{1/2} = \frac{\mu_0 IN}{2R}.2$

$B_{net} = \frac{\mu_0 IN}{R}$

**34. (2)**

**Sol:** $\oint \vec{B}.\vec{dl} = \mu_0 \frac{i}{\pi R^2}\times\pi r^2$



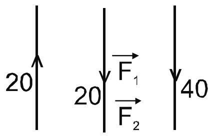

$= \frac{\mu_0 i r^2}{R^2}$

$\oint \vec{B}.\vec{dl} = \mu_0 i$

**35.** **(2)**

**Sol:** $F_1 = \dfrac{\mu_0(20\times20)}{2\pi l}$

$F_2 = \dfrac{\mu_0(20\times40)}{2\pi l}$




$F_1$ and $F_2$ both points in the same direction towards 40 *A* wire.

**36.** **(2)**

**Sol:** $r = \dfrac{\sqrt{2mE}}{Bq}$ (K.E = $E$)

$r \propto \dfrac{\sqrt{m}}{q}$

$r_p = k\dfrac{\sqrt{m}}{q}$ ($k$ = constant)

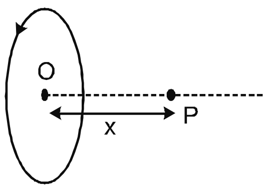
$r_D = k\dfrac{\sqrt{2m}}{q}$

$r_\alpha = k\dfrac{\sqrt{4m}}{2q} = \dfrac{k\sqrt{m}}{q}$

$\therefore\ r_p = r_\alpha < r_d$.

**37.** **(2)**

**Sol:**




$B_P = \dfrac{B_0}{8}$

$\dfrac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}} = \dfrac{\mu_0 i}{2R\times27}$, $R = a$ (given)

$27R^3 = (R^2+x^2)^{3/2}$

$3R = (R^2+x^2)^{1/2}$

$x^2 = 8R^2$

$x = 2\sqrt{2}a$ .

**38.** **(3)**

**Sol:** Magnetic field won't play any roll.

**39.** **(2)**

**Sol:** The magnetic field at the centre of circular coil is

$B = \dfrac{\mu_0 i}{2r}$

where $r$ = radius of circle = $\dfrac{1}{2\pi}$

$(\because\ l = 2\pi r)$

$r = \dfrac{1}{2\pi}$ $(\because\ l = 2\pi r)$

$\therefore\ B = \dfrac{\mu_0 i}{2}\times\dfrac{2\pi}{1}$

$= \dfrac{\mu_0 i\pi}{1}$ ...............(i)

when wire of length $l$ bents into a circular loops of $n$ turns, then

$l = n\times 2\pi r'$

$\Rightarrow r' = \dfrac{1}{n\times2\pi}$

Thus, new magnetic field

$B' = \dfrac{\mu_0 ni}{2r'} = \dfrac{\mu_0 ni}{2}\times\dfrac{n\times2\pi}{1}$

$= \dfrac{\mu_0 i\pi}{1}\times n^2$

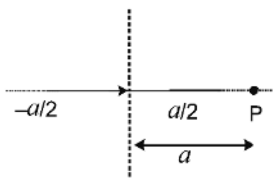
$= n^2B$ [From eq (i)]

**40.** **(2)**

**Sol:**

**41.** **(2)**

**Sol:**



Point $P$ on the extended part of line thus

$B_P$ = zero = 0

**42. (3)**

**Sol:** $B_1 = \dfrac{\mu_0 i}{2\pi a^2} r$ where $0 \le r \le a$, $B_1$

$= \dfrac{\mu_0 i}{2\pi a^2} \cdot \dfrac{a}{2}$ $\left(\text{at } r = \dfrac{a}{2}\right)$

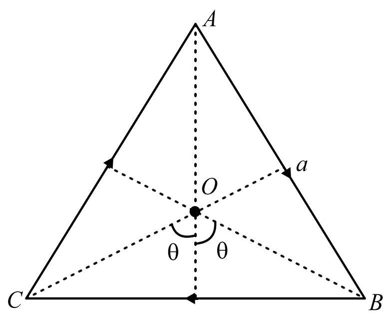
$B_1 = \dfrac{\mu_0 i}{4\pi a}$, $B_2 = \dfrac{\mu_0 i}{2\pi(2a)}$

$\dfrac{B_1}{B_2} = 1$

**43. (4)**

**44. (4)**

**Sol:**




$\theta = 60^\circ$

Perpendicular distance of $C$ from any side

$B = 3B_1$ as $B_{AB} = B_{BC} = B_{CA}$

$= B_1 = \dfrac{3 \times \mu_0 i}{4\pi r}(\sin\theta_1 + \sin\theta_2)$

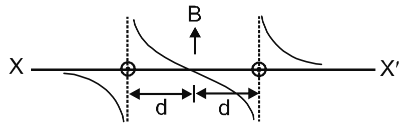
$r = \dfrac{a}{2\sqrt{3}}$ and $\theta_1 = 60^\circ = \theta_2$

$B_C = \dfrac{3 \times \mu_0 i\ 2\sqrt{3}}{4\pi\ a} \times \dfrac{2 \times \sqrt{3}}{2}$

$B_C = \dfrac{9\mu_0 i}{2\pi\ a}$

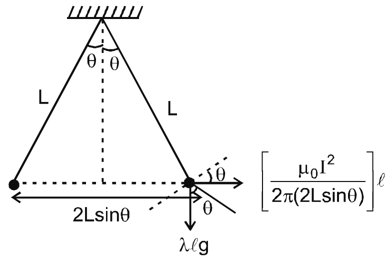
**45. (1)**

**Sol:**




Towards left of both wires direction of $B$ is downward and at mid point between two wires, magnetic field is zero

**46. (2)**




**Sol:**

$\lambda \ell g \sin\theta = \dfrac{\mu_0 I^2}{2\pi(2L\sin\theta)} \ell \cos\theta$

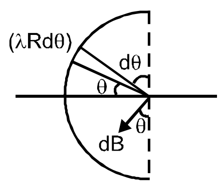
$2\sin\theta \sqrt{\dfrac{\lambda g \pi L}{\mu_0 \cos\theta}} = I.$

**47. (1)**

**Sol:** $\lambda = \dfrac{I}{\pi R}$

$dB = \dfrac{\mu_0 dI}{2\pi R}$

$\therefore B = \displaystyle\int_{-\pi/2}^{\pi/2} dB\cos\theta$



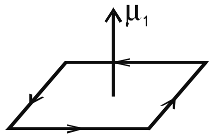

$= \dfrac{\mu_0 \lambda}{2\pi} \displaystyle\int_{-\pi/2}^{\pi/2} \cos\theta\ d\theta$

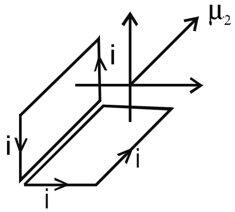
$= \dfrac{\mu_0 \lambda}{\pi} = \dfrac{\mu_0 I}{\pi^2 R}$

**48.** **(3)**

**Sol:** $\mu_1 = L^2 I$

$$\mu_2 = \sqrt{2} \times L \times \frac{L}{2} I$$




$$\mu_2 = \frac{L^2}{\sqrt{2}}$$

$$\frac{\mu_1}{\mu_2} = \sqrt{2}$$

**49.** **(1)**

**Sol:** Electrons, protons, and helium atoms are deflected in magnetic field so, the compound can emit electrons, protons and $He^{2+}$

**50.** **(4)**

**Sol:** The current through solid metallic cylinder also produces magnetic field inside the cylinder. Hence statement-1 is false

**51.** **(4)**

**Sol:** Since both charged particles move along same straight line, the magnetic field due to one particle at location of other is zero. Hence there is no magnetic interaction amongst the charged particles.

**52.** **(1)**

**Sol:** Magnetic force cannot do any work, so kinetic energy remains constant. Since initial velocity is perpendicular to magnetic field, hence momentum will change.

**53.** **(1)**

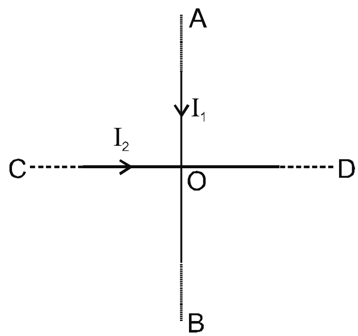
**Sol:** (A) Uniform electric field exerts constant force on the charged particle, hence the particle may move in straight line or a parabolic path.

(B) Under action of uniform magnetic field, the charged particle may move in straight line when projected along or opposite to direction of magnetic field. The charged particle moves in circle when it is projected perpendicular to the magnetic field. If the initial velocity of the charged particle makes an angle between 0° and 180° (except 90°) with magnetic field, the particle moves along a helical path of uniform pitch.

(C) If charged particle is shot parallel to both fields it moves along a straight line. If the charged particle is shot at any angle with both the field (except 0° and 180°), the particle moves along a helix with nonuniform pitch.

**54.** **(2)**

**Sol:** Magnetic field due to *AB* and *CD* are $\frac{\mu_0 I_1}{2\pi d}$ and $\frac{\mu_0 I_2}{2\pi d}$ respectively




$$B_{net} = \frac{\mu_0}{2\pi d}\sqrt{I_1^2 + I_2^2}$$

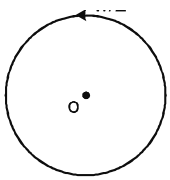
**55.** **(3)**

**Sol:** Magnetic field inside the infinitely long pipe is zero at all points.

## Integer Type Questions (56 to 69)

**56.** **(6)**

**Sol:** $B = \dfrac{\mu_0 i}{2R}$




$= \dfrac{\mu_0 qf}{2R}$

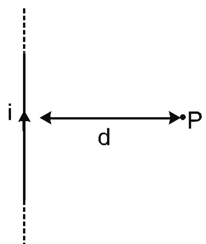
$= \dfrac{\mu_0}{2R}\dfrac{q\omega}{2\pi}\left(f = \dfrac{\omega}{2\pi}\right)$

or $B = \dfrac{\mu_0 100\times1.6\times10^{-19}\times10^{11}\times2\pi}{4\pi\times0.8}$

$B = 10^{-6}\,\mu_0$

**57.** **(2)**

**Sol:**



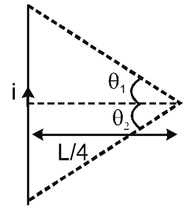

$B_P = \dfrac{\mu_0 i}{2\pi d}$

$B = \dfrac{\mu_0 i}{2\pi(d/2)}, \left(\text{at } x = \dfrac{d}{2}\right)$

$\Rightarrow \quad B_{(d/2)} = 2B$

**58.** **(4)**

**Sol:** $B = \dfrac{\mu_0 i}{4\pi R}$ $(\sin\theta_1 + \sin\theta_2)$




$\sin\theta_1 =$

$\dfrac{L/2}{\sqrt{(L/2)^2+(L/4)^2}} = \dfrac{1}{2\left(\sqrt{1/4+1/16}\right)} = \dfrac{4}{2\sqrt{5}}$

$\Rightarrow B = \dfrac{\mu_0 i}{4\pi R}\left(\dfrac{2\times4}{2\sqrt{5}}\right)$

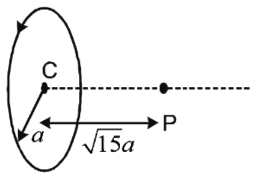
$B = \dfrac{4\mu_0 i}{\sqrt{5}\pi L}$

**59.** **(8)**

**Sol:** Formula based

**60.** **(64)**

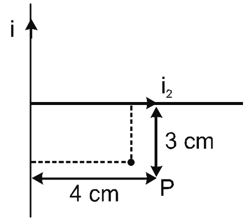
**Sol:**




$\dfrac{B_C}{B_P} = \dfrac{\mu_0 i/2a}{\mu_0 i a^2/2(a^2+15a^2)^{3/2}} = 64$

**61.** **(19)**

**Sol:**




$B_P = B_1\odot + B_2\odot$

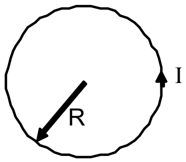
$= \dfrac{\mu_0}{2\pi}\dfrac{i_1}{r_1} + \dfrac{\mu_0}{4\pi}\dfrac{i_2}{r_2} + \dfrac{\mu_0}{4\pi}\dfrac{i_2}{r_2 5}\times\dfrac{4}{5}$

$= \dfrac{2\times10^{-7}\times2}{4\times10^{-2}} + \dfrac{10^{-7}\times1.5}{3\times10^{-2}} + \dfrac{10^{-7}\times1.5\times4}{15\times0^{-2}}$

$= \dfrac{19}{10}\times10^{-5}$ N/A–m

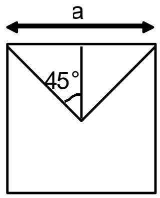
**62.** **(8)**

**Sol:**




Magnetic field at centre of circle

$B_A = \frac{\mu_0 I}{2R} = \frac{\mu_0 I\pi}{\ell}$ [Also $l = 2\pi R$]




Magnetic field at centre = $\frac{4\mu_0 I}{4\pi \frac{a}{2}}(2\sin 45°)$

$B_B = \frac{16\mu_0 I}{\sqrt{2}\pi\ell}$ [Also $4a = l$]

**63.** **(1)**

**Sol:** Magnetic field at centre of circular coil A is

$B_A = \frac{\mu_0 Ni}{2R}$

*R* is radius and *i* is current flowing in coil.

Similarly $B_B = \frac{\mu_0 N(2i)}{2.(2R)}$

$= \frac{\mu_0 Ni}{2R} = \frac{B_A}{B_B} = 1$

**64.** **(5)**

**Sol:** $\vec{F} = q[\vec{E} + \vec{v} \times \vec{B}]$

**65.** **(2)**

**Sol:** Force acting between two current carrying conductors

$F = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} l$ ..........(i)

where $d$ = distance between the conductors,

$l$ = length of each conductor

Again $F' = \frac{\mu_0}{2\pi}\frac{(-6I_1)(I_2)}{(3d)}.l$ ........(ii)

$= -\frac{\mu_0}{2\pi}.\frac{6I_1I_2}{3d} l$

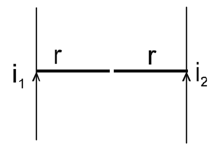
Thus, from equations (i) and (ii)

$\frac{F'}{F} = -2$

$\Rightarrow F' = 2F$

**66.** **(2)**

**Sol:**




$i_1 > i_2$

$\frac{\mu_0}{2r}(i_1 - i_2) = 10$

$\frac{\mu_0}{2r}(i_1 + i_2) = 30$

$\frac{i_1 + i_2}{i_1 - i_2} = \frac{3}{1} \Rightarrow \frac{i_1}{i_2} = \frac{2}{1}$

**67.** **(2)**

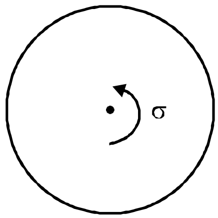
**Sol:** $R = \frac{mV}{qB}$

$\frac{R_1}{R_2} = \frac{V_1}{V_2} = 1 : 3$

**68.** **(4)**

**Sol:** $\frac{q}{2m} = \frac{\text{Magnetic dipole moment}}{\text{Angular momentum}}$

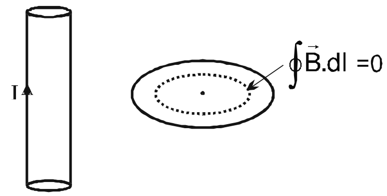
$\therefore$ Magnetic dipole moment(M)




$$M = \frac{q}{2m} \cdot \left(\frac{mR^2}{2}\right) \cdot \omega$$

$$= \frac{1}{4}\sigma.\pi R^4 \omega.$$

**69.** **(0)**




**Sol:**

$$\oint \vec{B}.\vec{dl} = 0$$

# MAGNETISM AND MATTER

## Single Option Correct Type Questions (01 to 20)

**1.** **(1)**

**Sol.** Diamagnetic property do not depend on the temperature

**2.** **(3)**

**Sol.** In non-polar molecules, centre of positive charge coincides with centre of negative charge. Hence, net dipole moment becomes zero.

When non-polar material is placed in external electric field, centre of charge does not coincide. Hence, they give non-zero moment.

**3.** **(3)**

**Sol.** When a soft ferromagnetic substance is placed in an external magnetic field, the size of domain lying in the direction of external magnetic field increases while size of domain lying in the opposite direction of field decreases if field is weak. However, if field is strong then the domain rotate in the direction of external magnetic field due to strong torque.

**4.** **(2)**

**Sol.** I: Ferromagnet becomes paramagnet at high temperature.

II: Domains area of ferromagnet tends to decrease at high temperature.

**5.** **(2)**

**Sol.** In ferromagnetic material , below Curie's temperature, a domain is defined as macroscopic region with saturation magentisation.

**6.** **(4)**

**Sol.** Magnetic field inside perfectly diamagnetic material remains zero.

**7.** **(1)**

**Sol.** As magnetic field lines going inside is equal to the magnetic field lines coming out.

$\Rightarrow \ \phi_i = -\phi_0$

**8.** **(3)**

**Sol.** Both A and R are true and R is the correct explanation of A

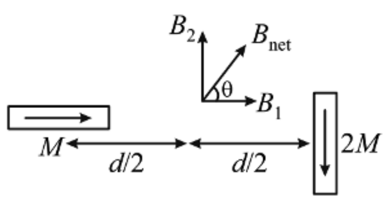
**9.** **(1)**

**Sol.** After some time, the magnet will move with constant speed because of two equal force on magnet.

**10.** **(4)**

**Sol.** For dipole $X$:

$$B_1 = 2\left(\frac{\mu_0}{4\pi}\right)\frac{M}{(d/2)^3}$$

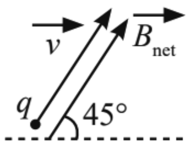



For dipole Y:

$$B_2 = \left(\frac{\mu_0}{4\pi}\right)\frac{2M}{(d/2)^3}$$

$\because B_1 = B_2$

$\therefore\ B_{net}$ is at 45° from the horizontal line.




Velocity of charge q at 45° from the horizontal line.

Force on charge,

$\vec{F} = q\left(\vec{v} \times \vec{B}\right) = 0$

**11.** **(4)**

**Sol.** Current sensitivity = voltage sensitivity ×R

Since current sensitivity is made 1.5 times. Therefore.

R also increases 1.5 times

Hence, voltage sensitivity

$= \dfrac{1.5 \text{ current sensitivity}}{1.5R}$ = no change

**12.** **(1)**

**Sol.** $\because\ T = 2\pi\sqrt{\dfrac{1}{\mu B}}$

$$\frac{T_h}{T_c} = \sqrt{\frac{I_h}{I_c} \times \frac{\mu_c}{\mu_h}} = \sqrt{\frac{2I_c}{I_c} \times \frac{\mu_c}{2\mu_c}} = 1$$

$\therefore T_h = T_c$

**13** **(4)**

**14.** **(1)**

**Sol.** If the temperature of a ferromagnetic material is raised above a certain critical value, called the Curie temperature, the exchange coupling ceases to be effective. Most such materials then become simply paramagnetic; that is, the dipoles still tend to align with an external field but much more weakly, and thermal agitation can now more easily disrupt the alignment.

**15.** **(4)**

**Sol.** The curie temperature or curie point of a ferromagnetic material is the temperature above which it loses its characteristic ferromagnetic ability to possess a net magnetization in the absence of an external magnetic field. Hence, above curie temperature material is purely paramagnetic.

**16.** **(1)**

**Sol.** Domain formation is the necessary feature of ferromagnetism

**17.** **(4)**

**Sol.** $F = \dfrac{\mu_0}{4\pi}.\dfrac{m_1 m_2}{r_2}$ …….(i)

When pole strength of each pole become double

$\therefore\ F' = \dfrac{\mu_0}{4\pi}.\dfrac{(2m_1)(2m_2)}{(2r)^2} = F$

**18.** **(2)**

**19.** **(2)**

**Sol.** When a paramagnetic liquid is taken in U-tube and one arm is placed between the poles of strong magnet, the liquid is feebly attracted by the magnet. Therefore, the level of the solution in the arm rises.

**20.** **(2)**

## *Integer Type Questions (21 to 29)*

**21.** **(14)**

**Sol.** Work done (W) = change in potential energy $(\Delta / U)$

$W = -MB\cos\theta_2 - (-MB\cos\theta_1)$

$= = -MB[\cos\theta_2 - \cos\theta_1]$

$= -2\times10^5 \times 14\times10^{-5}(c0s60^{o} - \cos 0^{o}) = -28\left(\dfrac{1}{2}-1\right) = 14J$

**22.** **(4)**

**Sol.** $M \propto \dfrac{B}{T}$

$\Rightarrow \dfrac{M_2}{M_1} = \dfrac{B_2}{B_1} \times \dfrac{T_1}{T_2} \Rightarrow \dfrac{x}{6} = \dfrac{0.3}{0.4} \times \dfrac{4}{24}$

$\Rightarrow\ x = 0.75A/m$

**23.** **(4)**

**Sol.** $W = -MB(\cos\theta_2 - \cos\theta_1)$

$W = 2MB = 2\times 5\times 0.4 = 4J$

**24.** **(8)**

**Sol.** $T_1 = 3\,\text{sec}, T_2 = 4\,\text{sec}, \frac{I_1}{I_2} = \frac{3}{2}$

Formula,

$T = 2\pi\sqrt{\frac{I}{\mu B}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{I_1\mu_2}{\mu_1 I_2}}$

$\Rightarrow \frac{\mu_2}{\mu_1} = \frac{I_2}{I_1}\times\left(\frac{T_1}{T_2}\right)^2 = \frac{2}{3}\times\frac{9}{16} = \frac{3}{8}$

$\therefore\ \frac{\mu_1}{\mu_2} = \frac{8}{3}$

**25.** **(2)**

**Sol.** $\tau = MB\sin\theta$

$0.018 = M\times 0.06\times 0.5 \Rightarrow M = 0.6Am^2$

$W = U_f - U_i = MB(\cos\theta_i - \cos\theta_f)$

$= 0.6\times 0.06(1-(-1)) = 7.2\times 10^{-2}J$

**26.** **(1)**

**Sol.** For the equilibrium of the coil of a moving coil galvanometer, $\tau = K\theta$

Where $k$ is torsional constant

$\Rightarrow\ NiAB = K\theta$

$\Rightarrow\ A = \frac{K\theta}{NiB} = \frac{4\times 10^{-5}\times 0.05}{200\times 10\times 10^{-3}\times 0.01}$

$\Rightarrow A = 1cm^2$

**27.** **(250)**

**Sol.** Fractional change in magnetic moment is

$\frac{\Delta M}{M} = \frac{\Delta\mu_r}{\mu_r} = \frac{250}{500} = \frac{1}{2}$

$\Rightarrow \frac{x}{500} = \frac{1}{2} \Rightarrow x = 250$

**28.** **(2)**

**Sol.** Time period $T = 2\pi\sqrt{\frac{I}{MB}}$

$T = 2s,\ I' = \frac{I}{2}, M' = \frac{M}{2}$

$\therefore\ \ T' = T$

$\Rightarrow\ \ T' = 2s$

**29.** **(10)**

**Sol.** When axes in the same line, $F = \frac{\mu_0}{4\pi}\frac{6M_1M_2}{r^4}$ *i.e* $F \propto \frac{1}{r^4}$

When $r$ becomes thrice, $F$ becomes $\frac{1}{(3)^4}$ time

i.e. $\frac{1}{81}$ time. Therefore, $F' = \frac{8.1}{81} = 0.1N$

# ELECTROMAGNETIC INDUCTION

## Single Option Correct Type Questions (01 to 60)

**1.** **(3)**

**Sol.** $\phi = NBA\cos 0° = 5 \times 3 \times 10^{-5} \times 1$

$= 15 \times 10^{-5}$ Wb

**2.** **(4)**

**Sol.** Flux emerging out from side *EACF*

is $\phi = B \cdot A = Ba^2$

Flux incoming from side *GDOH*

is $\phi = B \cdot A = -Ba^2$

Net flux = zero

**3.** **(4)**

**Sol.** Since $\Delta\phi = 0$ hence EMF induced is zero.

**4.** **(4)**

**Sol.** $e = -L\dfrac{di}{dt} = -L\dfrac{(-2-2)}{0.05}$

$8 = L\dfrac{(4)}{0.05}$

$L = \dfrac{8 \times 0.05}{4} = 0.1$ H

**5.** **(2)**

**Sol.** Since $P_2 = P_2$ or $i_1V_1 = i_2V_2$

& $\dfrac{V_1}{V_2} = \dfrac{L_1\dfrac{di_1}{dt}}{L_2\dfrac{di_2}{dt}}$

or $\dfrac{V_1}{V_2} = 4$ so $\dfrac{i_1}{i_2} = \dfrac{1}{4}$

$\Rightarrow \dfrac{W_2}{W_1} = \dfrac{\frac{1}{2}L_2i_2^2}{\frac{1}{2}L_1i_1^2} = 4$

**6.** **(4)**

**Sol.** $\phi = BA = \left(N\mu_0\left(\dfrac{N}{\ell}\right)\times I\right)A = LI$

$\Rightarrow L = \dfrac{\mu_0 N^2 \times A}{\ell}$

**7.** **(4)**

**Sol.** Since the magnitude flux in the ring due to motion of charge particle is zero hence the induced emf will be zero. So current is also zero.

**8.** **(4)**

**Sol:** Magnetic field cannot do work, hence statement-1 is false.

**9.** **(4)**

**Sol.** It the magnitude of IA is very large such that force due to magnetic field on PQ exceeds its weight then it will move upwards otherwise it will move downwards.

**10.** **(1)**

**Sol.** $Fl = F(0.5)$

$= 0.5 \times ILB$

$= 0.5 \times \dfrac{L^2B^2V}{R}\left(I = \dfrac{VBL}{R}\right)$

$= \dfrac{0.5 \times (0.5)^2 \times (1)^2 \times \left(\dfrac{0.5}{2}\right)}{10} = 3.125 \times 10^{-3}$ J

**11.** **(1)**

**Sol.** $\varepsilon_{max} = VB\ell = 7 \times 0.9 \times 0.4 = 2.52$ Volt

**12.** **(2)**

**Sol.** $L_1\dfrac{di_1}{dt} = L_2\dfrac{di_2}{dt}$

or $L_1di_1 = L_2di_2$ or $L_1i_1 = L_2i_2$

$\therefore \dfrac{i_1}{i_2} = \dfrac{L_2}{L_1}$

**13.** **(3)**

**Sol.** $C_{eq} = 3C$

$Q_{eq} = 3Q$

$$E = \frac{1}{2}\frac{Q_{eq}}{C_{eq}} = \frac{1}{2}\frac{(3Q)^2}{3C} = \frac{3Q^2}{2C}.$$

**14.** **(2)**

**Sol.** Since the tube is very long the force on magnet due to induced current will continue to oppose its motion till it acquires a constant speed.

**15.** **(1)**

**Sol.** When both $S_1$ and $S_2$ are either open or closed; current through ad is zero. With $S_1$ closed, current $5 \times 10^{-7}$ A flows from a to d. With $S_2$ closed, current $5 \times 10^{-7}$ A flows from d to a.

**16.** **(2)**

**Sol.** The rate of change of flux or emf induced in the coil is

$$\varepsilon = \frac{-\Delta\phi}{\Delta t}$$

$\therefore$ Induced current

$$i = \frac{\varepsilon}{R_{eq}} = -\frac{1}{R}\frac{\Delta\phi}{\Delta t} \quad ...(i)$$

Given: $R_{eq.} = R + 4R = 5R$, $\Delta\phi = n(W_2 - W_1)A$, $\Delta t = t$. (Here $W_1$ and $W_2$ are associated with one turn.)

Putting the given values in eq. (i), we get

$$\therefore \quad i = -\frac{n}{5R}\frac{(W_2 - W_1)}{t}\text{A}$$

**17.** **(4)**

**Sol.** The direction of current in the loop such that it opposes the the change in magnetic flux in it.

**18.** **(2)**

**Sol.** When $A$ is moved towards $B$. Magnetic flux through $B$ increases. So current induced in $B$ should be negative to decrease the flux.

**19.** **(4)**

**Sol.** We have $\varepsilon = (\vec{v} \times \vec{B}).\vec{\ell}$

$\Rightarrow$ when any two vectors are parallel then $\varepsilon = 0$

**20.** **(4)**

**Sol.** When switch S is closed magnetic field lines passing through Q increases in the direction from right to left. So, according to Lenz's law induced current in Q will flow in such a direction so that the magnetic flux through Q decreases. This is possible when current in Q flows in anticlockwise direction as seen by E. Opposite is the case when switch S is opened, induced current in Q will be clockwise as seen by E.

**21.** **(2)**

**Sol.** Initially the inductor offers infinite resistance hence $i_1$ is 1A. Finally, at steady state inductor offers zero resistance and current $i_2$ is 1.25 A in the battery.

**22.** **(4)**

**Sol.** When the coil is entering and coming out of the field the magnetic flux in it is changing but when it is within the field the magnetic flux in it is constant.

**23.** **(2)**

**Sol.** When the loop enters the magnetic field the magnetic flux in it changes till it covers a distance 'a'. Hence the EMF induced in the surface afer that flux in it remains constant till its back portion has not entered in magnetic field. No emf is induced during this time.when it is out of magnetic field the magnetic flux in it decreases. EMF is again induced in the circuit hence total time for which emf is induced is $\frac{2a}{v}$.

**24.** **(2)**

**Sol.** Power $P = \frac{e^2}{R}$

here $\varepsilon$ = induced emf $= -\left(\frac{d\phi}{dt}\right)$

Where $\phi$ = NBA

$$\therefore \quad e = -NA\left(\frac{dB}{dt}\right)$$

also $R \propto \frac{1}{r^2}$

where $R$ = resistance, $r$ = radius, $\ell$ = length

$\therefore \quad P \propto \frac{N^2 r^2}{\ell}$

$\therefore \frac{P_1}{P_2} = 1$

**25.** **(2)**

**Sol.** The current at any instant is given by

$I = I_0(1 - e^{-Rt/L})$

$\frac{I_0}{2} = I_0(1 - e^{-Rt/L})$

$\frac{1}{2} = (1 - e^{-Rt/L})$

$e^{-Rt/L} = \frac{1}{2}$

$\frac{Rt}{L} = ln\,2$

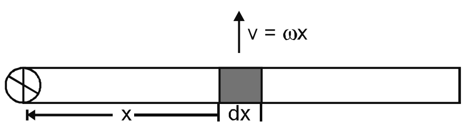
$\therefore \quad t = \frac{L}{R} In\,2$

$= \frac{300 \times 10^{-3}}{2} \times 0.693 = 150 \times 0.693 \times 10^{-3}$

$= 0.10395$ sec $= 0.1$ sec.

**26.** **(1)**

**Sol.**




$$\varepsilon = \int_0^L B(\omega x)dx = B\frac{\omega L^2}{2} = \frac{B(2\pi f)L^2}{2} = B\pi f L^2$$

**27.** **(2)**

**Sol.** $\phi = BA = \left(N\mu_0\left(\frac{N}{\ell}\right) \times I\right)A = LI$

$\Rightarrow L = \frac{\mu_0 N^2 \times A}{\ell}$

$\Rightarrow L \propto N^2$

**28.** **(2)**

**Sol.**

**29.** **(3)**

**Sol.** By moving away from solenoid the ring will resist the changing flux in it.

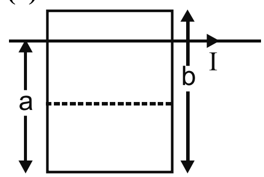
**30.** **(2)**

**Sol.** $\varepsilon = \left|(\vec{V} \times \vec{B}).\vec{\ell}\right| = \left|\left[1\hat{i} \times \left(3\hat{i} + 4\hat{j} + 5\hat{k}\right)\right].5\hat{j}\right|$

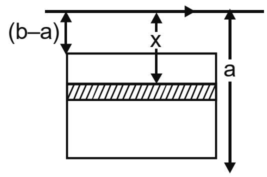
$= \left|\left(4\hat{k} - 5\hat{j}\right).5\hat{j}\right| = 25$ V

**31.** **(3)**

**Sol.**




$\Rightarrow$




$$\int d\phi = \int \frac{\mu_0 I}{2\pi x}(bdx)$$

$$\phi = \frac{\mu_0 Ib}{2\pi}\int_{(b-a)}^{a}\frac{dx}{x}$$

$$\phi = \frac{\mu_0 Ib}{2\pi}\ell n\left(\frac{a}{b-a}\right).$$

**32.** **(3)**

**Sol.** Since the magnetic flux in the loop is zero hence the current induced in it is zero.

**33.** **(2)**

**Sol.** $\varepsilon = VB\ell = 200 \times 2 \times 10^{-4} \times 50 = 2V$

**34.** **(2)**

**Sol.**

**35.** **(4)**

**Sol.** $R$ has dimensions $ML^2T^{-3}A^2$, $C$ has dimensions $M^{-1}L^{-2}T^4A^{-2}$, $L$ has dimensions $ML^2T^{-2}A^2$, frequency has dimensions $T^{-1}$.

$$\sqrt{LC} = \sqrt{ML^2T^{-2}A^2} \times \sqrt{M^{-1}L^{-2}T^4A^{-2}}$$

**36.** **(4)**

**Sol.** EMF induced $= -L\frac{di}{dt}$.

**37.** **(2)**

**Sol.** For constant $v$, $\frac{d\phi}{dt}$ will be same in both cases hence the induced emf and induced current will remain same.

**38.** **(4)**

**Sol.** Force acting on the rod because of the induced current due to change in magnetic flux will try to oppose the motion of rod. Hence the acceleration of the rod will decrease with time $\frac{dp}{dt} = F\frac{dv}{dt} = F \times a$. Thus, rate of power delivered by external force will be decreasing continuously.

**39.** **(4)**

**Sol.** Since magnetic field lines around the wire AB are circular, therefore magnetic flux through the circular loop will be zero, hence induced emf in the loop will be zero.

**40.** **(3)**

**Sol.** $I = I_0 \sin(\omega t + \phi) \Rightarrow \frac{dI}{dt} = I_0\omega\cos(\omega t + \phi)$

we have $\varepsilon = -\frac{d\phi}{dt} = -\frac{d(B.A)}{dt} = \frac{-A.d\left(\frac{\mu_0 I}{2r}\right)}{dt}$

$= -\frac{\mu_0 A}{2r} \times \frac{dI}{dt} = -\frac{\mu_0 A}{2r} \times I_0\omega\cos(\omega t + \phi)$

So, $\varepsilon \propto \omega \Rightarrow \varepsilon \propto n$ $\varepsilon_1 : \varepsilon_2 = n_1 : n_2$

**41.** **(3)**

**Sol.** $\varepsilon = -L\frac{dI}{dt}$

$\Rightarrow E \,.\, d = L\frac{dI}{dt}$

$\Rightarrow \frac{F}{q}d = L\frac{dI}{dt}$

$\Rightarrow \frac{MLT^{-2} \times L}{A \times T} = [L]AT^{-1}$

$\Rightarrow [L] = ML^2T^{-2}A^{-2}$

**42.** **(4)**

**Sol.** Initially inductor will offer infinite resistance and capacitors zero resistor and finally capacitor will offer infinite resistance and inductor will offer zero resistance. So initial and final current will be $I = \frac{E}{2R}$

**43.** **(4)**

**44.** **(2)**

**Sol.** At $t = 0$, current does not flow through inductor.

$\therefore i = \frac{V}{R_2}$

At $t = \infty$ inductor behaves as wire

$\Rightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

$\therefore i = \frac{V(R_1 + R_2)}{R_1 R_2}$

**45.** **(3)**

**Sol.** When the magnet goes away from the ring the flux in the ring decreases hence the induced current will be such that it opposes the decreasing flux in it hence ring will behave like a magnet having face A as north pole and face B as south pole.

**46.** **(2)**

**Sol.** Mutual inductance of the pair of coils depends on distance between two coils and geometry of two coils

**47.** **(1)**

**Sol.** When A is moved towards B. Magnetic flux through B increases. So current induced in B should be opposite to that of A to decrease the flux.

**48.** **(4)**

**Sol.** $\varepsilon = vBl = 1 \times 0.5 \times 2 = 1V$

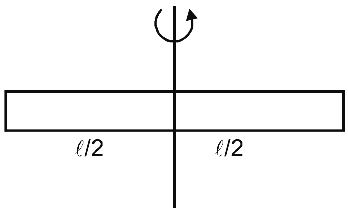
**49.** **(3)**

**Sol.** $I = \frac{1}{R}\frac{d\phi}{dt}$

$\Rightarrow \frac{d\phi}{dt} = IR = 0.2 \times 5 = 1\ Wb/s$

**50.** **(1)**

**Sol.**




both ends of rod will have same potential

$V = \frac{1}{2}B\omega\left(\frac{\ell}{2}\right)^2 = \frac{B\omega\ell^2}{8}$.

$\Delta V = \frac{B\omega\ell^2}{8} - \frac{B\omega\ell^2}{8} = 0$

**51.** **(3)**

**Sol.** $i = i_0\left(e^{\frac{-t}{\tau}}\right)$

Put $i_0 = 20$, $i = 18$ and $t = 2$ sec

We get time constant

$\left(\tau = 2/\ln\frac{10}{9}\right)$

**52.** **(2)**

**Sol.** $f = \frac{1}{2\pi}\frac{1}{\sqrt{L_{eff}\times c_{eff}}} = \frac{1}{2\pi\sqrt{3L\times 3C}}$

$= \frac{1}{6\pi\sqrt{LC}}$.

**53.** **(2)**

**Sol.** The emf induced between ends of conductor

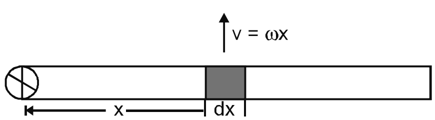
$e = \frac{1}{2}B\omega L^2$

$= \frac{1}{2}\times 0.2\times 10^{-4}\times 5\times(1)^2$

$= 0.5\times 10^{-4}$ V $= 5\times 10^{-5}$ V $= 50\ \mu$V

**54.** **(2)**

**Sol.**




$\varepsilon = \int_0^L B(\omega x)dx = B\frac{\omega L^2}{2}$

**55.** **(3)**

**Sol.** $\varepsilon = \int_{7cm}^{10cm} B(\omega x)dx$

$= B\omega\left[\frac{x^2}{2}\right]_{7cm}^{10cm}$

$= \frac{2\times 10}{2}\times(100-49)\times 10^{-4}$

$= 10^{-3}\times 51 = 0.051$ volt.

**56.** **(4)**

**Sol.** $\varepsilon = -L\frac{dI}{dt}$

So $L = 5\times 10^{-3} = 5$ mH

**57.** **(4)**

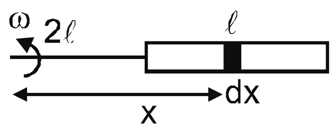
**Sol.** As the flux in the ring due to wire will be zero hence mutual inductance will be zero.

**58.** **(1)**

**Sol.** zero, as there is no flux change.

**59.** **(4)**

**Sol.** $\varepsilon = \int_{2\ell}^{3\ell}(\omega x)Bdx = B\omega\frac{[(3\ell)^2-(2\ell)^2]}{2}$




$= \frac{5B\ell^2\omega}{2}$

**60.** **(1)**

**Sol.** $\frac{\mu_0(2)(20\times 10^{-2})^2}{2\left[(0.2)^2+(0.15)^2\right]^{\frac{3}{2}}}\times\pi\,(0.3\times 10^{-2})^2$

on solving

$= 9.216\times 10^{-11}$

$\approx 9.2\times 10^{-11}$ weber

## *Integer Type Questions (61 to 75)*

**61.** **(625)**

**Sol.** At equilibrium (Steady state) inductor would act as a short circuit

$\therefore$ From ohm's law

$$I = \frac{V}{R} = \frac{5}{2} A$$

$$E = \frac{1}{2} LI^2 = \frac{1}{2} \times 2 \times \left(\frac{5}{2}\right)^2$$

$$= 6.25 = 625 \times 10^{-2} \text{ J}$$

**62.** **(15)**

**Sol.** $E_{ind} = B \times v \times \ell$

$= 5.0 \times 10^{-5} \times 1.50 \times 2$

$= 10.0 \times 10^{-5} \times 1.5$

$= 15 \times 10^{-5}$ volt.

$= 0.15$ mV

$= 15 \times 10^{-2}$ mV

So n = 15

**63.** **(8)**

**Sol.** The flux associated with coil of area A and magnetic induction $B$ is

$\phi = BA \cos \theta$

$$= \frac{1}{2} B\pi r^2 \cos \omega t$$

$$\left[\because A = \frac{1}{2} \pi r^2\right]$$

$$\therefore \quad e_{induced} = -\frac{d\phi}{dt}$$

$$= -\frac{d}{dt}\left(\frac{1}{2} B\pi r^2 \cos \omega t\right)$$

$$= \frac{1}{2} B\pi r^2 \omega \sin \omega t$$

$$\therefore \quad \text{Power } P = \frac{e_{induced}^2}{R}$$

$$= \frac{B^2 \pi^2 r^4 \omega^2 \sin^2 \omega t}{4R}$$

Hence, $P_{mean} = \langle P \rangle$

$$= \frac{B^2 \pi^2 r^4 \omega^2}{4R} \cdot \frac{1}{2}$$

$$\left[\because \langle \sin \omega t \rangle = \frac{1}{2}\right]$$

$$= \frac{\left(B\pi r^2 \omega\right)^2}{8R}$$

**64.** **(2)**

**Sol.** Relative velocity = V – (– V ) = 2 V = $\frac{dl}{dt}$

Now $\quad e = \frac{d\phi}{dt}$

$$e = \frac{BIdl}{dt} \quad \left(\frac{dl}{dt} = 2\text{v}\right)$$

Induced emf

$e = 2\,Blv$

so $n = 2$

**65.** **(2)**

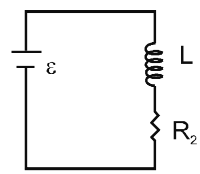
**Sol.** Here effective length is $2R$ ;

$$\varepsilon = \frac{1}{2} B\omega(2R)^2 = 2B\omega R^2$$

So $n = 2$

**66.** **(12)**

**Sol.**




$$V_L = \varepsilon\, e^{-\frac{R_2 t}{L}} = 12.e^{-\frac{2t}{400 \times 10^{-3}}} = 12\,e^{-5t}$$

**67.** **(6)**

**Sol.** $\text{EMF} = \left|-M \frac{dI}{dt}\right|$

$25 \times 10^{-3} = M \times 15$

or $\quad M = \frac{5}{3} \times 10^{-3}\ H$

$\phi = M\text{I} = \frac{5}{3} \times 10^{-3} \times 3.6 = 6.00$ mWb.

So $n = 6$

**68. (2)**

**Sol.** $U = \frac{1}{2}LI^2$ … (i)

$P = I^2R$ … (ii)

From Equation (i) & (ii) we get

$\frac{2U}{P} = \frac{L}{R} = \tau.$

So, $n = 2$

**69. (12)**

**Sol.** $I = I_1 + I_2$

$I_1 = \varepsilon/R$

$L\frac{dI_2}{dt} = E$

$\Rightarrow \frac{dI_2}{dt} = \frac{\varepsilon}{L} \Rightarrow dI_2 = 5dt \Rightarrow \int_0^{I_2} dI_2 = 5\int_0^2 dt$

$I_2 - O = 10A$

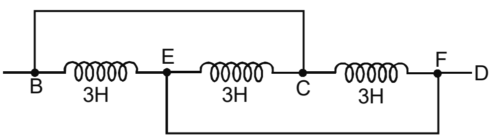
$I_2 = \frac{Et}{L}$

$I = E/R + \frac{Et}{L}$

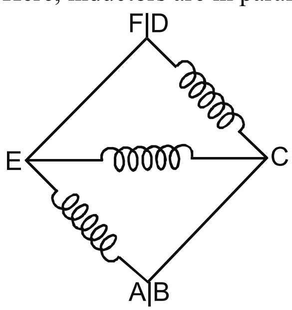
$I = 12A.$

**70. (1)**

**Sol.**




Here, inductors are in parallel




$\therefore \quad \frac{1}{L} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$

$L = 1$

**71. (2)**

**Sol.** $\frac{1}{2}Li^2 = \frac{1}{2}\frac{q^2}{C}$

$\Rightarrow q^2 = Li^2C$ .....(i)

and $U_{E(\max)} = U_{B(\max)}$ (given) .....(ii)

Since, $U_B = \frac{1}{2}Li^2$

where $i = \frac{\varepsilon}{R}(1 - e^{Rt/L})$

at $t = \infty$, $i_\infty = \frac{\varepsilon}{R}$

$U_{B(\max)} = \frac{1}{2}Li_\infty^2$ .....(iii)

and $U_{E(\max)} = \frac{Q^2}{2C}$ .....(iv)

Where $Q$ is maximum charge on capacitor. The energy is equally divided between electric and magnetic fields. Therefore

$\therefore \quad U_B = \frac{U_{B(\max)}}{2}$

$\Rightarrow \frac{1}{2}Li^2 = \frac{1}{2}\left(\frac{1}{2}Li_\infty^2\right)$

$\Rightarrow i_\infty^2 = 2i^2$ ......(v)

From equation (ii), (iii), (iv) and (v), we get

$\therefore \quad \frac{1}{2}L.\,2i^2 = \frac{1}{2}\frac{Q^2}{C}$

$LCi^2 = \frac{Q^2}{2}$

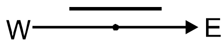
$\therefore \quad q^2 = \frac{Q^2}{2}$ [from equation (i)]

$q = \frac{Q}{\sqrt{2}}$ So $n = 2$.

Method II

$\frac{q^2}{2C} = \frac{1}{2}\left(\frac{Q^2}{2C}\right) \Rightarrow q = \frac{Q}{\sqrt{2}}$

**72. (3)**

**Sol.** 


$\varepsilon_{ind} = Bv\ell$

$= 0.3 \times 10^{-4} \times 5 \times 20$

$= 3 \times 10^{-3}\ v$

$= 3$ mV.

So $x = 3$

**73. (250)**

**Sol.** $\Delta Q = \int i\,dt$ = Area under $i - t$ graph

$$\Delta Q = \frac{\Delta\phi}{R} = \frac{\Delta\phi}{100} = \frac{1}{2} \times 10 \times 0.5$$

$\Rightarrow \Delta\phi = 2.5 \times 100 = 250$

**74. (12)**

$$\phi = \vec{B} \cdot \vec{A} = (3t^3\hat{j} + 3t^2\hat{k}) \cdot (\pi(1)^2\hat{k})$$

$$\phi = 3t^2\pi$$

$$\varepsilon_{ind} = \left|\frac{d\phi}{dt}\right| = 6t\pi$$

At, $t = 2$, $\varepsilon_{ind} = 2\pi$

The value of $n$ is 12.

**75. (2)**

$$\phi = \frac{2}{3}(9 - t^2) = 0$$

$\Rightarrow t = 3$ sec is the time when flux becomes zero

$$emf = \frac{-d\phi}{dt} = \frac{4t}{3}$$

$$I = \frac{emf}{R} = \frac{\frac{4}{3}t}{8} = \frac{t}{6}$$

Heat produced $= \int I^2 R dt = \int_0^3 \frac{t^2}{36} \times 8dt = 2\,\text{J}$

# ALTERNATING CURRENT

## Single Option Correct Type Questions (01 to 56)

**1.** **(2)**

**Sol:** $E = 10\cos\left(2\pi \times 50 \times \dfrac{1}{600}\right) = 5\sqrt{3}$

**2.** **(3)**

**Sol:** Resultant voltage = 200 volt

Since $V_1$ and $V_3$ are 180° out of phase, the resultant voltage is equal to $V_2$

$\therefore \quad V_2 = 200$ volt

**3.** **(1)**

**Sol:** $\tan\phi = \dfrac{x_c}{R} = \dfrac{1/\omega C}{R} \Rightarrow \phi = \tan^{-1}\dfrac{1}{\omega CR}$

**4.** **(4)**

**Sol:** $\dfrac{V_2}{V_1} = \dfrac{N_2}{N_1} = \dfrac{8}{1}$

$V_2 = 8 \times 120 = 960$ volt

$I = \dfrac{960}{10^4} = 96$ mA.

**5.** **(1)**

**Sol:** At resonance,

$\omega L = \dfrac{1}{\omega C}$ $\qquad L \propto \dfrac{1}{C}$

**6.** **(2)**

**Sol:** $I_{\text{rms}} = \left[\dfrac{\int_O^T i^2\,dt}{T}\right]^{\frac{1}{2}}$

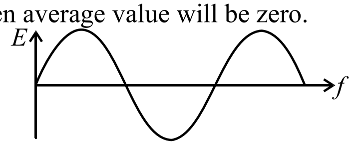
**7.** **(2)**

**Sol:** $I_{\text{rms}} = \dfrac{V_{rms}}{Z} = \dfrac{100}{\sqrt{R^2 + \left(\omega L - \dfrac{1}{\omega C}\right)^2}}$

P.d. across resistance = $R\ I_{\text{rms}}$.

**8.** **(4)**

**Sol:** If net area of $E$-$t$ curve is zero for given interval then average value will be zero.




**9.** **(3)**

**Sol:** $\tan\phi = \dfrac{\omega L}{R} = \dfrac{10 \times 0.1}{1} = 1$

$\phi = 45° = \pi/4$

**10.** **(1)**

**Sol:** $X_C = \dfrac{1}{\omega c}$ will decrease if we increase frequency then $z$ will decrease so current will increase & intensity will increase.

**11.** **(3)**

**Sol:** $V_L = 8\text{V},\ V_R = 6\text{V},\ V = \sqrt{V_L^2 + V_R^2} = 10$ V

power factor = $\cos\phi = \dfrac{V_R}{V} = \dfrac{6}{10} = 0.6$

**12.** **(4)**

**Sol:** $V_{\text{rms}}{}^2 = \dfrac{\int_0^T e_1 \sin\omega t + e_2 \cos\omega t\ ^2\,dt}{T}$

$= \sqrt{\dfrac{e_1^2 + e_2^2}{2}}$

where, $\omega = \dfrac{2\pi}{T}$.

**13.** **(3)**

**Sol:** The current lags the *EMF* by $\pi/2$, so the circuit should contain only an inductor.

**14.** **(3)**

**Sol:** $\tan\phi = \tan 45^\circ = \dfrac{\omega L}{R}$

$X_L = \omega L = R$

**15.** **(1)**

**Sol:** $I_{\text{rms}} = \dfrac{V_{rms}}{Z} = \dfrac{V_{rms}}{\sqrt{R^2 + (\omega L)^2}}$

$\tan\phi = \dfrac{\omega L}{R}$.

**16.** **(1)**

**Sol:** $\varepsilon = 2 + 3\sin\omega t + 3\cos\omega t$

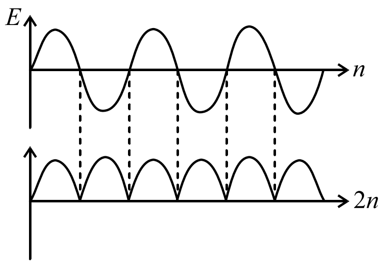
$= 2 + 3\sqrt{2}\,\sin(\omega t + \pi/4)$

$v_{rms} = \sqrt{2^2 + \dfrac{18}{2}} = \sqrt{13}$.

**17.** **(1)**

**18.** **(2)**

**Sol:**




**19.** **(3)**

**Sol:** $V = 100 \sin/\pi t \cos 100\,\pi t$

$V = 50 \sin 200\,\pi t$

Here, $V_0 = 50$ &

$\omega = 200\,\pi$

$f = 100$ Hz

**20.** **(3)**

**Sol:** $(2)^2 R = P_2$ ....(i)

$I^2_{rms} \times R = 3P_2 = 12\,R$ ....(ii)

**21.** **(1)**

**Sol:** Initially at resonance:

$X_L = X_E$

$\Rightarrow\ Z = R.$

$\therefore\ i_0 = \dfrac{\varepsilon_o}{R} = 10\sqrt{2}$ A

After increasing frequency:

$X_L > X_c$

$\omega L > 1/\omega C$

$\omega > \dfrac{1}{\sqrt{LC}}$

$\Rightarrow\ \omega > \omega_0$ (i.e frequency increases) and $i'$

$= \dfrac{\varepsilon_o}{\sqrt{R^2 + X^2}} = \dfrac{\varepsilon_o}{\sqrt{2}R} = i_0 / \sqrt{2} = 10$ amp.

**22.** **(2)**

**Sol:** $I^2 R = 100$

$R = \dfrac{100}{I^2} = \dfrac{100}{(2)^2} = 25.$

**23.** **(2)**

**Sol:** $V_{\text{net}} = \sqrt{V_R^2 + V_L^2} = \sqrt{(20)^2 + (16)^2} = 25.6$

**24.** **(4)**

**Sol:** $I_1 E_1 = I_2 E_2$

$I_2 = \dfrac{I_1 E_1}{E_2} = \dfrac{5 \times 220}{22000} = .05$ A

**25.** **(2)**

**26.** **(2)**

**Sol:** $P = VI$

For secondary:

$V_2 = \dfrac{P_2}{I_2} = \dfrac{500}{12.5} = 40$ volts

For an ideal transformer (100% efficient)

$P_{\text{input}} = P_{\text{output}}$

$\Rightarrow\ V_1 I_1 = V_2 I_2$

$\Rightarrow \dfrac{5}{1} = \dfrac{V_1}{40}$.

$\Rightarrow\ I_1 = \dfrac{V_2 I_2}{V_1} = \dfrac{40(12.5)}{40 \times 5} = 2.5$

$[\because \dfrac{n_1}{n_2} = \dfrac{V_1}{V_2}]$

**27.** **(2)**

**Sol:** Wattless current = $I_{rms}\sin\phi$

Where, $\tan\phi = \frac{\omega L}{R} = \frac{2\pi f L}{R}$

and $I_{rms} = \frac{v_{rms}}{z} = \frac{v_{rms}}{\sqrt{R^2+(\omega L)^2}}$

**28.** **(3)**

**29.** **(2)**

**Sol:** $i_{rms} = \frac{E_0}{\sqrt{2}Z}$

$$\Rightarrow \frac{i_{rms,1}}{i_{rms,2}} = \frac{Z_2}{Z_1} = \frac{\sqrt{R^2+\left(\frac{1}{\omega kC}\right)^2}}{\sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}}$$

Solving:

$$\Rightarrow \frac{i_{rms,1}}{i_{rms,2}} = 0.34$$

**30.** **(4)**

**Sol:** Frequency of the current remains same, only magnitudes of current changes in a transformer.

**31.** **(1)**

**Sol:** $P_{av} = v_{\text{rms}} I_{\text{rms}} \cos\phi$

Here, $\phi = 90^o$, so $P_{av} = 0$

**32.** **(3)**

**Sol:** $Z = \sqrt{3^2+(5-1)^2} = 5\Omega$

$i = 2\cos(100\pi t + 53^o)$

$V_{AB} = 8\cos(100\pi t + 53^o - 90^o)$ volt

$V_{AB} = 8\cos(100\pi t - 37^o)$ volt

**33.** **(1)**

**Sol:** $I = I_0\cos\omega t$

Since, = current is changing from its maximum value to *rms* value therefore, $I = I_0/\sqrt{2}$

$$\therefore \frac{I_0}{\sqrt{2}} = I_0\cos\omega t$$

$$\cos\omega t = \frac{1}{\sqrt{2}}$$

$$\cos(2\pi f t) = \cos\frac{\pi}{4}$$

$$\Rightarrow 2\pi\times 50t = \frac{\pi}{4}$$

$t = 2.5$ ms

**34.** **(2)**

**Sol:** The peak value of the current is:

$$I_0 = \frac{V_0}{\sqrt{R^2+\frac{1}{\omega^2C^2}}} = \frac{V_0}{\sqrt{2}\ R}$$

when the angular frequency is changed to $\frac{\omega}{\sqrt{3}}$

The new peak value is:

$$I_0' = \frac{V_0}{\sqrt{R^2+\frac{3}{\omega^2C^2}}} = \frac{V_0}{\sqrt{4R^2}} = \frac{V_0}{2R}$$

$$\therefore I_0' = \frac{I_0}{\sqrt{2}}$$

**35.** **(2)**

**Sol:** $\langle P\rangle = I^2_{\text{rms}} R = \left(\frac{I_P}{\sqrt{2}}\right)^2 R = \frac{I_P^2 R}{2}$

**36.** **(3)**

**Sol:** The circuit will have inductive nature if

$\omega > \frac{1}{\sqrt{LC}}\left(\omega L > \frac{1}{\sqrt{LC}}\right)$.

Hence (1) is false. Also, if circuit has inductive nature the current will lag behind voltage. Hence (4) is also false.

If $\omega = \frac{1}{\sqrt{LC}}\left(\omega L = \frac{1}{\omega C}\right)$ the circuit will have resistive nature. Hence (2) is false

Power factor

$$\cos\phi = \frac{R}{\sqrt{R^2+\left(\omega L-\frac{1}{\omega C}\right)^2}}$$

$= 1$ it $\omega L = \frac{1}{\omega C}$.

**37.** **(1)**

**Sol:** impedance of circuit

$= \sqrt{R^2 + (X_C - X_L)^2}$

$Z = \sqrt{8^2 + (8-2)^2} = 10\Omega$

**38.** **(4)**

**Sol:** As current is leading the source voltage, so circuit should be capacitive in nature and as phase difference is not $\frac{\pi}{2}$, it must contain resistor also.

**39.** **(3)**

**Sol:** $\eta\% = \frac{E_2 l_2}{E_1 l_1} \times 100$

**40.** **(1)**

**Sol:** Since current is going out of the body,

$i = -\frac{dq}{dt}$

Given,

$\frac{di}{dt} = q$

$\therefore \quad q = \frac{-d^2q}{dt^2}$

$\Rightarrow \quad q + \frac{d^2q}{dt^2} = 0$

This is differential equation of *SHM* with $\omega = 1$

$\therefore \quad T = \frac{2\pi}{\omega} = 2\pi$ sec

The min. time for the charge to become zero = $T/4 = \frac{\pi}{2}$ sec.

**41.** **(2)**

**Sol:** $\tan\phi = \frac{x}{R} = \frac{4}{3} \Rightarrow \cos\phi = \frac{3}{5} = 0.6$

**42.** **(1)**

**Sol:** $I_{rms} = \frac{60}{120} = \frac{1}{2}$ Amp.

$V_L = I_{rms} \times (\omega L)$

$40 = \frac{1}{2} \times (40 \times 10^3) \times L$

$L = 20$ mH

At resonance

$V_C = I_{rms}\left(\frac{1}{\omega c}\right) = V_L$

$C = \frac{1}{2} \times \frac{1}{4 \times 10^3} \times \frac{1}{40}$

$C = \frac{25}{8}$ μF.

**43.** **(2)**

**44.** **(1)**

**Sol:** Power factor = $\frac{R}{Z} = \frac{30}{50} = \frac{3}{5}$

Here. $Z = \sqrt{R^2 + (x_L - y_c)^2}$

$= \sqrt{(30)^2 + (60-20)^2}$

$Z = 50$

$I = \frac{V}{Z} = \frac{100}{50} = 2$ Amp.

**45.** **(2)**

**Sol:** $\tan\phi = \frac{X}{R} = \infty = \frac{1}{0} \quad \Rightarrow \quad R = 0$

**46.** **(2)**

**Sol:** $i_{\text{rms}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{1}{\omega^2 c^2}}}$

when ω increases, $i_{\text{rms}}$ increases so the bulb glows brighter

$i_{\text{rms}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{1}{\omega^2 c^2}}}$

**47.** **(4)**

**Sol:** $I_0 = \frac{V_0}{x_C} = \frac{200\sqrt{2}}{1/\omega C}$ ; $I_{RMS} = \frac{I_0}{\sqrt{2}} = 200$ mA

**48.** **(4)**

**Sol:** $I_0 = \sqrt{2}\, I_{rms} = \sqrt{2}\frac{V_{rms}}{Z}$

$I_0 = \frac{\sqrt{2}\times 130\sqrt{2}}{\sqrt{R^2 + (\omega L)^2}}$

$\tan\phi = \frac{\omega L}{R}$

$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$.

**49.** **(3)**

**Sol:** $\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{1}{5}$

$E_2 = \frac{1000}{5} = 200$ volt.

**50.** **(2)**

**Sol:** At resonance voltages across $C$ and $L$ are in opposite phase so net voltage will be zero.

**51.** **(4)**

**Sol:** Statement 1 is false because the given relation is true if all voltages are instantaneous

**52.** **(1)**

**Sol:** When current through inductor decreases, the magnetic energy stored in inductor decreases and this energy is absorbed by the ac source.

**53.** **(1)**

**Sol:** Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

**54.** **(4)**

**Sol:** In resonance condition when energy across capacitor is maximum, energy stored in inductor is zero, vice versa is also true. Hence statement 1 is false.

**55.** **(4)**

**Sol:** If $n > n_r$

$\omega L > \frac{1}{\omega c}$

$X_L > X_C$

So, current lags behind voltage.

**56.** **(4)**

**Sol:** *D.C.* Voltmeter measures Average value only

## Integer Type Questions (57 to 70)

**57.** **(102)**

**Sol:** At resonance,

$(V_C = V_L)$

$V = I_{rms} \times R$

$= \frac{V_{rms}}{Z} \times \text{R}$ (here $z = R$)

$V = V_{rms} = 100$ volt &

$I_{rms} = \frac{100}{50} = 2$ Amp.

**58.** **(8)**

**Sol:** Power factor

$= \cos\phi = \frac{R}{Z}$

$= \frac{12}{15} = \frac{4}{5}$

$= 0.8$

**59.** **(100)**

**Sol:** $\cos\phi = \frac{R}{Z}$

$Z \propto \frac{1}{\cos\phi}$,

% change in impedance = 100%

**60.** **(20)**

**Sol:** $I_0 = \frac{V_0}{\omega L} = \frac{10}{100\times 5\times 10^{-3}}$

**61.** **(400)**

**Sol:** When all ($L, C, R$) are connected then net phase difference = 60 – 60 = 0. So, there will be resonance.

$I = \frac{V}{R} = 2\text{A}$

& $P = I^2 R = 400$ watt.

**62.** **(2)**

**Sol:** $I_{rms} = \left[\int_0^T \frac{2+4\cos 100\pi t^{\ 2}\, dt}{T}\right]^{1/2} = 2\sqrt{3}$

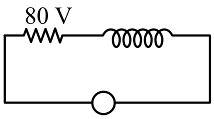
**63.** **(1)**

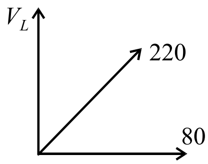
**Sol:** $I_{RMS} = \frac{I_0}{\sqrt{2}} = \frac{5}{\sqrt{2}}$ A,

$t = \frac{T}{4} = \frac{1}{240} s$

**64.** **(65)**

**Sol:** $R = \frac{80}{10} = 8\Omega$




$V_L^2 + 80^2 = 220^2$

$V_L^2 = (220 + 80)(220 - 80)$

$= 300 \times 140$

$\Rightarrow V_L = 204.9$

$I_{rns} X_L = 204.9$

$\frac{220}{\sqrt{64 + x_L^2}} x_L = 2.5$

**65.** **(5)**

**Sol:** $R = \frac{V_{rms}}{I_{rms}} = \frac{200}{5/\sqrt{2}} = 40\ \Omega$

(For circuit $x$)

$X_L = \frac{V_{rms}}{I_{rms}} = 40\ \Omega$

(For circuit $y$)

If $x$ & $y$ are in series,

$I = \frac{200}{40 \times \sqrt{2}}$

$I_{rms} = \frac{5}{2}$ A

**66.** **(2)**

**Sol:** $\frac{H_{D.C.}}{H_{A.C.}} = \frac{I^2 R}{I_{rms}^2 R} = 2$

**67.** **(1)**

**Sol:** Given, $L = 10$ H, $f = 50$ Hz.

For maximum power,

$X_C = X_L$

$\frac{1}{\omega C} = \omega L$

$C = \frac{1}{\omega^2 L}$

$C = \frac{1}{4\pi^2 \times 50 \times 50 \times 10}$

$\therefore\ C = 0.1 \times 10^{-5}$ F = 1 μF

**68.** **(11)**

**Sol:** For the current, $i(t) = A_0 \sin \omega t + B_0$

$RMS$ value $= \sqrt{\frac{A_0^2}{2} + B_0^2}$

$I_{rms}^2 = \left(\frac{\sqrt{42}}{2}\right)^2 + 10^2 = 121$

$\Rightarrow\ I_{rms} = 11$ A

**69.** **(20)**

**Sol:** $I = \frac{200\sqrt{2}}{X_C \times \sqrt{2}} = 200 \times \omega C = 20$ mA.

**70.** **(4)**

**Sol:** $Q$- factor $= \frac{1}{R}\sqrt{\frac{L}{C}}$

$Q$-factor $= \frac{1}{100} \times \sqrt{\frac{1}{6.25 \times 10^{-6}}} = 4$

# ELECTROMAGNETIC WAVES

## Single Option Correct Type Questions (01 to 58)

**1.** **(1)**

**Sol:** Direction of magnetic field vector will be in the direction of $\hat{K} \times \hat{E}$

Magnitude of magnetic field $B = \frac{E}{C} = \frac{K}{\omega} E$

$\Rightarrow \vec{B} = \frac{1}{\omega}(\vec{K} \times \vec{E})$

**2.** **(2)**

**Sol:** Second and fourth statements are correct.

**3.** **(2)**

**Sol:** $\vec{E} \times \vec{B}$ must be in the direction of propagation.

**4.** **(3)**

**Sol:** The statement II is wrong as the velocity of wave in a medium is $\frac{1}{\sqrt{\mu_r \mu_0 \varepsilon_r \varepsilon_0}}$

**5.** **(3)**

**Sol:** Reflected wave will be

$3.1 \cos[1.8z + (5.4 \times 10^6)t]\hat{i}$ N/C,

comparing it with $E_0 \cos(Kz + \omega t)\hat{i} \frac{\text{N}}{\text{C}}$

$K = 1.8$

$\frac{2\pi}{\lambda} = 1.8$

$\lambda = \frac{2\pi}{1.8} = \frac{\pi}{0.9} = \frac{10\pi}{9} = 3.48$ m

**6.** **(3)**

**Sol:** EM wave is in direction $\rightarrow \frac{\hat{i} + \hat{j}}{\sqrt{2}}$

Electric field is in direction $\rightarrow \hat{k}$

$\vec{E} \times \vec{B} \rightarrow$ direction of propagation of EM wave

**7.** **(4)**

**Sol:** Electric field at $t = 0$, & $(x, y, z) = \left(0, 0, \frac{\pi}{k}\right)$

$\vec{E} = -\left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right) E_0$ and $\vec{F} = \vec{E}q$

Due to electric field $\vec{F} = -\left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right) q$

Hence net force is antiparallel to $\left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right)$.

**8.** **(3)**

**Sol:** Magnetic field when electromagnetic wave propagated in +z direction

$B = B_0 \sin(kz - \omega t)$

Where $B_0 = \frac{60}{3 \times 10^8} = 2 \times 10^{-7} T$

$k = \frac{2\pi}{\lambda} = 0.5 \times 10^3$

$\omega = 2\pi f = 1.5 \times 10^{11}$

**9.** **(3)**

**Sol:** $\vec{E} = E_0 \hat{n} \sin(\omega t + (6y - 8z)) = E_0 \hat{n} \sin(\omega t + \vec{k} \cdot \vec{r})$

where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ and $\vec{k} \cdot \vec{r} = 6y - 8z$

$\Rightarrow \vec{k} = 6\hat{j} - 8\hat{k}$

Direction of propagation $\hat{s} = \left(\frac{-3\hat{j} + 4\hat{k}}{5}\right)$

**10. (3)**

**Sol:** According to Maxwell's equation.

$$\oint \vec{E}\cdot\vec{dl} = \frac{-d\phi_B}{dt}$$

**11. (1)**

**Sol:** Gauss's Law of electrostatic is

$$\oint \vec{E}\cdot d\vec{s} = \frac{q}{\epsilon_0}$$

Faraday's law of EMI, $\oint \vec{E}\cdot d\vec{l} = \frac{-d\phi_B}{dt}$

Gauss's law of magnetism is, $\oint \vec{B}\cdot d\vec{A} = 0$

Ampere Maxwell law

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 i_C + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$$

**12. (4)**

**Sol:** $C = \epsilon_r \frac{\epsilon_0 A}{d}$

$$\Rightarrow \frac{A}{d} = \frac{C}{\epsilon_r \epsilon_0}$$

$$\therefore i = \frac{V}{R} = \frac{VA}{\rho d} = \left(\frac{V}{\rho}\right)\left(\frac{C}{\epsilon_r \epsilon_0}\right)$$

$$= \left(\frac{40}{200}\right)\left(\frac{2\times10^{-12}}{50\times8.85\times10^{-12}}\right)$$

= 0.9 mA

**13. (2)**

**Sol:** $B = \frac{E}{C}$

$$= \frac{6.6}{3\times10^8}$$

$$B = 2.2\times10^{-8}$$

Also, $\hat{j}\times\hat{B} = \hat{i} \Rightarrow \hat{B} = \hat{k}$

**14. (2)**

**Sol:** $E_0 = CB_0$

$= 3 \times 10^8 \times 6 \times 10^{-7}$

$= 180$ vm$^{-1}$

**15. (1)**

**Sol:** $\because C = \frac{\omega}{k}$

$$\Rightarrow \frac{\omega}{k} = \frac{E_0}{B_0}$$

**16. (1)**

**Sol:** EM waves are neutral and $E_0 = \sqrt{\frac{1}{\mu_0\varepsilon_0}}B_0$

Statement-I is correct and
Statement-II is wrong

**17. (3)**

**Sol.** $E_0 = B_0\, c = 2 \times 10^{-8} \times 3 \times 10^8 = 6$ V/m

Since, $B \to \hat{j}$ and $v \to \hat{i}$

Therefore, $E \to \hat{k}$

Direction will be along z-axis

**18. (1)**

**Sol.** Given, $E_y = 540\sin\pi \times 10^4 (x - ct)$ Vm$^{-1}$

$\therefore E_0 = 540 Vm^{-1}$

$$c = \frac{E_0}{B_0} \Rightarrow B_0 = \frac{E_0}{c} = \frac{540}{3\times10^8} = 18\times10^{-7} T$$

**19. (3)**

**Sol.** $c' = \frac{c}{\sqrt{\mu_r \varepsilon_r}}$

$B = \mu_0 \times \mu_r H$

$E = BC'$

**20. (3)**

**Sol.** $c = \frac{E}{B} \Rightarrow E = cB = 24$ V / m

As we know that direction of propagation of wave

$\hat{E}\times\hat{B} = \hat{c}$, so $\hat{E} = -\hat{x}$, hence $\vec{E} = -24\hat{x}$ V / m

**21. (3)**

**Sol.** Average electric energy density is equal to average magnetic energy density,

$$\Rightarrow \langle u_E \rangle = \langle u_B \rangle = \frac{1}{2}\langle u_{\text{total}} \rangle$$

$$\Rightarrow \frac{u_E}{u_{\text{total}}} = \frac{1}{2}$$

**22.** **(4)**

**Sol.** We know that,

$$\frac{E_0}{B_0} = C \Rightarrow B_0 = \frac{E_0}{c} = \frac{800}{3\times10^8}\text{T}$$

$$F_{\max} = evB_0$$

$$= 1.6\times10^{-19}\times3\times10^7\times\frac{800}{3\times10^8} = 12.8\times10^{-18}N$$

**23.** **(3)**

**Sol.** Direction of propagation of *em* wave is perpendicular to both $\vec{E}$ and $\vec{B}$

**24.** **(2)**

**Sol.** $\vec{E}\times\vec{B}\parallel\vec{C}$

Hence $\vec{B}$ should be in $\hat{k}$ direction.

Also, $E_0 = B_0C, C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$$\Rightarrow \vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}$$

**25.** **(3)**

**Sol.** $\vec{B} = 1.2\times10^{-7}\sin(0.5\times10^3x + 1.5\times10^{11}t)\hat{k}]T$

Wave is travelling along $-x$ axis and $\vec{B}$ is along $+z$ axis

$$E_0 = cB_0 = 36\frac{V}{m}$$

$\vec{E}$ must be along $-y$ axis

**26.** **(4)**

**Sol.** $I_d = C_d\frac{dV}{dt} = \frac{\varepsilon_0 A}{d}\frac{d}{dt}920\sin\omega t) = \frac{\varepsilon_0 A}{d}\times20\omega\cos\omega t$

$\therefore$ Amplitude of oscillating displacement current

$$= \frac{\varepsilon_0 A}{d}\times20\omega = \frac{8.85\times10^{-12}\times1\times20\times100\pi}{2\times10^{-3}} = 27.79\mu A$$

**27.** **(2)**

**Sol.** $E_0 = B_0C = 3\times10^8\times3\times10^{-8} = 9V/m$

Pointing vector $\vec{s} = \frac{\vec{E}\times\vec{B}}{\mu_0}$

$\therefore E = -9\sin[200\pi(y+ct)]\hat{k}$

(along $-ve$ $z$-axis)

**28.** **(3)**

**Sol.** $\vec{E}\times\vec{B}$ is along $\vec{C}$

$$\hat{E}\times\hat{B} = \hat{C}$$

$$\Rightarrow \vec{B} = \frac{E_0}{c}(-\hat{x}+\hat{y})\sin(kz-\omega t)$$

**29.** **(4)**

**Sol.** $\frac{E_0}{B_0} = c$

$$E_0 = B_0c = 3\times10^{-8}\times3\times10^8 = 9N/C$$

So $\vec{E} = 9\sin(1.6\times10^3x + 48\times10^{10}t)\hat{k}\ v/m$

**30.** **(3)**

**Sol.** $\vec{C} = \hat{k}\times\left(2\hat{i}-2\hat{j}\right)$

$\therefore$ unit vector along em wave

$$= \frac{\left(\hat{i}+\hat{j}\right)}{\sqrt{2}}$$

**31.** **(1)**

**Sol.** Magnetic field vectors associated with this electromagnetic wave are given by

$$\vec{B}_1 = \frac{E_0}{c}\hat{k}\cos(kx-\omega t)\ \&\ \overrightarrow{B_2} = \frac{E_0}{C}\hat{i}\cos(ky-\omega t)$$

$$\vec{F} = q\vec{E} + q(\vec{V}\times\vec{B})$$

$$= q(\vec{E}_1 + \vec{E}_2 + q(\vec{V}\times(\vec{B}_1+\vec{B}_2))$$

By putting the value of $\vec{E}_1, \vec{E}_2, \vec{B}_1\ \&\ \vec{B}_2$

The net Lorentz force on the charged particle is

$$\vec{F} = qE_0[0.8\cos(kx-\omega t)\hat{i} + \cos(kx-\omega t)\hat{j} + 0.2\cos(kx-\omega t)\hat{k}]$$

At $t = 0$ and $x = y = 0$

$$\vec{E} = qE_0[0.8\hat{i} + \hat{j} + 0.2\hat{k}]$$

**32.** **(2)**

**Sol.** $\because\ \vec{E}\times\vec{B}\parallel\vec{v}$

Given that wave is propagating along positive z-axis and $\vec{E}$ along positive $x$-axis. Hence $\vec{B}$ long y-axis. From Maxwell equation

$$\frac{\partial E}{\partial Z} = -\frac{\partial B}{\partial t} \text{ and } B_0 = \frac{E_0}{C}$$

**33. (2)**

**Sol.** $\vec{E} = 6.6\hat{j}, v = 20\ MHz, \vec{c} = 3\times10^8\hat{i}$

From, $C = \dfrac{|E|}{|B|}$

$|\vec{B}| = \dfrac{|\vec{E}|}{c} = \dfrac{6.6}{3\times10^8} = 2.2\times10^{-8}T$

For direction $\hat{E}\times\hat{B} = \hat{c}$

$\hat{j}\times\hat{B} = \hat{i} \Rightarrow \hat{B} = \hat{k}$

$\vec{B} = 2.2\times10^{-8}\hat{k}T$

**34. (3)**

**Sol.** The direction of propagation of an EM wave is direction

$\vec{E}\times\vec{B}$

$\hat{i} = \hat{j}\times\hat{B} \Rightarrow \hat{B} = \hat{k}$

$c = \dfrac{E}{B} \Rightarrow B = \dfrac{E}{c} = \dfrac{6}{3\times10^8}$

$B = 2\times10^{-8}$ $T$ along $z$-direction

**35. (4)**

**Sol.** Maximum Electric field $E = B(c)$

$\vec{E}_0 = (3\times10^{-5})c(-\hat{j})$

$\vec{E}_1 = (2\times10^{-6})c(-\hat{i})$

$\vec{F}_{net} = q\vec{E} = qc(-3\times10^{-5}\hat{j} - 2\times10^{-6}\hat{i})$

$|\vec{F}_{\max}| = 10^{-4}\times3\times10^8\sqrt{(3\times10^{-5})^2+(2\times10^{-6})^2}$

$= 0.9$ N

$F_{rms} = \dfrac{F}{\sqrt{2}} = 0.6N$ (approx.)

**36. (2)**

**Sol.** $\vec{E} = 10\hat{j}\cos(6x+8z-10ct)$

$B_0 = \dfrac{E_0}{c} = \dfrac{10}{c}$

$\omega = 10c$

$\because \hat{E}\times\hat{B} = \hat{C}$

$$\begin{vmatrix} \hat{i} & \hat{j} & k \\ 0 & 1 & 0 \\ B_x & B_y & B_z \end{vmatrix} = \frac{6\hat{i}+8\hat{k}}{10}$$

$\Rightarrow B_z\hat{i} - 0\hat{j} - B_x\hat{k} = \dfrac{3}{5}\hat{i} + \dfrac{4}{5}\hat{k}$

$\Rightarrow B_z = \dfrac{3}{5}, B_y = 0, B_x = -\dfrac{4}{5}$

$\therefore \vec{B} = \dfrac{1}{C}(-8\hat{i}+6\hat{k})\cos(6x+8z-10ct)$

**37. (3)**

**Sol.** $\dfrac{E_i}{B_i} = c$ ……..(i)

$\dfrac{E_f}{B_f} = \dfrac{c}{n}$ ……..(ii)

$\Rightarrow \dfrac{E_iB_f}{E_fB_i} = n \Rightarrow \dfrac{E_i}{E_f} = n\dfrac{B_i}{B_f}$

Hence ratio will be $\sqrt{n} : \dfrac{1}{\sqrt{n}}$

**38. (2)**

**Sol.** $E = cB$

**39. (1)**

**Sol.** Electric energy density $= \dfrac{1}{2}\in_0 E^2_{rms}$

Magnetic energy density $= \dfrac{B^2_{rms}}{2\mu_0}$

$$\therefore \frac{\text{Electric enrgy density}}{\text{Magnetic energy density}} = \frac{\frac{1}{2}\in_0 E^2_{rms}}{\left(\frac{B^2_{rms}}{2\mu_0}\right)}$$

$= \left(\dfrac{E_{rms}}{B_{rms}}\right)^2 .\mu_0\in_0 \qquad \left[\therefore c = \dfrac{1}{\sqrt{\mu_0\in_0}}\right]$

$\left(\dfrac{E_0}{\sqrt{2}}\times\dfrac{\sqrt{2}}{B_0}\right)^2 .\dfrac{1}{c^2} = \dfrac{c^2}{c^2} = 1 \quad \left[\because \dfrac{E_0}{B_0} = C\right]$

**40. (3)**

**Sol.** Frequency of Energy of electromognetic wave has double value than frequency of wave

**41. (2)**

**Sol.** $I_{EF} = \dfrac{1}{2}\times\dfrac{100\times5\%}{4\pi(5)^2} = \dfrac{1}{2}\times\dfrac{5}{4\pi\times5^2}$

$= \dfrac{1}{40\pi}W/m^2$

**42.** **(2)**

**Sol.** $I = \frac{1}{2}\varepsilon_0 E_0^2 c$

**43.** **(4)**

**Sol.** $A = 36cm^2 = 36\times10^{-4} m^2$

$< F > 7.2\times10^{-9} N, t = 20\min$

$< F >= \frac{\Delta P}{\Delta t} = \frac{E}{C\Delta t}$

$\Rightarrow \frac{E}{A\Delta t} = \frac{< F > c}{A} = \frac{7.2\times10^{-9}\times3\times10^8}{36}$

$= 0.06$ W/cm$^2$

**44.** **(2)**

**Sol.** $B = \frac{E}{c}$

$\Rightarrow U_E = \frac{1}{2}\varepsilon_0 E^2$

$U_B = \frac{B^2}{2\mu_0} = \frac{E^2}{2\mu_0 c^2} = \frac{E^2}{2\mu_0}(\mu_0\varepsilon_0) = U_E$

**45.** **(4)**

**Sol.** Intensity,

$I = \frac{1}{2}C\varepsilon_0 E_0^2 = \frac{1}{2}C\varepsilon_0(CB_0)^2 = \frac{1}{2}C^3\varepsilon_0 B_0^2$

$\therefore$ Magnetic field, $B_0 = \sqrt{\frac{2I}{\varepsilon_0 C^3}}$

$= \sqrt{\frac{2\times0.092}{8.85\times10^{-12}\times27\times10^{24}}}$

$= \sqrt{\frac{0.184}{229.5\times10^{12}}} = 2.77\times10^{-8} T$

**46.** **(4)**

**Sol.** $\frac{B^2}{2\mu_0} = 1.02\times10^{-8} \Rightarrow B^2 = (1.02\times10^{-8})\times2\mu_0$

Also $\frac{1}{\sqrt{\mu_0\varepsilon_0}} = C \Rightarrow \mu_0 = \frac{1}{C^2\varepsilon_0}$

$\Rightarrow B^2 = (1.02\times10^{-8})\times\frac{4\pi\times9\times10^9}{9\times10^{16}}\times2$

$\Rightarrow B \cong 160\, nT$

**47.** **(2)**

**Sol.** Magnetic energy density $= \frac{B^2}{2\mu_0}$

$\frac{\text{Displacement}\times\text{force}}{(\text{Displacement})^3} = \frac{L.MLT^{-2}}{L^3} = (ML^{-1}T^{-2})$

**48.** **(4)**

**Sol.** Intensity of EM wave is given by

$I = \frac{\text{Power}}{\text{Area}} = \frac{1}{2}\varepsilon_0 E_0^2 C$

$= \frac{27\times10^{-3}}{10\times10^{-6}} = \frac{1}{2}\times9\times10^{-12}\times E^2\times3\times10^8$

$E = \sqrt{2}\times10^3 kV/m = 1.4$ kV/m

**49.** **(4)**

**Sol.** $\because I = \frac{B^2 c}{\mu_0}$

$\Rightarrow B\sqrt{\frac{I\mu_0}{c}}$

$\Rightarrow B = \sqrt{\frac{10^8\times4\pi\times10^{-7}}{3\times10^8}} \simeq 10^{-4} T$

**50.** **(2)**

**Sol.** Increasing order of wave length

| | |
|---|---|
| Micro wave | 0.1 m to 1 mm |
| Infra red | 1 mm to 700 nm |
| Ultra Violet | 400 nm to 1 nm |
| X-ray | 1 nm to $10^{-3}$ nm |

**51.** **(2)**

**Sol.** Based on theory

**52.** **(3)**

**Sol.** Microwaves are used for aircraft navigation. *IR* is used for physiotherapy. *X*-rays are used for cancer treatment. *UV* rays are used for Lasik eye surgery

**53.** **(1)**

**Sol.** Fact based

**54.** **(2)**

**Sol.** From electromagnetic wave spectrum

**55.** **(3)**

**Sol.** Based on theoretical data

**56. (3)**

**Sol.** Fact based

**57. (1)**

**Sol.** Here, We have

$$E_{\gamma\text{-Rays}} > E_{X\text{-Rays}} > E_{\text{microwave}} > E_{\text{AM Radiowaves}}$$

$$\therefore\ \lambda_{\gamma\text{-Rays}} < \lambda_{X\text{-Rays}} < \lambda_{\text{mixrowave}} < \lambda_{\text{AM Radiowaves}}$$

(a) Microwave → (iv) $10^{-3}$ m

(b) Gamma Rays → (ii) $10^{-15}$ m

(c) AM Radio wave → (i) 100 m

(d) $X$-Rays → (iii) $10^{-10}$ m

**58. (3)**

**Sol.** Fact based

## Integer Type Questions (59 to 71)

**59. (8)**

**Sol:** displacement current,

$$I_d = C_d \frac{dv}{dt} = \frac{\varepsilon_0 A}{d}\frac{dv}{dt}$$

$$= \frac{8.85\times10^{-12}\times40\times10^{-4}}{x\times10^{-3}}\times10^{6}$$

$$\Rightarrow 4.425\times10^{-6} = \frac{8.85\times10^{-12}\times40\times10^{-4}\times10^{6}}{x\times10^{-3}}$$

$$\Rightarrow x = 8$$

**60. (9)**

**Sol:** Given: $E = 20\cos(2\times10^{10}t - 200x)V/m$

$$\Rightarrow \omega = 2\times10^{10}, K = 200$$

Wave speed $= \dfrac{2\times10^{10}}{200} = 10^8 m/s$

Refractive Index $= \dfrac{C}{\text{speed}} = \dfrac{3\times10^8}{10^8} = 3$

$$3 = \sqrt{\varepsilon_r\times1}$$

[$\therefore$ As refractive index $= \sqrt{\mu_r\varepsilon_r}$ ]

**61. (6)**

**Sol:** $J_C = \dfrac{E}{\rho} = \dfrac{V}{\rho d} = \dfrac{V_0\sin(2\pi ft)}{\rho d}$

$$J_d = \frac{\in}{d}\frac{dV}{dt} = \frac{2\pi f \in}{d}V_0\cos(2\pi ft)$$

$$\frac{J_c}{J_d} = \frac{\tan(2\pi ft)}{2\pi f \in \rho}$$

$$= \frac{\tan\left(2\pi\times\frac{900}{800}\right)}{2\pi\times9\times10^2\times80\in_0\times0.25} = 10^6$$

**62. (667)**

**Sol:** $f = 3GHz = 3\times10^9 Hz$

$$\lambda_{vacuum} = \frac{v}{f} = \frac{3\times10^8 m/s}{3\times10^9 m/s} = 10^{-1}m = 0.1m$$

$$\lambda_{\text{medium}} = \frac{\lambda_{\text{vacuum}}}{\mu_{\text{medium}}} = \frac{0.1}{\mu_{\text{medium}}}$$

$$\mu_{\text{medium}} = \sqrt{\mu_r \in_r} = \sqrt{1\times2.25} = 1.5$$

$$\therefore\ \mu_{\text{medium}} = \frac{0.1m}{1.5} = 0.0667m$$

$$= 6.67cm = 667\times10^{-2}cm$$

**63. (15)**

**Sol:** We know that, velocity of electromagnetic wave in any medium,

$v = \dfrac{1}{\sqrt{\in\mu}}$ According to the question,

$\in_r = 2, \mu_r = 2$

$$\therefore\ v = \frac{1}{\sqrt{\varepsilon_0\in_r\mu_0\mu_r}} = \frac{1}{\sqrt{2\varepsilon_0\times2\mu_0}} = \frac{1}{2\sqrt{\varepsilon_0\mu_0}} = 15\times10^7 m/s$$

**64. (2)**

**Sol:** We know that,

Bc = E

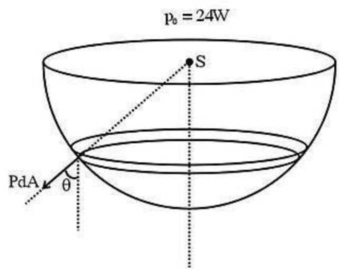
$$\Rightarrow B = \frac{E}{c} = \frac{6}{3\times10^8} = 2\times10^{-8}T$$

$$\Rightarrow x = 2$$

Hence, $x$= 2 is the correct answer

**65.** **(4)**

**Sol:**




Force $= \int PdA\cos\theta$

$$= \frac{2I}{C}\int dA\cos\theta = \frac{2I}{C}\pi R^2 = 2\frac{p_0}{4\pi R^2}.\frac{\pi R^2}{C}$$

$$= \frac{p_0}{2C} = \frac{24}{2\times 3\times 10^8} = 4\times 10^{-8}N$$

**66.** **(43)**

**Sol:** $I = \left(\frac{1}{2}\varepsilon_0 E_0^2\right)C \Rightarrow E_0\sqrt{\frac{2I}{\varepsilon_0 C}}$

$$B_0 = \frac{E_0}{C}$$

**67.** **(25)**

**Sol:** $F = \frac{IA}{C} \therefore I = \frac{Fc}{A}$

$$= \frac{2.5\times 10^{-6}\times 3\times 10^8}{30} = 25 \text{ W/cm}^2$$

**68.** **(3)**

**Sol:** $I = \frac{1}{2}c \in_0 E^2$

$E^2 \propto I$

$I = \frac{\text{Power}}{\text{Area}}$

$E^2 \propto \frac{P}{A}$

$E \propto \sqrt{P}$

$\frac{E'}{E} = \sqrt{\frac{60}{100}}$

$E'\sqrt{\frac{3}{5}}E$

So that value of $x = 3$

**69.** **(137)**

**Sol:** Intensity of the electromagnetic wave

$I = \frac{1}{2}c\varepsilon_0 E_0^2 = \eta\times\left(\frac{P}{4\pi r^2}\right)$ Hence $\eta$ is the efficiency

$$E_0 = \sqrt{\frac{\eta P}{2\pi r^2 c\varepsilon_0}}$$

$$= \sqrt{\frac{1.25}{100}\times\frac{1000}{2\times 3.14\times 4\times 3\times 10^8\times 8.85\times 10^{-12}}}$$

Hence, value of x is 136.9

**70.** **(500)**

**Sol:** Electric field in an electromagnetic field,

$E = 50\sin\omega(t - x/c)$

Energy $= 5.5\times 10^{-12} J, Vol., V = ?$

$u = \frac{1}{2}\varepsilon_0 E_0^2 \rightarrow$ Energy density

$\because u = \frac{U}{V} \Rightarrow U = uV$

$= \frac{1}{2}\varepsilon_0 E_0^2.V$

$5.5\times 10^{-12} = \frac{1}{2}\times 8.85\times 10^{-12}\times 50^2\times V$

$V = \frac{5.5\times 10^{-12}\times 2}{8.55\times 2500\times 10^{-12}}\times 10^6\ cm^3$

$= 0.0497\times 10^4 = 497 \cong 500 cm^3$

**71.** **(2)**

**Sol:** $I = \frac{1}{2}c\varepsilon_0 E_0^2 \Rightarrow \frac{8}{4\pi(10)^2}\times\frac{1}{10}$

$= \frac{1}{2}\times c\times\frac{1}{c^2\mu_0}\times E_0^2$

$\Rightarrow E_0 = \frac{2}{10}\sqrt{\frac{\mu_0 c}{10\pi}} \Rightarrow x = 2$

# RAY OPTICS

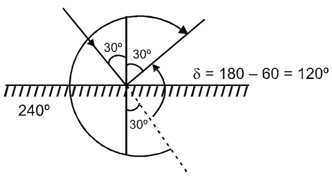
## *Single Option Correct Type Questions (01 to 58)*

**1.** **(1)**

**Sol.** 11: 60 – 08 : 20 = 3 : 40

**2.** **(4)**

**Sol.**




$\delta = 120^\circ$ Anticlockwise

$= (360^\circ - 120^\circ)$ clockwise

**3.** **(3)**

**Sol.** $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

$\frac{1}{v}+\frac{1}{-f}=\frac{1}{f}$

$v=\frac{f}{2}$

**4.** **(2)**

**Sol.** $\frac{n_R-n_i}{R}=\frac{n_R}{v}-\frac{n_i}{u}$

$\frac{2-1}{10}=\frac{2}{v}-\frac{1}{-20}$

$\Rightarrow v = 40$ cm

**5.** **(2)**

**Sol.** $\vec{V}_0 = 3\hat{i}+4\hat{j}+5\hat{k}$  $\vec{V}_m = 4\hat{i}+5\hat{j}+8\hat{k}$

$V_{IZ} = 2\,V_{mz} - V_{oz} = 2 \times 8 - 5 = 11$

$V_{Ix} = V_{ox} = 3$

$V_{Iy} = V_{oy} = 4$

$\Rightarrow \vec{V}_I = 3\hat{i}+4\hat{j}+11\hat{k}$

**6.** **(2)**

**Sol.** $(\mu_{rel} = 1)$

$\frac{1}{f}=(\mu_{rel}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

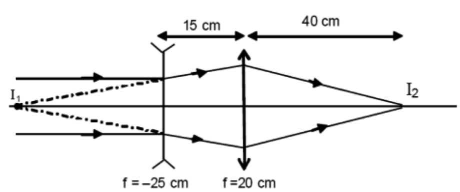
$\frac{1}{f}=0 \Rightarrow f=\infty$

**7.** **(2)**

**Sol.** Image formed by first lens is $I_1$ which is 25 cm left of diverging lens.

For second lens $u$ = 40 cm (i.e. at 2F) so final image will be 40 cm right of converging lens.

Image will be real.



**8.** **(3)**

**9.** **(2)**

**Sol.** A thick mirror forms a number of images. Image is formed by front surface which is unpolished and hence, reflects only a small part of light, while second image is formed by polished surface which reflects most of intensity. Hence second image is brightest.

**10.** **(3)**

**Sol.** $\because u < f$

so image is virtual, enlarged and at a distance of 10 cm from the lens.

**11.** **(2)**

**Sol.** $\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ $\quad \frac{\mu_2}{V} - \frac{\mu_1}{-R} = \frac{\mu_2 - \mu_1}{-R}$

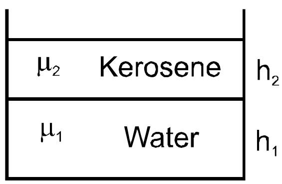
$V = -R$ for all values of μ.

**12.** **(1)**

**Sol.**

**13.** **(2)**

**Sol.**



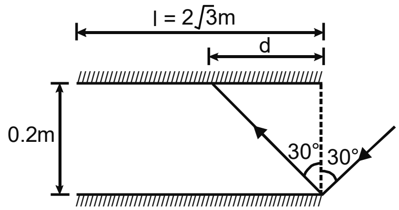

Apparent shift :

$$= h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right)$$

**14.** **(2)**

**Sol.** $d = 0.2 \tan 30^\circ = \frac{0.2}{\sqrt{3}}$

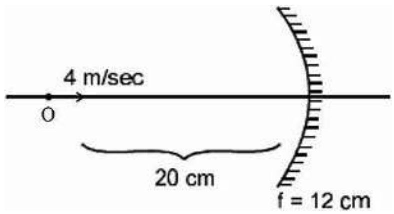
$$\frac{l}{d} = \frac{2\sqrt{3}}{0.2/\sqrt{3}} = 30$$




Therefore, maximum number of reflections are 30.

**15.** **(3)**

**Sol.**




$\frac{1}{f} = \frac{1}{V} + \frac{1}{4}$ $\quad \frac{1}{-12} = \frac{1}{V} + \frac{1}{-20}$

$\Rightarrow \frac{1}{V} = \frac{1}{20} - \frac{1}{12}$

$\Rightarrow$ V = – 30 cm

velocity of image $\frac{dV}{dt} = -\left(\frac{V^2}{u^2}\right)\frac{du}{dt} =$

$-\left(\frac{-30}{-20}\right)^2 4. = -9$ cm/sec.

$\Rightarrow$ 9 cm/sec away from mirror

**16.** **(4)**

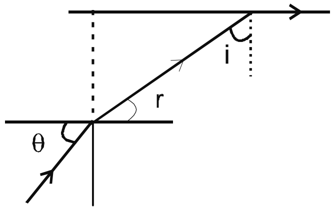
**Sol.** $C = \sin^{-1}\left(\frac{1}{\mu}\right)$

μ is greatest for violet

$\Rightarrow C$ is minimum for voilet.

**17.** **(3)**

**Sol.**




$\sin\theta = \frac{2}{\sqrt{3}}\sin r = \frac{2}{\sqrt{3}}\cos I$ ....(i)

and $\frac{2}{\sqrt{3}}\sin i = \sin 90^\circ$

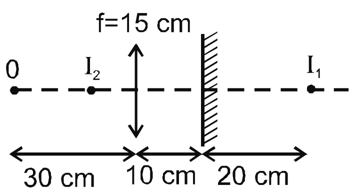
$\Rightarrow i = 60^\circ$ ....(ii)

From (i) and (ii)

$\sin\theta = \frac{1}{\sqrt{3}}$

**18.** **(2)**

**Sol.**




First image, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-30} = \frac{1}{15}$

$v$ = 30, image is formed 20 cm behind the mirror.

Second image, by plane mirror will be at 20 cm in front of plane mirror.

For third image $\frac{1}{v} - \frac{1}{10} = \frac{1}{15}$

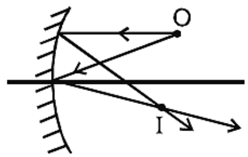
$\frac{1}{v} = \frac{1}{10} + \frac{1}{15} = \frac{3+2}{30} = \frac{5}{30}$

$v$ = 6 cm

Final image is real & formed at a distance of 16 cm from mirror.

**19.** **(2)**

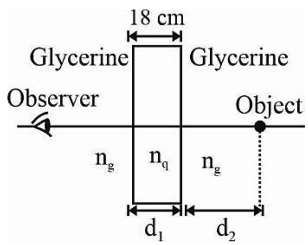
**Sol.**




**20.** **(1)**

**Sol.** $n_{\text{quartz}} = 2$ ; $n_{\text{glycerine}} = \frac{4}{3}$ $\frac{n_{quartz}}{n_{glycerine}} = \frac{2}{4/3} = \frac{3}{2}$

$= \mu_{\text{rel}}$




shift $= t\left(1 - \frac{1}{\mu_{rel}}\right) = 18\left(1 - \frac{1}{3/2}\right) = 6$ cm

**21.** **(2)**

**Sol.** $\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f} = \frac{1}{2x} \Rightarrow f = 2x$ here $\left(\frac{1}{x} = \frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f_1} = \left(\frac{3/2}{4/3} - 1\right)\frac{1}{x}$

$\frac{1}{f_2} = \left(\frac{3/2}{5/3} - 1\right)\left(\frac{1}{x}\right) \Rightarrow f_2$ is negative

$$\frac{1}{f_1}=\frac{1}{8x}=\frac{1}{4(2x)}=\frac{1}{4f}$$

$\Rightarrow f_1 = 4f$

Analytically, If a lens is inserted in a denser surrounding the sign of focal length changes and if lens is inserted in a rarer surrounding, the sign of focal length remain same.

If lens is inserted in rarer medium the focal length increases.

**22.** **(2)**

**Sol.** For normal adjustment

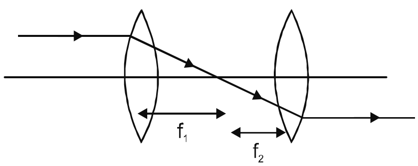
$$m=-\frac{f_0}{f_e}$$

When final image is at least distance of distinct vision from eyepiece,

$$m'=-\frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right)=10\left(1+\frac{5}{25}\right)=12$$

**23.** **(3)**

**Sol.**



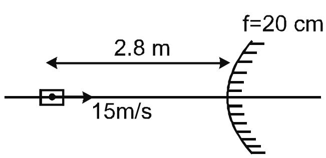

Distance between lens is $= f_1 + f_2$,

**24.** **(3)**

**Sol.** $t=\frac{x}{v}=\frac{x\mu}{c}$

**25.** **(2)**

**Sol.** Mirror formula:




$$\frac{1}{v}+\frac{1}{-280}=\frac{1}{20}$$

$$\frac{1}{v}=\frac{1}{20}+\frac{1}{280}$$

$$\frac{1}{v}=\frac{14+1}{280}$$

$$v=\frac{280}{15}$$

$$v_I=-\left(\frac{v}{u}\right)^2.v_{om}$$

$$\therefore\ v_I=-\left(\frac{280}{15\times 280}\right)^2.15$$

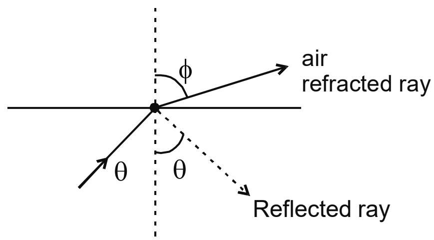
$$\therefore\ v_I=\frac{-15}{15\times 15}$$

$$v_I=-\frac{1}{15}\text{ m/s}$$

**26.** **(3)**

**Sol.** There will be partial reflection and refraction as shown in figure.

Angle between the reflected ray and the refracted ray $= 180° - (\theta + \phi)$ which is less than $180° - 2\theta$ (because $\phi > \theta$)




**27.** **(2)**

**Sol.** $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$ ...... (1)

$$\frac{1}{f}=\frac{1}{10}-\frac{1}{-10}$$

$f = +5$

Differentiate eq. (1)

$$\Rightarrow \frac{-\Delta f}{f^2}=\frac{-\Delta v}{v^2}+\frac{\Delta u}{u^2}=\frac{1}{+v^2}\Delta v+\frac{1}{u^2}\Delta u$$

$$\Rightarrow + \frac{\Delta f}{5^2} = \frac{1\times(0.1)}{+10^2} + \frac{1\times(0.1)}{10^2}$$

$$\Delta f = \frac{0.2}{100}\times 25 = \frac{0.2}{4} = 0.05$$

So, $f = 5 \pm 0.05$

**28.** **(4)**

**Sol.** $f_A = f_B = f_C = f_{\text{net}}$

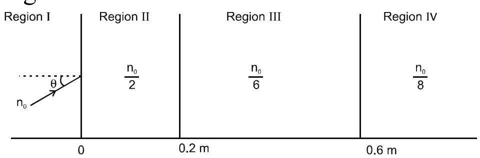
$\Rightarrow P_A = P_B = P_C = P_{net} = P$

**29.** **(1)**

**Sol.** Optics fibres are based on total internal reflection

**30.** **(2)**

**Sol.** As the beam just suffers TIR at interface of region III and IV.



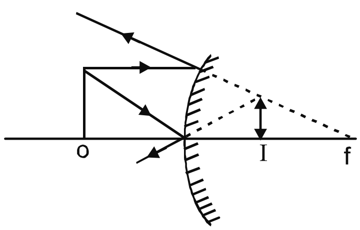

$$n_0 \sin\theta = \frac{n_0}{2}\sin\theta_1 = \frac{n_0}{6}\sin\theta_2 = \frac{n_0}{8}\sin 90°$$

$$\sin\theta = \frac{1}{8}$$

$$\theta = \sin^{-1}\frac{1}{8}$$

**31.** **(3)**

**Sol.**




**32.** **(2)**

**Sol.** $r_2 = \sin^{-1}\left(\frac{1}{\mu}\right) = 45^o$

$r_1 = A - r_2 = 75^o - 45^o = 30^o$

$$\frac{\sin i}{\sin r_1} = \sqrt{2}$$

$$\Rightarrow \sin i = \sqrt{2}\sin 30 = \sqrt{2}\times\frac{1}{2}$$

$\Rightarrow i = 45^o$.

**33.** **(2)**

**Sol.** Applying Snell's law ($\mu \sin i$ = constant)

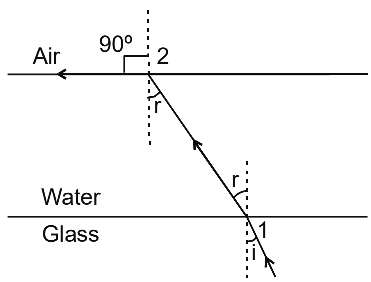
at 1 and 2 we have

$\mu_1 \sin i_1 = \mu_2 \sin i_2$

Here $\mu_1 = \mu_g$; and $\mu_2 = 1$ and $i_2 = 90°$

$i_1 = i$

$\mu_g \sin i = (1)(\sin 90°)$




$$\mu_g = \frac{1}{\sin i}$$

**34.** **(3)**

**Sol.** The objective of compound microscope is a lemax lens and it forms real and enlarged image when an object is placed between its focus and lens

**35.** **(3)**

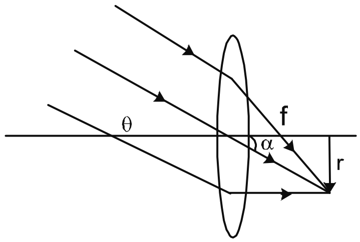
**Sol.** $\frac{3}{2}\sin C = \frac{4}{3}\sin 90° \Rightarrow C = \sin^{-1}\left(\frac{8}{9}\right)$

**36.** **(4)**

**Sol.** $MP = \left(1+\frac{D}{f}\right) = \left(1+\frac{25}{5}\right) = 6$

**37.** **(2)**

**Sol.** $r = f\tan\alpha$




Hence, $\pi r^2 \propto f^2$.

**38.** **(1)**

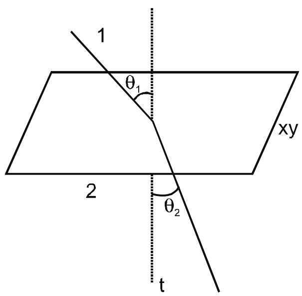
**Sol.** $v = 2u$

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$u = -30$ cm

**39.** **(2)**

**Sol.**




$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2$

$\cos\theta_1$

$$=\frac{10}{\sqrt{\left(6\sqrt{3}\right)^2+\left(8\sqrt{3}\right)^2+100}}=\frac{10}{\sqrt{400}}=\frac{10}{20}$$

$\cos\theta_1 = \dfrac{1}{2}$

$\theta_1 = 60°$

$\sqrt{2}\sin 60° = \sqrt{3}\sin\theta_2$

$\sqrt{2}\times\dfrac{\sqrt{3}}{2} = \sqrt{3}\sin\theta_2$

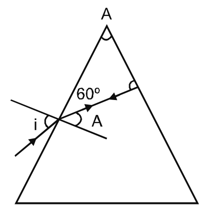
$\theta_2 = 45°$

**40.** **(1)**

**Sol.** $x = \dfrac{24}{\left(\dfrac{3}{4}\right)} = \dfrac{24\times 4}{3} = 32$ cm

**41.** **(3)**

**Sol.**




$$\frac{\sin i}{\sin A} = \mu$$

since $i$ and $A$ are small angle. $\dfrac{i}{A} = \mu$

**42.** **(4)**

**Sol.** $\dfrac{1}{f}=\dfrac{1}{f_1}+\dfrac{1}{f_2}-\dfrac{d}{f_1 f_2}=0$

$$\frac{1}{25}+\frac{1}{-20}-\frac{d}{-500}=0$$

$$=\frac{20-25}{500}=-\frac{d}{500}$$

$d = 5$ cm.

**43.** **(3)**

**Sol.** Angle of minimum deviation $D = (\mu - 1)A$

$\because \mu_{blue} > \mu_{red}$

$\therefore D_2 > D_1$

**44.** **(3)**

**Sol.** By mirror - lens combination formula

$$\frac{1}{F}=\frac{1}{f_m}-\frac{2}{f_L}$$

$$\frac{1}{F} = \frac{1}{\infty} - \frac{2}{15}$$

By mirror formula

$$\frac{1}{F} = \frac{1}{u} + \frac{1}{v} \Rightarrow -\frac{2}{15} = \frac{1}{-20} + \frac{1}{v}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{2}{15} \qquad = \frac{3-8}{60}$$

$v = -12$ cm negative means towards left

**45.** **(2)**

**Sol.** The effective focal length is 5 cm

The height of final image is

$$= \frac{v}{u} \times h_O = \frac{f}{u+f} h_O = \frac{5}{-7.5+5} \times 1 = 2 \text{ cm}$$

**46.** **(2)**

**Sol.** $n_{rel} < 1$

So, f is negative

**47.** **(3)**

**Sol.** $$\frac{1}{10} = \left(\frac{3}{2}-1\right)\left(\frac{1}{R} - \frac{1}{\infty}\right) \Rightarrow \frac{1}{2R} = \frac{1}{10}$$

$\Rightarrow R = 5$ cm

Rays should retrace the path $\Rightarrow$ incident rays on mirror should be normal

$$\Rightarrow \frac{3/2}{\infty} - \frac{1}{-d} = \left(\frac{\frac{3}{2}-1}{5}\right)$$

[$u = -d$, as lens is their]

$$\Rightarrow \quad \frac{1}{d} = \frac{1}{10}$$

$\Rightarrow \quad d = 10$ cm

**48.** **(1)**

**Sol:** $R_1 = R$, $R_2 = -R$

$$P = \frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

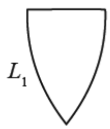
$$P = \frac{1}{f} = (\mu-1)\left(\frac{1}{R} - \left(\frac{1}{-R}\right)\right)$$

$$P = \frac{(\mu-1)2}{R}$$

For lens -1,

$R_1 = R$, $R_2 = -R$

$$P_1 = \frac{1}{f''} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

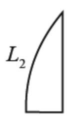



$$P_1 = \frac{(\mu-1)\times 2}{R} = P$$

For lens – 2

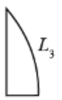
$R_1 = R$, $R_2 = \infty$

$$P_2 = \frac{1}{f'} = (\mu-1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$$




$$P_2 = \frac{P}{2}$$

For lens–3



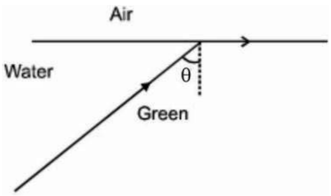

$$R_1 = \infty, R_2 = -R$$

$$P_3 = \frac{1}{f''}(\mu - 1)\left(\frac{1}{\infty} - \left(-\frac{1}{R}\right)\right)$$

$$P_3 = \frac{\mu - 1}{R} = \frac{P}{2}$$

**49.** **(3)**

**Sol.**




Here $\sin\theta = \frac{1}{n_{water}}$

and $n_{water} = a + \frac{b}{\lambda^2}$

If frequency is less ⇒ λ is greater and hence R.I. ($n_{water}$) is less and therefore, critical angle increases.

**50.** **(3)**

**Sol.** $x' = \frac{x}{n_{rel}}$ , $v' = \frac{v}{n_{rel}}$

$$= \frac{\sqrt{2 \times 10 \times (20 - 12.8)}}{1} \times \frac{4}{3} = 16 \text{ m/s.}$$

**51.** **(3)**

**Sol.** $5 + 2 = \frac{t_1}{1.5} + \frac{t_2}{1.5}$

$\Rightarrow 7 \times 1.5 = t_1 + t_2$

$10.5 = t_1 + t_2$

**52.** **(4)**

**Sol.** $\frac{1}{f} = \frac{1}{12} + \frac{1}{240} = \frac{20+1}{240}$

$f = \frac{240}{21} m$

shift = $1(1 - \frac{2}{3}) = \frac{1}{3}$

Now $v' = 12 - \frac{1}{3} = \frac{35}{3}$ cm

$\therefore \frac{21}{240} = \frac{3}{35} - \frac{1}{u}$

$\frac{1}{u} = \frac{3}{35} - \frac{21}{240} = \frac{1}{5}\left(\frac{3}{7} - \frac{21}{48}\right)$

$\frac{5}{u} = \left|\frac{144 - 147}{48 \times 7}\right|$

$u$ = 560 cm = 5.6 m

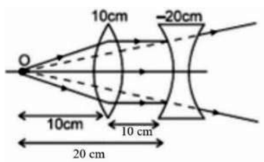
**53.** **(3)**

**Sol.** $P_L = P_1 + P_2$

$P_L = \frac{1}{f_L}$

**54.** **(1)**

**Sol.**




**55.** **(2)**

**Sol.** When the object is placed at the centre of the glass sphere, the rays from the object fall normally on the surface of the sphere and emerge undeviated.

**56.** **(1)**

**Sol.** For refraction by upper surface

$$\frac{1.6}{V_1} - \frac{1}{-2} = \frac{1.6 - 1}{1}$$

$$\Rightarrow \frac{1.6}{V_1} = 0.6 - 0.5 = 0.1$$

$V_1 = 16\text{m}$

For refraction by lower surface

$$\frac{2}{V_2} - \frac{1}{-2} = \frac{2-1}{1}$$

$$\frac{2}{V_2} = 1 - 0.5 = 0.5$$

$$V_2 = \frac{2}{0.5} = 4m$$

Distance between images = (16-4) = 12m

**57.** **(2)**

**Sol.** $i > c$ for TIR

$$\therefore 45° > \sin^{-1}\left(\frac{1}{n}\right)$$

$$\Rightarrow n > \sqrt{2}$$

**58.** **(3)**

**Sol.** Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.

$\mu_{lens} < 1.33$

## *Integer Type Questions (59 to 72)*

**59.** **(4)**

**Sol.** $n = \left(\frac{360}{72} - 1\right) = 4$

**60.** **(90)**

**Sol.** $L_{min} = \frac{H}{2} = \frac{180}{2} = 90$ cm

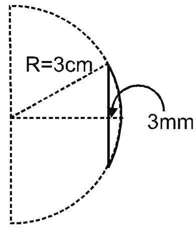
**61.** **(90)**

**Sol.** $v = \frac{u}{4}$ $\qquad \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$u = 90$ cm

**62.** **(30)**

**Sol.** $n = \frac{3}{2}$




$3^2 + (R - 3\text{mm})^2 = R^2$

$\Rightarrow 3^2 + R^2 - 2R\,(3\text{mm}) + (3\text{mm})^2 = R^2$

$\Rightarrow R \approx 15$ cm

$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{15}\right)$$

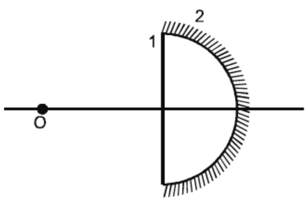
$\Rightarrow f = 30\text{cm}$

**63.** **(20)**

**Sol.** To get real image of the size of the object, object should be placed at the centre of curvature of equivalent mirror.

$$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_l}$$

$f_m = -15$ cm




And $\frac{1}{f_2} = \frac{1}{-15} - \frac{2}{60}$

$F_2 = -10$ cm

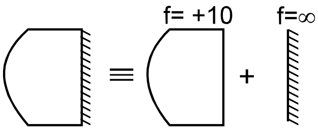
Hence, object should be placed at 20cm from the combination

**64.** **(5)**

**Sol.** $n = \left(\frac{360°}{\theta}\right) - 1 = \left(\frac{360}{60} - 1\right) = 5$

**65.** **(5)**

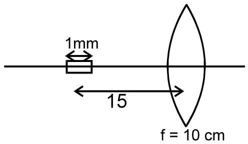
**Sol.**




$$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L} = 0 - \frac{2}{10} \Rightarrow F = 5$$

**66.** **(4)**

**Sol.**




$$\frac{1}{10} = \frac{1}{v} - \frac{1}{(-15)} \Rightarrow v = +30 \text{ cm}$$

for small object $dv = \frac{v^2}{u^2}du$

$$= \left(\frac{30}{15}\right)^2 \times 1 = 4 \text{ mm}$$

**67.** **(6)**

**Sol.** From displacement method

$O = \sqrt{I_1 I_2}$

$O = \sqrt{9 \times 4} = 6$ cm

**68.** **(12)**

**Sol.** $\frac{1}{f} = (\mu_{rel} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $(R_1 = R, R_2 = -R)$

**69.** **(1)**

**Sol.** $P = P_1 + P_2$

$= +4 + (-3) = +1$

**70.** **(400)**

**Sol:** $u = -100$ cm

$$f = \frac{R}{2} = -100 \text{cm}$$

After 10 sec, d = 2 × 10 = 20 cm

$u = -80$cm

As per mirrors formula

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-100} - \frac{1}{-80} = \frac{1}{400}$$

$\therefore$ $v = 400$ cm

**71.** **(113)**

**Sol:** $v_A - v_B = 2.6 \times 10^7 m/s$

$v = \frac{c}{\mu}$,

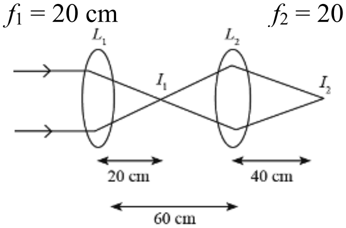
$$\Rightarrow v_B = \frac{3 \times 10^8}{1.47} = 2.04 \times 10^8 = 20.4 \times 10^7 m/s$$

$$\therefore v_A = (20.4 + 2.6) \times 10^7 = 23 \times 10^7 m/s$$

$$\therefore \frac{\mu_B}{\mu_A} = \frac{v_A}{v_B} = \frac{23 \times 10^7}{20.4 \times 10^7} = 1.13$$

**72.** **(100)**

**Sol:** $f_1 = 20$ cm $\quad f_2 = 20$ cm




For $L_1$ apply lens formula

$$\frac{1}{v} - \frac{1}{\infty} = \frac{1}{f_1}$$

$\therefore$ $v = f = 20$ cm

For $L_2$, $I_1$ is object and $I_2$ is image

$\therefore$ $u = -40$ cm

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_2}$$

$$\frac{1}{v} - \frac{1}{(-40)} = \frac{1}{20}$$

$$\frac{1}{V} = \frac{1}{20} - \frac{1}{40} = \frac{6-3}{120}$$

$$\frac{1}{V} = \frac{3}{120} = \frac{1}{40}$$

$\therefore$ $v = 40$ cm

Therefore, total distance = 60 + 40 = 100 cm

# WAVE OPTICS

## Single Option Correct Type Questions (01 to 60)

**1.** **(1)**

**Sol.** We know $I \propto A^2$.

$\Rightarrow \frac{I_1}{I_2} = \frac{A_1^2}{A_2^2}$

$\Rightarrow \sqrt{\frac{4}{1}} = \frac{A_1}{A_2} \Rightarrow A_1 : A_2 = 2 : 1$

**2.** **(4)**

**Sol.** $I_m = I_0 + 4I_0 + 2\sqrt{I_0 \times 4I_0} \cos\phi$

$I_m = I_0 + 4I_0 + 4I_0 \cos\phi$

$= \frac{I_m}{9}(5 + 4\cos\phi)$

$= \frac{I_m}{9}\left(1 + 8\cos^2\phi/2\right)$

**3.** **(3)**

**Sol.** $\beta_1 = \frac{\lambda D}{d} = \frac{650 \times 10^{-9} \times 1.5}{5 \times 10^{-4}}$

$= 650 \times 0.3 \times 10^{-5}$

$= 1.95$ mm

$\beta_2 = \frac{520 \times 10^{-9} \times 1.5}{5 \times 10^{-4}}$

$= 520 \times 0.3 \times 10^{-5}$

$= 1.56$ mm

$4\beta_1 = 5\beta_2 = 7.8$ mm

**4.** **(4)**

**Sol.** $w = \frac{D\lambda}{d}$

since $v = f\lambda$

since vacuum is made, $\lambda$ increased fringe width increases

**5.** **(1)**

**Sol.** If it is performed with white light. the central point will have maxima of all the colours, hence it will look white.

$\beta = \frac{\lambda D}{d}$ ; as $\lambda_v$ is minimum

So, first maxima after white as will be that of violet.

So there will be no dark fringe as it is not possible be have minimas of all the colors at the same point.

**6.** **(1)**

**Sol.** When unpolarized light passes through a Polaroid, its intensity becomes 50%.

**7.** **(3)**

**Sol.** $1.22\frac{\lambda}{a} = \frac{1mm}{D}$

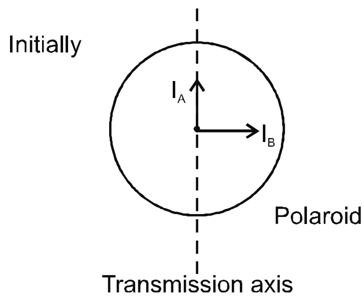
$a = 3$mm, $\lambda = 500$nm

**8.** **(4)**

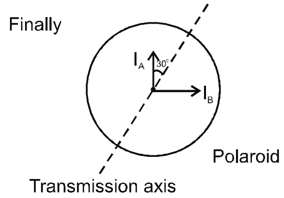
**Sol.** It will be concentric circles

**9.** **(4)**

**Sol.**



Finally



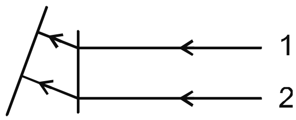

$I_A \cos^2 30^0 = I_B \cos^2 60^0$

$\Rightarrow I_A = \frac{3}{4} I_{B.} \ \frac{1}{4} \ \frac{d.(PP')}{Dt}$

$\frac{I_A}{I_B} = \frac{1}{3}$

**10.** **(4)**

**Sol.**




Ray 2 will travel faster than 1, so beam will bend upward

**11.** **(3)**

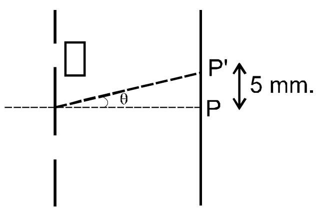
**12.** **(1)**

**Sol.** We know that $\beta = \&\ \lambda_{yellow} > \lambda_{blue}$.

$\Rightarrow$ as $\lambda$ decreases, so $\beta$ also decreases.

**13.** **(1)**

**Sol.**




Clearly the central maxima at $P$ (initially) shifts to $P$' where $PP$' = 5 mm.

So now, path difference at $P$' must be zero.

$y = \frac{(\mu - 1)tD}{d}$

$\mu = 1 + \frac{yd}{Dt}$ get $\mu = 1.2$

**14.** **(1)**

**Sol.** $\Delta x_1 = 0$

$\Delta\phi = 0°$

$I_1 = I_0 + I_0 + 2\, I_0 \cos 0° = 4I_0$

$\Delta x_2 =$

$\Delta\theta = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \left(\frac{\pi}{2}\right)$

$I_2 = I_0 + I_0 + 2I_0 \cos\frac{\pi}{2} = 2I_0$

$\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = \frac{2}{1}$

**15.** **(4)**

**Sol.** $I_R = I_0 \cos^2 \frac{\phi}{2}$

$\phi = \frac{2\pi}{\lambda}(\Delta x) = \frac{\pi}{3}$

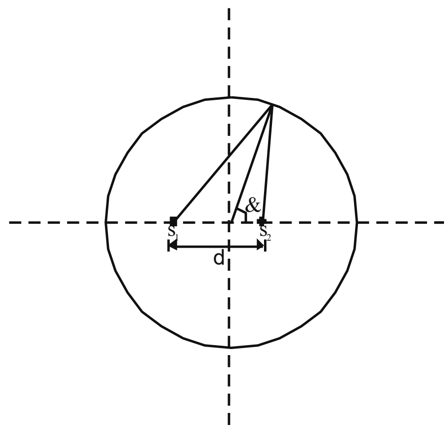
$\because I_R = \cos^2 \frac{\pi}{6}$

$\frac{I}{I_0} = \frac{3}{4}$

**16.** **(2)**

**17.** **(3)**

**Sol.**




$\Delta x = d \cos\theta = n\lambda$

$d = 2\lambda$

$\because \cos\theta = \frac{n}{2}$

$n = 1$

$\cos\theta = \frac{1}{2}$

$\theta = 60°$

**18.** **(2)**

**Sol.** For strong reflection.

$2\mu t =$ ......

$\Rightarrow \lambda = 4\mu t, \frac{4\mu t}{3}, \frac{4\mu t}{5}, \frac{4\mu t}{7}$ ......

$\Rightarrow$ 3000 nm. 1000 nm, 600 nm, 430 nm, 333 nm.

$\Rightarrow$ only option is 600 nm.

**19.** **(2)**

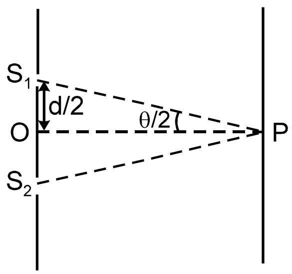
**Sol.** $\because \theta = \frac{\lambda}{a} = \frac{R}{D}$

and $\lambda_{x\text{-Ray}} < \lambda_{visible}$

$\therefore R_{x\text{-Ray}} < 0.1$

**20.** **(1)**

**Sol.**




In $\Delta S_1PO$:

$\tan\frac{\theta}{2} = \frac{d/2}{D}$

As $D >> d$

$\therefore \theta$ is very small.

$\Rightarrow \tan\frac{\theta}{2} \approx \frac{\theta}{2} \Rightarrow \frac{\theta}{2} = \frac{d}{2\ D}$

$\Rightarrow \frac{D}{d} = \frac{1}{\theta} \Rightarrow$ Fringe width

**21.** **(2)**

**22.** **(3)**

**Sol.** Fourth maxima will be at $y = 4\beta$.

$\Rightarrow y = \frac{4\lambda D}{d} \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$

as $\lambda_{Green} > \lambda_{blue}$.

$\Rightarrow \beta_{Green} > \beta_{blue}$

$\Rightarrow X_{Green} > X_{blue}$

Also get $\frac{X(blue)}{X(green)} = \frac{4360}{5460}$

**23.** **(1)**

**Sol.** For coherent sources:

$I_1 = 4I_0$

For incoherent sources

$I_2 = 2I_0$

$\frac{I_0}{I_2} = \frac{2}{1}$.

**24.** **(3)**

**Sol.** Contrast indicates the ratio of maximum possible intensity on screen to the minimum possible intensity.

As $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$

so it only depends on the source intensity.

**25.** **(4)**

**Sol.** Statement 1 is false because constructive interference can be obtained if phase difference of sources is $2\pi$, $4\pi$, $6\pi$, etc.

**26.** **(3)**

**Sol.** The beautiful colours are seen an account of interference of light reflected from the upper and the lower surfaces of the thin film. As conditions for constructive & destructive interference depend upon the wavelength of light, therefore coloured interference fringes are observed.

**27.** **(4)**

**Sol.** If maximum intensity is observed at $P$ then for maximum intensity to be also observed at $Q$, $S_1$ and $S_2$ must have phase difference of $2m\pi$ (where m is an integer).

**28.** **(3)**

**Sol.** $A_2P - A_1P = \frac{\lambda}{2}$ (Condition of minima)

$\sqrt{D^2 + a^2} - D = \frac{\lambda}{2}$

$D\left(1 + \frac{a^2}{D^2}\right)^{1/2} - D = \frac{\lambda}{2}$

$$D\left(1+\frac{1}{2}\times\frac{a^2}{D^2}\right)-D=\frac{\lambda}{2}$$

$$\frac{a^2}{2D}=\frac{\lambda}{2}$$

$$\Rightarrow a=\sqrt{\lambda D}$$

$$=\sqrt{800\times10^{-6}\times50}$$

$a = 0.2$ mm

**29.** **(3)**

**Sol.** $I=I_1+I_2+2\sqrt{I_1I_2}\cos\phi$

$I_0+I_0+2I_0\cos\phi=2I_0(1-\cos\phi)$

For $\phi=\frac{\pi}{3}\Rightarrow I_p=3I_0$

For $\phi=\frac{\pi}{2}\Rightarrow I_Q=2I_0$

$$\frac{I_P}{I_Q}=\frac{3I_0}{2I_0}=\frac{3}{2}$$

**30.** **(2)**

**Sol.** $\beta = 12$ mm $= 12\times10^{-3}$m

Formula of fringe width

$$\beta=\frac{\lambda D}{d}$$

Wavelength with respect to medium

$$\lambda'=\frac{\lambda}{\mu}$$

Fringe width in medium,

$$\beta'=\frac{\lambda' D}{d}=\frac{\lambda D}{\mu d}$$

$$\beta'=\frac{\beta}{\mu}=\frac{12\times10^{-3}}{\frac{4}{3}}=9\times10^{-3}m$$

$\beta' = 9$mm

**31.** **(3)**

**Sol.** Intensity of light after passing through the polarizer

$$I_A=\frac{I_o}{2}$$

Intensity of light after passing through the polariserc

$$I_C=\frac{I_0}{2}\cos^2 45=\frac{I_0}{4}$$

$$\Rightarrow I_B=I_C\cos^2 45=\frac{I_0}{8}$$

**32.** **(2)**

**Sol.** $I=I_0\cos^2(\omega t)\Rightarrow I_{av}=\frac{I_0}{2}$

$$\therefore E=\frac{I_0}{2}\times A\times(\Delta t)$$

$$\Delta t=\frac{2\pi}{\omega}=\frac{2\times3.14}{31.4}=\frac{1}{5}s$$

$$\therefore E=\frac{3.3}{2}\times3\times10^{-4}\times\frac{1}{5}=1\times10^{-4}J$$

**33.** **(2)**

**Sol.** $\frac{I}{3}=\left(\frac{I}{2}\cos^2\frac{\phi}{2}\right)\times\cos^2\frac{\phi}{2}$

$$\Rightarrow \cos^4\frac{\phi}{2}=\frac{2}{3}$$

**34.** **(3)**

**Sol.** $\beta=\frac{\lambda D}{d}\frac{\lambda D}{d_0+a_0\sin\omega t}$

For the largest fringe width, $\sin\omega t=-1$

For the smallest fringe width, $\sin\omega t=+1$

$\therefore$ Difference between the largest to smallest fringe

width $=\beta_1-\beta_2$.

$$\beta_1-\beta_2=\frac{\lambda D}{d_0-a_0}-\frac{\lambda D}{d_0+a_0}$$

$$=\lambda D\left[\frac{(d_0+a_0)-(d_0-a_0)}{d_0^2-a_0^2}\right]=\frac{2\lambda D a_0}{d_0^2-a_0^2}$$

**35.** **(3)**

**Sol.** We know that, $\sin\theta=\frac{n\lambda}{a}$

if $a\uparrow\rightarrow\theta\downarrow$

So width decrease as a result intensity increases.

**36.** **(4)**

**Sol.** $I = I_0 \cos^2 \theta$

$\frac{I_0}{10} = I_0 \cos^2 \theta$

$\cos\theta = \frac{1}{\sqrt{10}} 0.31$ which is 0.707

So θ > 45° and 90 – θ < 45° so only one option i.e. 18.4º

Angel rotated should be = 90º – 71.6º = 18.4º

**37.** **(4)**

**Sol.** $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2 = \left(\frac{5}{1}\right)^2$

$= \frac{25}{1}$

**38.** **(1)**

**Sol.** P.D. = $(d) \sin\theta$

$= \frac{Y}{D} = \frac{(10^{-3})(1.27\times10^{-3})}{1} = 1.27\,\mu m$

**39.** **(3)**

**Sol.** The fringe separation

$\beta = \frac{\lambda D}{d} = \frac{500\times10^{-9}\times1}{2\times10^{-3}}$

$= 250 \times 10^{-6}$ m $= 250 \times 10^{-3}$ mm = 0.25 mm

**40.** **(1)**

**Sol.** $N_1\lambda_1 = N_2\lambda_2$

$16\times700 = N_2 \times 400$

$\Rightarrow N_2 = 28$

**41.** **(4)**

**Sol.** Since unpolarised light falls on $P_1 \Rightarrow$ intensity of light transmitted from $P_1(I_1) = \frac{I_0}{2}$

∴ Intensity of light transmitted form $P_2$

$I_2 = \frac{I_0}{2}\cos^2 30° = \frac{3I_0}{8}$

Intensity of light transmitted from $P_3$ is

$I = I_2 \cos(60°)^2$

$\Rightarrow I = \frac{3I_0}{8}\times\frac{1}{4}$

$\Rightarrow \frac{I_0}{I} = \frac{32}{3} = 10.67$

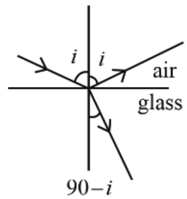
**42.** **(3)**

**Sol.** $\theta = \frac{\lambda}{d} = \frac{500\times10^{-9}}{5\times10^{-5}}$

= 0.01 rad = 0.57°

**43.** **(2)**

**Sol.**




Using snell's law,

$\mu_a \sin i_1 = \mu_g \sin(90 - i_1)$

$\Rightarrow \tan i_1 = \frac{\mu_g}{\mu_a}$

For the ray going from glass to air

$\tan i_2 = \frac{\mu_a}{\mu_g} = \cot i_1$

$\Rightarrow i_2 = \frac{\pi}{2} - i_1$

**44.** **(4)**

**Sol.** We know that, at any point intensity $I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$

Ratio of the intensity of light at that point of the centre of a bright fringe

$\frac{I}{I_0} = \cos^2\left[\frac{\frac{2\pi}{\lambda}\times\Delta x}{2}\right] = \cos^2\left(\frac{\pi}{8}\right) = 0.853$

**45.** **(1)**

**Sol.** $\because\, y_{nth} = \frac{n\lambda D}{d}$

$\Rightarrow \frac{5\times600\times10^{-9}\times1}{d} = 5\times10^{-2}$

$\Rightarrow d = 60\mu m$

**46. (2)**

**Sol.** Intensity of light after passing through the first sheet

$$I_1 = \frac{I}{2}$$

Intensity of light after passing through the second sheet

$$I_2 = I_1 \cos^2(45°) = \frac{I}{4}$$

After passing through $n^{th}$ sheet

$$I_n = \frac{1}{2^n} = \frac{I}{64}$$

$\Rightarrow n = 6$

**47. (2)**

**Sol.** We know that,

$\beta = \frac{\lambda D}{d}$ and $\lambda_{red} > \lambda_{violet}$

Therefore, if the source of light used in a Young's double slit experiment is changed from red to violet fringe width decreases and fringe lines will come close.

**48. (1)**

**Sol.** For 2nd minima

$d \sin\theta = 2\lambda$

$$\sin\theta = \frac{\sqrt{3}}{2}(given)$$

$$\Rightarrow \frac{\lambda}{d} = \frac{\sqrt{3}}{4} \quad \ldots (i)$$

So for 1st minima is

$d \sin\theta = \lambda$

$\sin\theta = \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$ (From equation (i))

$\theta = 25.65^o$ (from sin table)

$\theta \approx 25^o$

**49. (1)**

**Sol.** $\beta = \frac{\lambda D}{d}$

From formula, fringe width is directly proportional to wavelength and wavelength of orange light is greater than the blue light therefore,

So, $\beta_{Orange} > \beta_{Blue}$

Hence, distance between consecutive fringes will decrease.

**50. (2)**

**Sol.** Given position of second minima is

$$x_2 = \frac{2\lambda D}{d} = 0.03$$

position of fourth minima is

$$x_4 = \frac{4\lambda D}{d} = 0.06$$

$$x_4 - x_2 = \frac{2\lambda D}{d} = 0.03$$

width of central maxima is

$$w = \frac{2\lambda D}{d}$$

$= 0.03$ m

**51. (3)**

**Sol.** $I = I_0 \cos^2 30°$

$$= I_0\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4}I_0$$

**52. (2)**

**Sol.** From the equation, $\frac{A_1}{A_2} = \frac{2}{1}$

$I \propto (\text{Amplitude})^2$

$$\frac{I_{max}}{I_{min}} = \left(\frac{A_1 + A_2}{A_1 - A_2}\right)^2 = \frac{9}{1} = 9:1$$

**53. (3)**

**Sol.** $\beta = \frac{\lambda D}{d} = \frac{589\times10^{-9}\times1.5}{0.15\times10^{-3}} = 5.9\,mm$

**54. (4)**

**Sol.** Fringe width, $\beta = \frac{D\lambda}{d}$

$\lambda_1 = 5000\mathring{A}$

$$\beta_1 = \frac{D}{d}(5000\times10^{-10} = 5\times10^{-4}\,m) \quad \ldots (i)$$

$$\beta_2 = \frac{D}{(2d)}(6000\times10^{-10}) = x(let) \quad \ldots (ii)$$

Divide (ii) and (i)

$$\frac{\beta_2}{\beta_1} = \frac{3000\times10^{-10}}{5000\times10^{-10}} = \frac{x}{5\times10^{-4}}$$

$x = 3 \times 10^{-4}$ m or 0.3 mm

**55. (2)**

**Sol.** For diffraction

Location of 1st minima

$$y_1 = \frac{D\lambda}{a} = 0.2469D\lambda$$

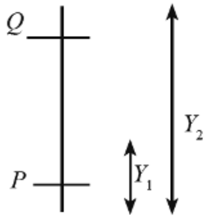
Location of 2nd minima

$$y_2 = \frac{2D\lambda}{a} = 0.4938D\lambda$$

Now for interference

Path for interference

Path difference at $P$




$$\frac{dy}{D} = 4.8\lambda$$

Path difference at $P$.

$$\frac{dy}{D} = 9.6\lambda$$

So orders of maxima in between $P$ and $Q$ is 5, 6, 7, 8, 9

So 5 bright fringes all present between $P$ and $Q$.

**56. (3)**

**Sol.** $\phi_A = \frac{\pi}{2} - \frac{2\pi}{\lambda} \times \frac{5}{20} = 0$

$\phi_B = \frac{\pi}{2}$

$\phi_C = \frac{\pi}{2} + \frac{2\pi}{\lambda} \times \frac{5}{20} = \pi$

$I_A = 4I_0$

$I_B = 2I_0$

$I_C = 0$

**57. (1)**

**Sol.** Resolving Power, $R_P \propto \frac{1}{\lambda}$

As $\lambda = \frac{h}{P} = \frac{h}{mv}$

$\therefore R_P \propto mv$

$\Rightarrow R_P \propto P$

$R_P \propto m$

Therefore, $\frac{R_{P_{pr}}}{R_{P_{ei}}} = 1837$

**58. (1)**

**Sol.** $\sqrt{(2d)^2 + (d)^2} - 2d = \frac{\lambda}{2}$

$\Rightarrow (\sqrt{5} - 2)d = \frac{\lambda}{2} \Rightarrow d = \frac{\lambda}{2\left(\sqrt{5} - 2\right)}$

**59. (2)**

**Sol.** $y_n = \frac{n\lambda D}{d}$

$\therefore 2\beta = \frac{2\lambda D}{d}$

$= 2 \times 5890 \times 10^{-10} \times \frac{0.5}{(0.5 \times 10^{-3})} = 1178 \times 10^{-6} m$

**60. (3)**

**Sol.** Formula of fringe width $(\beta) = \frac{D\lambda}{d} \Rightarrow \beta \propto \lambda$

$\therefore \Rightarrow \frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1} \Rightarrow \beta_2 = \frac{\lambda_2}{\lambda_1} \times \beta_1$

$\Rightarrow \beta_2 \frac{600\,nm}{400\,nm} \times 2mm$

$\Rightarrow \beta_2 = 3\,mm$

## *Integer Type Questions (61 to 75)*

**61. (48)**

**Sol.** It is given,

Wavelength of 1st wave $\lambda_1 = 800$ nm

Wavelength of 2nd wave $\lambda_2 = 600$ nm

Distance of screen from the slit, $D = 7$ m

Distance between the two slits, $d = 0.35$ mm

$n_1 \frac{\lambda_1 D}{d} = n_2 \frac{\lambda_2 D}{d}$

$800n_1 = 600n_2 \Rightarrow \frac{n_1}{n_2} = \frac{3}{4}$

Minimum $n_1 = 3$ & $n_2 = 4$

Minimum separation $= \frac{n_1 \lambda_1 D}{d}$

$= \frac{3 \times 800nm \times 7m}{0.35\,mm} = 48$

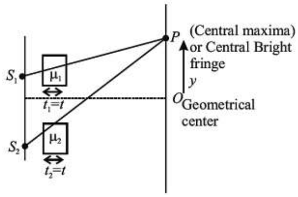
**62. (600)**

**Sol.** $\beta = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{\beta d}{D} = \frac{6\times10^{-3}\times1\times10^{-3}}{10} = 6\times10^{-7} m$

= 600 nm

**63. (10)**

**Sol.**




Path difference at P be Δx

$\Delta x = (\mu_2 - \mu_1)t = (1.55 - 1.51)\,0.1 mm$

$=0.04 \times 10^{-4}$

$\Delta x = 4 \times 10^{-6} = 4\mu m$

$\lambda = \frac{\Delta x D}{d} = 4\times10^{-6}\frac{D}{d}$

{$y$ is the distance of central maxima from geometric center}

Fringe width

$= \frac{\lambda D}{d} = 4\times10^{-6} m\frac{D}{d} = 4\mu m\frac{D}{d}$

∴ Central bright fringe spot will shift by '$x$'

Number of shift = $\frac{y}{\beta}$

$= \frac{4\times10^{-6} D/d}{4\times10^{-7} D/d} = 10$

**64. (600)**

**Sol.** $\beta = \frac{\lambda D}{d}$

$\Delta\beta = \frac{\lambda}{d}\Delta D$

$\lambda = \frac{\Delta\beta . d}{\Delta D}$

$= \frac{3\times10^{-5}\times1\times10^{-3}}{5\times10^{-2}}$

$= 60 \times 10^{-8} = 600 \times 10^{-9}$ m

= 600 nm

**65. (09)**

**Sol.** $\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{6} = \frac{\pi}{3}$

$I = k\cos^2\left(\frac{\phi}{2}\right) = \frac{3K}{4}$

$n = 9$

**66. (462)**

**Sol.** $d = 2.5$ mm, $D = 150$ cm

Fringe width $\beta = \frac{\lambda D}{d}$

Let $n^{th}$ bright tringle of $\lambda_1$ match with $m^{th}$ bright triangle of $\lambda_2$

$n\beta_1 = m\beta_2$

$\frac{n\lambda_1 D}{d} = \frac{m\lambda_2 D}{d} \Rightarrow \frac{n}{m} = \frac{\lambda_2}{\lambda_1} = \frac{5500}{7000} = \frac{11}{14}$

Distance where bright fringe will match

$= \frac{n\lambda . D}{d}$

$= \frac{11\times7000 Å\times150 cm}{0.25 cm} = 462\times10^{-5}$

**67. (7)**

**Sol.** $\Rightarrow \tan i = \frac{\mu_2}{\mu_1} = \sqrt{\frac{6.8}{2.8}}$

$\tan i = \left(\frac{2.8+4}{2.8}\right)^{1/2} \Rightarrow i = \tan^{-1}\left(1+\frac{10}{7}\right)^{1/2}$

$\Rightarrow \theta = 7$

**68. (1)**

**Sol.** $I_{max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2$

$= \left(3\sqrt{I_2}+\sqrt{I_2}\right)^2$

$= 16I_2$

$I_{min} = \left(\sqrt{I_1}-\sqrt{I_2}\right)^2$

$= \left(3\sqrt{I_2}-\sqrt{I_2}\right)^2$

$= 4I_2$

$\frac{I_{min}}{I_{max}} = \frac{1}{4}$

$x = 1$

**69. (750)**

**Sol.** We will use the formula, $\frac{n_1\lambda_1 D}{d} = \frac{n_2\lambda_2 D}{d}$

[$D$ is the distance from the screen to the slits and $d$ is the separation between the slits.]

$$15\times 500\times \frac{D}{d} = 10\times \lambda_2 \times \frac{D}{d}$$

$\lambda_2 = 15 \times 50$ nm

$\lambda_2 = 750$ nm

Hence, value of $\lambda$ is 750.

**70. (30)**

**Sol.** Using Malus Law, we get,

$$\frac{I}{2}\cos^2\theta = \frac{3I}{8}$$

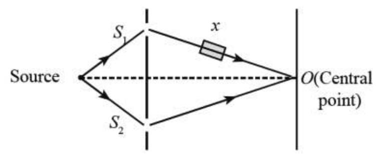
$$\Rightarrow \cos\theta = \frac{\sqrt{3}}{2}$$

$\Rightarrow \theta = 30°$

Hence, $\theta = 30°$ is the correct answer.

**71. (2)**

**Sol.**




Path difference at $O = (\mu - 1)t$.

If the intensity at $O$ remains unchanged.

$\Rightarrow (\mu - 1)t = n\lambda$

$(1.5 - 1)\,x\lambda = n\lambda$

$\Rightarrow x = 2n$

For $n = 1$, $x = 2$

**72. (300)**

**Sol.** For first fringe of Red wavelength

$$\frac{dy_1}{D} = 1\times\lambda_1 \qquad [n = 1]$$

For first fringe of violet wavelength

$$\frac{dy_2}{D} = 1\times\lambda_2 \qquad [n = 1]$$

$$\frac{d}{D}(y_1 - y_2) = \lambda_1 - \lambda_2$$

$$y_1 - y_2 = \frac{D}{d}(\lambda_1 - \lambda_2)$$

$$= \frac{0.3\times 10^{-3}}{1.5}(3.5-2)\times 10^{-3}$$

$= 300 \times 10^{-9} = 300$ nm

**73. (3)**

**Sol.** $\because I = 4I_0\cos^2\left(\frac{\Delta\phi}{2}\right)$ and path difference

$$= \frac{\lambda}{2\pi}\times \text{ phase diff.}$$

For path difference $\frac{\lambda}{4}$, phase difference $\phi = \frac{\pi}{2}$

$$\Rightarrow I_1 = 4I_0\cos^2\left(\frac{\pi}{4}\right) = 2I_0$$

For path difference $\frac{\lambda}{3}$, path difference $\phi = \frac{2\pi}{3}$

$$\Rightarrow I_2 = 4I_0\cos^2\left(\frac{\pi}{3}\right) = I_0$$

$$\Rightarrow \frac{I_1 + I_2}{I_0} = 3$$

**74. (75)**

**Sol.** Using Malus' law,

$I = I_0\cos^2\theta = 100\times\cos^2(30°) = 75$ Lumens

**75. (4)**

**Sol.** Fringe shift $= \frac{t(\mu-1)}{\lambda}\beta_0$

$$= \frac{10\times 10^{-6}}{5\times 10^{-7}}\beta_0 = 4\beta_0$$

# DUAL NATURE OF MATTER AND RADIATION

## Single Option Correct Type Questions (01 to 54)

**1.** **(3)**

Energy of one photon $E = \dfrac{\text{Power}}{\text{Photon frequency}}$

$= \dfrac{15 \times 10^{3}}{10^{16}}$

$\because E = hv$

$\Rightarrow v = \dfrac{15 \times 10^{-13}}{6 \times 10^{-34}} = 2.5 \times 10^{21}$

So the radiation belongs to gamma Rays.

**2.** **(4)**

We know that, $\lambda = \dfrac{h}{mv}$

Therefore, two photons having equal linear momenta have equal wavelength. As wavelength decreases, momentum and energy of a photon increases.

**3.** **(3)**

$P = \dfrac{n.\,hc}{\lambda}$

$n = \dfrac{p\lambda}{h.c}$

$= \dfrac{2 \times 10^{-3} \times 500 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^{8}} = 5 \times 10^{15}$

**4.** **(4)**

For photoelectrons emission $hv > \phi$

Given that, wavelength of radiation $\lambda = 350\ nm$

$\therefore$ Energy of photon, $E = \dfrac{hc}{\lambda} = \dfrac{12400}{\lambda(\text{Å})}$

$\Rightarrow E = \dfrac{12400}{350 \times 10^{-9}} = \dfrac{12400}{3500\text{Å}} = \dfrac{124}{35} = 3.4\ eV$

Since, $E < \phi_A$ and $E > \phi_B$

So, second plate will be able to emit electron.

**5.** **(4)**

From the equation of photoelectric effect

$eV_0 = \dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_0}$

$\dfrac{eV_0}{4} = \dfrac{hc}{2\lambda} - \dfrac{hc}{\lambda_0}$

$\Rightarrow \dfrac{1}{4}\left(\dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_0}\right) = \dfrac{hc}{2\lambda} - \dfrac{hc}{\lambda_0}$

$\dfrac{1}{4}\dfrac{hc}{\lambda} - \dfrac{hc}{2\lambda} = \dfrac{hc}{4\lambda_0} - \dfrac{hc}{\lambda_0}$

$\dfrac{3}{4\lambda_0} = \dfrac{1}{4\lambda}$

$\Rightarrow \lambda_0 = 3\lambda$

**6.** **(1)**

Intensity of light $\propto$ photo current

$KE_{max} = hv - \phi$

$KE_{max}$ depends on frequency

**7.** **(3)**

$eV_0 = hv - \phi$

$\therefore$ work function, $\phi = hv_0$

$= 6.6 \times 10^{-34} \times 5 \times 10^{14} = 33 \times 10^{-20}\ J$

Stopping potential will be zero when incident and threshold frequencies are equal

$\phi_{(eV)} = \dfrac{33 \times 10^{-20}}{1.6 \times 10^{-19}} = 2.07\ eV$

**8.** **(1)**

*UV* rays are most effective for emission of electrons from a metallic surface because they have maximum frequency.

$KE_{max.} = hv - hv_0$

**9.** **(4)**

As the threshold wavelength is 5500Å, therefore for photoelectric emission wavelength of radiation,

$\lambda < 5500$Å and wavelength of *UV* radiation, $\lambda_{uv} < 5500$Å

∴ option (4) is correct

**10.** **(2)**

$$\frac{hc}{\lambda} - \phi = E \quad \text{..........(i)}$$

$$\frac{hc}{\lambda'} - \phi = 2E \quad \text{..........(ii)}$$

Eqn (ii) – eqn (i) gives

$$hc\left(\frac{1}{\lambda'} - \frac{1}{\lambda}\right) = E$$

$$\lambda' = \frac{hc\lambda}{E\lambda + hc}$$

**11.** **(2)**

According to the question,

$$K_1 = \frac{hc}{\lambda_1} - \phi_0 = \frac{hc}{3\lambda_2} - \phi_0 \quad \text{...........}(i)$$

[Given, $\lambda_1 = 3\lambda_2$]

$$K_2 = \frac{hc}{\lambda_2} - \phi_0 \quad \text{...........}(ii)$$

From (i) and (ii)

$$K_2 - K_1 = \frac{hc}{\lambda_2} - \frac{hc}{3\lambda_2} = \frac{2}{3}\frac{hc}{\lambda_2}$$

$$\therefore K_2 - K_1 = \frac{2}{3}K_2 + \frac{2}{3}\phi_0$$

$$\Rightarrow K_1 = \frac{K_2}{3} - \frac{2}{3}\phi_0$$

$$\therefore K_1 < \frac{K_2}{3}$$

**12.** **(2)**

Assertion A is correct: The photoelectric effect does not occur if the energy of the incident radiation is less than the work function of a metal. The work function is the minimum amount of energy required to remove an electron from the metal surface. If the energy of the incident radiation is lower than the work function, the photons do not possess enough energy to overcome the binding energy of the electrons, and no photoelectrons are emitted

$hv = w_0 + K.E_{max}$

If $hv = w_0$

$\Rightarrow K.E_{max} = 0$

**13.** **(3)**

$$K.E. = \frac{hc}{\lambda} - \phi$$

$$\therefore K.E_1 = \frac{1230}{800} - \phi \quad \text{............}(i)$$

$$K.E_2 = 2K.E_1 = \frac{1230}{500} - \phi \quad \text{...........}(ii)$$

From (i) & (ii)

$$2 \times \frac{1230}{800} - 2\phi = \frac{1230}{500} - \phi$$

$$\phi = \frac{1230}{400} - \frac{1230}{500}$$

$$\phi = 0.615\ eV$$

**14.** **(3)**

$$E_1 = 5\phi - \phi = 4\phi = \frac{1}{2}mv_1^2$$

$$E_2 = 10\phi - \phi = \frac{1}{2}mv_2^2$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{\sqrt{\frac{8\phi}{m}}}{\sqrt{\frac{18\phi}{m}}}\sqrt{\frac{8}{18}} = \sqrt{\frac{4}{9}} = \frac{2}{3}$$

**15.** **(2)**

$KE_1 = h\upsilon_1 - \phi_0$

$$\frac{1}{2}mv_1^2 = 3.8 - 0.6 = 3.2\ eV \quad \text{..........}(i)$$

Similarly.

$KE_2 = h\upsilon_2 - \phi_0$

$\frac{1}{2}mv_2^2 = 1.4 - 0.6 = 0.8\ eV$ ..........(*ii*)

On dividing equation (*i*) with equation (*ii*)

$\left(\frac{v_1}{v_2}\right)^2 = 4 \Rightarrow \frac{v_1}{v_2} = 2:1$

**16.** **(1)**

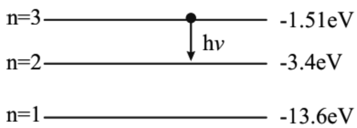
$\frac{1}{2}mv_1^2 = hf_1 - \phi$

$\frac{1}{2}mv_2^2 = hf_2 - \phi$

$v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

**17.** **(1)**

$hv = 3.4 - 1.51 = 1.89\ eV$




As we know that radius of circular path in magnetic

field is given by $r = \frac{\sqrt{2mK}}{qB} \Rightarrow K = \frac{r^2q^2B^2}{2m}$

$\Rightarrow K = \frac{(7\times10^{-3})^2 \times (1.6\times10^{-19}) \times (5\times10^{-4})^2}{2\times9.1\times10^{-31}} eV$

$= 107.7 \times 10^{-2}\ eV = 1.08\ eV$

$\Rightarrow \phi = hv - K = 1.89 - 1.08 = 0.81\ eV$

**18.** **(1)**

$hv - \phi = 6\ eV$

$\frac{hc}{\lambda} - \phi = 6\ eV$ ...........(*i*)

and $\frac{hc}{4\lambda} - \phi = 0.6\ eV$ ...........(*ii*)

(*i*) – (*ii*)

$\frac{3hc}{4\lambda} = 5.4\ eV$

$\therefore \lambda = \frac{3hc}{4\times5.4\ eV} = \frac{3\times1.24\times10^{-6}}{4\times5.4} = 1.72 \times 10^{-7}\ m$

from equation (*i*)

$\frac{hc}{1.72\times10^{-7}} \times \frac{1}{1.6\times10^{-19}} - \phi = 6\ eV$

$\frac{2\times10^{-25}}{2.75\times10^{-26}} - \phi = 6$

$\Rightarrow \phi = (7.27 - 6) \cong 1.2\ eV$

**19.** **(1)**

We have given the energy of electron = 3 $eV$

In 2[nd] excited state, $E = -\frac{(13.6)}{9} = -1.51\ eV$

Energy of photon, $\frac{hc}{\lambda} = 4.512\ eV$

$KE_{max} = 4.512 - \frac{12400\ eV\text{Å}}{4000\text{Å}} = 1.41\ eV$

**20.** **(1)**

Given, $\lambda_1 = 280\ nm$

$\lambda_2 = 400\ nm$

$\phi = 2.5\ eV$.

$\frac{hc}{\lambda_1} = \phi + eV_1$ and $\frac{hc}{\lambda_2} = \phi + eV_2$

$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$

$V_1 - V_2 = \frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$

$= 12400\left(\frac{1}{2800} - \frac{1}{4000}\right)$ [$\lambda_1$ and $\lambda_2$ are taken in Å]

$= 4.4 - 3.1$

$= 1.3\ V$

**21.** **(4)**

Here we have, $eV_{stop} = \frac{hc}{\lambda} - \phi$

Slope of curve, $\tan\theta = \frac{hc}{e} = \text{constant}$

As intensity of incident radiation is increased, there will be no change in the graph.

**22.** **(4)**

$KE_{max} = E - \phi \Rightarrow K.E_{max} = \frac{12400}{\lambda(\text{in Å})} - \phi$ (in $eV$)

$\therefore r = \frac{\sqrt{2m(KE)}}{eB}$

$KE_{max} = \frac{r^2e^2B^2}{2m}$ (in $J$)

$= \frac{r^2eB^2}{2m}$ (in $eV$)

$\therefore \phi = \frac{12400}{6561} - \frac{r^2eB^2}{2m} = 1.1\,eV$

**23.** **(3)**

Number of photons incident/unit time,

$= \frac{n}{t} = \frac{IA}{E} = \frac{16\times10^{-3}\times10^{-4}}{10\times1.6\times10^{-19}} = 10^{12}$

∴ Number of emitted photo electrons

$= \frac{10}{100}\times10^{12} = 10^{11}$

$(K.E.)_{max} = (10 - 5)\,eV = 5\,eV$

**24.** **(4)**

$hv = \frac{eV_0}{2} + \phi_0$ .....(i)

$\frac{hv}{2} = ev_0 + \phi_0$ ......(ii)

Solving (i) and (ii)

$v_0 = \frac{3v}{2}$

**25.** **(4)**

The maximum kinetic energy of the photoelectrons, $KE_{max} = hv_{max} - \phi$

[Here $\phi$, is work function]

$\frac{(6.6\times10^{-34})\,(6.28\times10^{7})\,(3\times10^{8})}{1.6\times10^{-19}\times2\times3.14} - 4.7$

$= 12.37 - 4.7 = 7.67\,eV$

**26.** **(1)**

$K_{max} = hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)$

$K_{max} = (1237)\left(\frac{380-260}{280\times260}\right) = 1.5\,eV$

**27.** **(3)**

If $\phi$ is the work function

$\frac{hc}{\lambda_1} = \phi + eV_1$ ...........($i$)

$\frac{hc}{\lambda_2} = \phi + eV_2$ ...........($ii$)

Now equation ($i$)–equation ($ii$)

$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$

$\therefore V_1 - V_2 = \frac{1240\times100}{300\times400} = 1.03\,V \simeq 1V$

**28.** **(2)**

$KE = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$

$\Rightarrow KE \propto \frac{1}{m}$

$\Rightarrow \frac{KE_p}{KE_\alpha} = \frac{m_\alpha}{m_p} = 4:1$

**29.** **(4)**

$\because \lambda = \frac{h}{\sqrt{2meV}}$

$\therefore \lambda \alpha \frac{1}{\sqrt{V}} \Rightarrow \frac{\lambda}{\lambda_0} = \sqrt{\frac{20}{40}}$

$\Rightarrow \lambda = \frac{\lambda_0}{\sqrt{2}}$

**30.** **(2)**

de-broglie wavelength is given by

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$

$\therefore \lambda \propto \frac{1}{\sqrt{m}}$

$\because m_\alpha > m_p > m_e$

$\Rightarrow \lambda_e > \lambda_p > \lambda_\alpha$

**31.** **(3)**

$\because \lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow \frac{\lambda_\alpha}{\lambda_p} = \frac{h}{\sqrt{2m_\alpha q_\alpha V}} \times \frac{\sqrt{2m_p q_p V}}{h}$

$\Rightarrow m = 8$

**32.** **(1)**

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$

$\therefore \lambda \propto \frac{1}{\sqrt{m}} \Rightarrow \frac{\lambda_p}{\lambda_e} = \sqrt{\frac{m_e}{m_p}} = \sqrt{\frac{1}{1849}} = 1:43$

**33.** **(2)**

$\because KE = \frac{P^2}{2m}, P = \frac{h}{\lambda}$

$\Rightarrow eV_1 = \frac{\left(\frac{h}{\lambda}\right)^2}{2m}$ ............$(i)$

$\Rightarrow eV_2 = \frac{\left(\frac{h}{1.5\lambda}\right)^2}{2m}$ ............$(ii)$

$\Rightarrow \frac{V_1}{V_2} = (1.5)^2 = \frac{9}{4}$

**34.** **(1)**

$\because \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mq\Delta V}}$

$\left(\because p = \sqrt{2mE} \text{ and } E = q\Delta v\right)$

$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha V_\alpha q_\alpha}{m_p V_p q_p}}$

$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{4\times4\times2}{1\times2\times1}} = \frac{4}{1}$

$\Rightarrow \lambda_p : \lambda_\alpha = 4:1$

**35.** **(3)**

de - Broglie wavelength

$\lambda = \frac{h}{\sqrt{2mK}}$

$\because$ Mass, $M_e = \frac{m}{1840}, m_\alpha = 4m, m_p = m$

Kinetic energy, $K_e = 4K, K_\alpha = 2K, K_p = K$

Charge, $q_e = e, q_\alpha = 2e, q_p = e$

$\therefore \lambda_\alpha < \lambda_p < \lambda_e$

**36.** **(2)**

$\lambda = \frac{h}{\sqrt{2Em}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$

$\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$

**37.** **(3)**

Let $M_1 = \frac{M'}{3}$ and $M_2 = \frac{2M'}{3}$

Applying the law of conservation of linear momentum

$M_1V_1 + M_2V_2 = 0$

$\Rightarrow \quad M_1V_1 = -M_2V_2$

And, De-Broglie wave length, $\lambda = \frac{h}{MV}$

**38.** **(4)**

Given that $\vec{v} = v_0 i$ and $\vec{E} = -E_0\hat{i}$

Acceleration of e in the magnetic field,

$a = \frac{F}{m} = \frac{eE_0}{m}$

$\therefore \ \vec{v} = \left(v_0 + \frac{eE_0 t}{m}\right)\hat{i}$

So, de Broglie wave length, $\lambda = \frac{h}{mv}$

$\Rightarrow \ \lambda = \frac{h}{mv_0\left(1+\frac{eE_0}{mv_0}t\right)} = \frac{\lambda_0}{\left(1+\frac{eE_0}{mv_0}t\right)}$

**39.** **(4)**

As, $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$

Put m, q for an electron, we get

$\lambda = \frac{1.227}{\sqrt{V}} nm$

On comparing to $\lambda = \frac{1.227}{x}$, we get

$x = \sqrt{V}$

**40.** **(4)**

De-Broglie wavelength,

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$$\frac{\lambda_{\text{electron}}}{\lambda_{\text{proton}}} = \sqrt{\frac{m_{\text{proton}}}{m_{\text{electron}}}} = \sqrt{\frac{m_p}{m_e}}$$

**41.** **(4)**

According to the question,

$$\lambda' = \lambda \times \frac{75}{100} = \frac{3}{4}\lambda$$

We know that,

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mE}}$$

$$\Rightarrow \frac{E'}{E} = \left(\frac{\lambda}{\lambda'}\right)^2 = \left(\frac{4}{3}\right)^2 \Rightarrow E' = \frac{16}{9}E$$

Therefore, extra energy required

$$= E' - E = \frac{16}{9}E - E = \frac{7}{9}E$$

**42.** **(2)**

According to Heisenberg uncertainty principle:

$$\Rightarrow \Delta x \Delta p \ge \frac{h}{4\pi}$$

$$\Rightarrow \Delta x (m\Delta v) \ge \frac{h}{4\pi}$$

$$\Rightarrow \Delta x\left(m\sqrt{\frac{3RT}{m}}\right) \ge \frac{h}{4\pi} \qquad \left[v = \sqrt{\frac{3RT}{m}}\right]$$

$$\Rightarrow \Delta x \propto \frac{1}{\sqrt{m}} \quad \Rightarrow \frac{\Delta x_e}{\Delta x_p} = \sqrt{\frac{m_p}{m_e}}$$

**43.** **(2)**

We know that De Broglie wavelength

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

$$E = \frac{3}{2}KT$$

$$\Rightarrow \lambda = \frac{h}{\sqrt{3mKT}} = \frac{6.6\times10^{-34}}{\sqrt{3\times9\times10^{-31}\times1.38\times10^{-23}\times300}}$$

$$\Rightarrow \lambda = 6.26\times10^{-9}\,m$$

$$\therefore \lambda = 6.26\ nm$$

**44.** **(3)**

We know that, $KE = \frac{P^2}{2m} \Rightarrow P = \sqrt{2m(KE)}$

Also, de-broglie wavelength, $\lambda$ is given by

$$\lambda = \frac{h}{P}$$

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$\because$ $\lambda \rightarrow$ same for both

$\therefore$ $K_P < K_e$

Again $\lambda = \frac{h}{P}$

$P \rightarrow$ same for both

$P_P = P_e$

**45.** **(4)**

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_P}{m_e}} = \sqrt{1831} = 42.79$$

**46.** **(3)**

We know that, $\lambda = \frac{h}{mv}$

Given, $\lambda_p = \lambda_\alpha$

$$\Rightarrow \frac{h}{m_p v_p} = \frac{h}{m_\alpha v_\alpha}$$

$$\therefore \frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} = \frac{4\times m_p}{m_p} = 4$$

**47.** **(2)**

$$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}}$$

$$\frac{\lambda}{\lambda/2} = \sqrt{\frac{E_f}{E_i}}$$

$$4E_i = E_f$$

$$\Rightarrow \Delta E = 4E_i - E_i = 3E$$

**48.** **(4)**

$$\Delta E = 5.6eV - 0.7eV = 4.9eV$$

Now $\lambda = \frac{hc}{\Delta E} = \frac{12410eV - \mathring{A}}{4.9eV} \approx 250nm$

**49.** **(1)**

Initially $m\left(\sqrt{2}v_0\right)=\dfrac{h}{\lambda_0}$

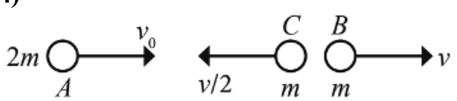
Final Velocity,

$$v=\sqrt{v_0^2+v_0^2+\left(\frac{eE_0}{m}t\right)^2}=\sqrt{2v_0^2+\frac{e^2E_0^2}{m^2}t^2}$$

So wavelength, $\lambda=\dfrac{h}{mv}=\dfrac{h}{m\sqrt{2v_0^2+\dfrac{e^2E_0^2}{m^2}t^2}}$

$$\lambda=\frac{\lambda_0}{\sqrt{1+\dfrac{e^2E_0^2}{2m^2v_0^2}t^2}}$$

**50.** **(4)**




Let mass of $B$ and $C$ be m each. By conservation of momentum

$$2mv_0=mv-\frac{mv}{2}$$

$$v=4v_0$$

$$p_A=2mv_0,\, p_B=4mv_0,\, p_c=2mv_0$$

De-Broglie wavelength $\lambda=\dfrac{h}{p}$

$$\lambda_A=\frac{h}{2mv_0};\lambda_B=\frac{h}{4mv_0};\lambda_C=\frac{h}{2mv_0}$$

**51.** **(3)**

$$\lambda=\frac{h}{\sqrt{2mqV}}\quad\frac{\lambda_A}{\lambda_B}=\sqrt{\frac{4\times1\times2500}{1\times1\times50}}=10\sqrt{2}=14.14$$

**52.** **(3)**

$$\vec{P}_x=\frac{h}{\lambda_x}\hat{i}\ \ \&\ \ \vec{P}_y=\frac{h}{\lambda_y}\left(-\hat{i}\right)$$

Using momentum conservation

$$\vec{P}=\vec{P}_x+\vec{P}_y$$

$$\frac{h}{\lambda}=\frac{h}{\lambda_x}-\frac{h}{\lambda_y},\frac{1}{\lambda}=\frac{1}{\lambda_x}-\frac{1}{\lambda_y}$$

$$|\lambda|=\left|\frac{\lambda_x\lambda_y}{\lambda_x-\lambda_y}\right|$$

**53.** **(1)**

For electron,

$$(KE)_e=\frac{1}{2}mv^2=\frac{pv}{2}$$

For photon,

$$(K.E)_p=\frac{hc}{\lambda}=pc$$

$$\frac{KE_e}{KE_p}=\frac{pv/2}{pc}=\frac{v}{2c}$$

**54.** **(2)**

$$\lambda=\frac{h}{P}=\frac{h}{\sqrt{2M(K.E)}}$$

$\because$ $K.E.=$ constant

$$\therefore\ \lambda\propto\frac{1}{\sqrt{m}}$$

$$\Rightarrow\ \frac{\lambda_\alpha}{\lambda_{C_{12}}}=\sqrt{\frac{m_{C_{12}}}{m_\alpha}}=\sqrt{\frac{12}{4}}=\sqrt{3}:1$$

## *Integer Type Questions (55 to 69)*

**55.** **(3)**

From $\dfrac{1}{\lambda}=Rz^2\left[\dfrac{1}{3^2}-\dfrac{1}{4^2}\right]$

$$=Rz^2\left(\frac{16-9}{9\times16}\right)=\frac{7}{9\times16}Rz^2$$

$$E=K_{\max}+\phi+K_{\max}+\frac{hc}{\lambda_0}$$

$$=1.95+\frac{1240}{310}=1.95+4=5.95eV$$

$$\frac{hc}{\lambda}=5.95eV$$

$$\frac{hc\times7Rz^2}{9\times16}=5.95$$

$$\therefore\ Z=3$$

**56.** **(2)**

$$hv=hv_{th}+\frac{1}{2}mv_1^2$$

For $v=2v_{th}$

$\frac{1}{2}mv_1^2 = h\nu_{th}$ .....(i)

For $\nu = 5\nu_{th}$

$5h\nu_{th} = h\nu_{th} + \frac{1}{2}mv_2^2 \Rightarrow \frac{1}{2}mv_2^2 = 4h\nu_{th}$ ......(iii)

$\therefore \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \frac{h\nu_{th}}{4h\nu_{th}}$

$\left(\frac{v_1}{v_2}\right)^2 = \frac{1}{4} \Rightarrow v_2 = 2v_1$

**57.** **(35)**

$eV_0 = \frac{hc}{\lambda} - h\nu_0$

$\Rightarrow 6.63\times10^{-34}\nu_0 = \frac{6.63\times10^{-34}\times3\times10^8}{6630\times10^{-10}}$

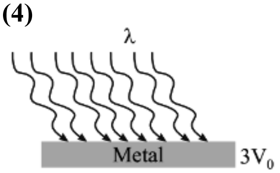
$-1.6\times10^{-19}\times0.42$

$\Rightarrow 6.63\times10^{-34}\upsilon_0 = 3\times10^{-19} - 1.6\times10^{-19}\times0.42$

$\Rightarrow 6.63\times10^{-34}\upsilon_0 = 10^{-19}(3-1.6\times0.42)$

$\nu_0 = 0.35\times10^{15} = 35\times10^{13}s^{-1}$

**58.** **(4)**




Let the work function of metal is $W_0$

$K_1 = 3V_0e = \frac{hc}{\lambda} - W_0$ ......(i)

$K_2 = V_0e = \frac{hc}{2\lambda} - W_0$ ......(ii)

On solving (i) and (ii),we get

$\Rightarrow W_0 = \frac{hc}{4\lambda}$

The threshold wavelength $= \frac{hc}{W_0} = 4\lambda$

**59.** **(4)**

We know that, $E - \phi = \frac{1}{2}mv^2$

When $E = 2\phi, v = v_1$

$2\phi - \phi = \frac{1}{2}mv_1^2$ .......(i)

When $E = 10\phi, v = v_2$

$10\phi - \phi = \frac{1}{2}mv_2^2$ .......(ii)

Using equation (i) and (ii)

$\Rightarrow \frac{1}{9} = \frac{v_1^2}{v_2^2} \Rightarrow v_1 : v_2 = 1:3 \Rightarrow x + y = 4$

**60.** **(2)**

$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$

$\frac{1}{2}mv_1^2 = 4 - \phi$ .......(i)

$\frac{1}{2}mv_2^2 = 2.5 - \phi$ ........(ii)

Given $\frac{v_1}{v_2} = 2$

$\Rightarrow 4 = \frac{4-\phi}{2.5-\phi} \Rightarrow \phi = 2eV$

**61.** **(9)**

$\frac{hc}{\lambda} = \phi + eV$ .......(1)

$\frac{hc}{3\lambda} = \phi + \frac{eV}{4}$ .......(2)

On subtracting (2) from (1)

$\frac{hc}{\lambda}\left(1-\frac{1}{3}\right) = \frac{3}{4}eV \Rightarrow \frac{hc}{\lambda}\frac{2}{3} = \frac{3}{4}eV$

Now, $eV = \frac{8}{9}\frac{hc}{\lambda}$

$\frac{hc}{\lambda} = \phi + \frac{8hc}{9\lambda}$

[Putting value of eV in eq (*i*) we get]

$\phi = \frac{hc}{9\lambda} = \frac{hc}{\lambda_{th}}$

$\lambda_{th} = 9\lambda$ $\therefore n = 9$

Hence, value of *n* is 9

**62.** **(11)**

Energy of photon,

$E = \frac{hc}{\lambda} = \frac{1240}{310} = 4eV > 2eV$

(Hence photoelectric effect will take place)

$= 4\times1.6\times10^{-19} = 6.4\times10^{-19}$ Joule

Number of photons incident per second

$$n = \frac{IA}{E} = \frac{6.4\times10^{-5}\times1}{6.4\times10^{-19}} = 10^{14}$$

As, I out of every 1000 photons are responsible in ejecting 1 photoelectron

Therefore, number of photoelectron emitted per second $= \frac{10^{14}}{10^3} = 10^{11}$

**63. (910)**

For photon

$$\lambda_1 = \frac{h}{p} = \frac{6.6\times10^{-34}}{10^{-27}}$$

For a particle

$$\lambda_2 = \frac{h}{mv} = \frac{6.6\times10^{-34}}{9.1\times10^{-31}\times10^6}$$

Therefore,

$$\frac{\lambda_1}{\lambda_2} = 910$$

**64. (1)**

$$eV_s = K_{\max} = hf - \phi$$

$$V_s = \left(\frac{h}{e}\right)f + \left(\frac{-\phi}{e}\right)$$

Slope of stopping potential is independent of nature of metal.

Hence,, slope $(V_s)$ Gold = slope $(V_s)_{\text{Aluminium}}$

**65. (138)**

Formula of work function $\phi = \frac{hc}{\lambda}$

$$\lambda_A = \left(\frac{1242}{9}\right) = 138nm$$

$$\lambda_B = \left(\frac{1242}{4.5}\right) = 276nm$$

$$\lambda_B - \lambda_A = 138nm$$

**66. (382)**

We know that,

$$\frac{hc}{\lambda} = \phi + ev_s$$

$$\therefore \frac{1240}{491} = \phi + 0.71 \quad \text{........(i)}$$

$$\therefore \frac{1240}{\lambda} = \phi + 1.43 \quad \text{........(ii)}$$

Using above two equation we can calculate $\lambda = 382nm$

**67. (4)**

Given, $V_{s_1} = 4.8V, \lambda_1 = \lambda$

$V_{s_2} = 1.6V, \lambda_2 = 2\lambda$

By Einstein's equation of photoelectric effect

$$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$e\times4.8 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \quad \text{.......(i)}$$

$$e\times1.6 = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} \quad \text{........(ii)}$$

By dividing (i) by (ii)

$$\frac{hc\left(\frac{\lambda_0-\lambda}{\lambda_0.\lambda}\right)}{hc\left(\frac{\lambda_0-2\lambda}{2\lambda_0.\lambda}\right)} = 3$$

$$\frac{2(\lambda_0-\lambda)}{(\lambda_0-2\lambda)} = 3$$

$$2\lambda_0 - 2\lambda = 3\lambda_0 - 6\lambda \Rightarrow \lambda_0 = 4\lambda$$

**68. (4)**

Relation between K.E. and De-Broglie wavelength is

$$\lambda = \frac{h}{\sqrt{2(KE)m_e}} \Rightarrow \lambda \propto \frac{1}{\sqrt{KE}}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{\sqrt{kE_B}}{\sqrt{kE_A}} \Rightarrow \frac{1}{2} = \sqrt{\frac{T_A - 1.5}{T_A}}$$

$$\Rightarrow T_A = 2eV$$

$$\therefore KE_B = 2 - 1.5 = 0.5eV$$

Thus, $\phi_B = 4.5 - 0.5 = 4eV$

**69. (2)**

From de Broglie, $\lambda = \frac{h}{p}$

$$\lambda = \frac{h}{\sqrt{2mE}} \qquad (\because p = \sqrt{2mE})$$

$$\lambda' \frac{h}{\sqrt{2m\left(\frac{E}{4}\right)}} = \frac{2h}{\sqrt{2mE}} = 2\lambda$$

# ATOMS

## Single Option Correct Type Questions (01 to 57)

**1.** **(3)**

**Sol:** Angular momentum, $L = \frac{nh}{2\pi}$

For Bohr orbit is, $L_1 = L = \frac{1.h}{2\pi}$

In second orbit of hydrogen atom ($n = 2$),

$$L_2 = \frac{2h}{2\pi} = 2L$$

So, change in angular momentum

$= L_2 - L_1 = 2L - L = L$

**2.** **(1)**

**Sol:** $U = \frac{1}{2}m\omega^2 r^2$

$$F = -\frac{du}{dr} = -m\omega^2 r = \frac{mv^2}{r} \Rightarrow v = \omega r$$

$\because \quad mvr = \frac{nh}{2\pi}$

$\therefore \quad m\omega r^2 = \frac{nh}{2\pi} \Rightarrow r = \sqrt{\frac{nh}{2\pi m\omega}} \Rightarrow r \propto \sqrt{n}$

**3.** **(2)**

**Sol:** Potential energy: An electron possesses some potential energy because it is found in the field of nucleus potential energy of an electron in $n^{th}$ orbit of radius $r_n$ is given by

$$U = -\frac{kZe^2}{r_n}$$

Where $Z$ = atomic number, $n$ = orbit number and $r_n$ = radius of the $n^{th}$ orbit

Kinetic energy: Electron possesses kinetic energy because of its motion. Closer orbits have greater kinetic energy than outer ones.

$$K = \frac{kZe^2}{2r_n} = -\frac{U}{2} = \frac{kZe^2}{2r_n}$$

Total energy: Total energy ($TE$) is the sum of potential energy and kinetic energy i.e.

$E = K + U$

$$TE = -13.6\frac{Z^2}{n^2}eV$$

The relationship between $PE/TE$, and $KE$ is given by:

$KE = -TE = -PE/2$

From above it is clear that as $n$ increases, the potential energy increases, kinetic energy decreases and total energy increases.

**4.** **(1)**

**Sol:** $\nu_n \propto \frac{1}{n}$

**5.** **(1)**

**Sol:** For a hydrogen atom, $E = \frac{-13.6\ eV}{n^2}$

$$\Rightarrow \frac{hc}{\lambda} = \left[1 - \frac{1}{16}\right](13.6\ eV)$$

$\Rightarrow \lambda = 94.1$ nm

**6.** **(1)**

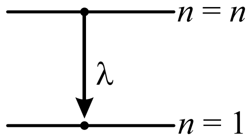
**Sol:** $\Delta E_1 = -\frac{E_0}{4} + \frac{E_0}{1} = \frac{3}{4}E_0$

$\Delta E_2 = 0 - (-E_0) = E_0$

$$\frac{\Delta E_1}{\Delta E_2} = \frac{3}{4}$$

**7. (2)**

**Sol:** According to definition of wave number, we can write




$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\Rightarrow \quad 1 - \frac{1}{n^2} = \frac{1}{\lambda R}$$

$$\Rightarrow \quad \frac{1}{n^2} = 1 - \frac{1}{\lambda R} = \frac{\lambda R - 1}{\lambda r} \Rightarrow n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$$

**8. (4)**

**Sol:** $v_n = k\frac{2\pi e^2}{nh}$

We know that in cgs system $k = 1$

$\therefore v_{\text{n}} = \frac{2\pi e^2}{nh} \Rightarrow v_1 = \frac{2\pi e^2}{h}$

So, $\frac{v_1}{c} = \frac{2\pi e^2}{ch}$

**9. (4)**

**Sol:** $\because \quad E_n = -\frac{13.6 Z^2}{n^2}\text{eV}$

$$\Rightarrow \quad \Delta E = 13.6 Z^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]\text{eV}$$

$$= 13.6 \times (4)^2 \left(\frac{1}{4} - \frac{1}{16}\right)\text{eV}$$

$$\Rightarrow \quad \Delta E = 40.8 \text{ eV}$$

**10. (2)**

**Sol:** We know that, Radius of $n^{\text{th}}$ orbit,

$$R = 0.529\frac{n^2}{z}\,\text{Å}$$

$$\frac{R_3}{R_2} = \frac{9}{4}$$

$$R_3 = \frac{9}{4}R_2$$

$$\therefore \quad R_3 = 2.25\ R$$

**11. (2)**

**Sol:** $E \propto \frac{1}{r}, r \propto \frac{1}{m}$

$E \propto m$

Ionization potential $= 13.6 \times \frac{(m_\mu)\text{eV}}{(e_e)}$

$= 13.6 \times 207$ eV $= 2815.2$ eV

**12. (2)**

**Sol:** Energy levels in Hydrogen like atom is given by

$$E = -13.6\frac{z^2}{n^2}eV$$

As $He^+$ is 1st excited state

$\therefore \quad z = 2, n = 2$

$E = -13.6$ eV

As total energy of $He^+$ in 1st excited state is –13.6 eV, ionization energy should be +13.6 eV.

**13. (1)**

**Sol:** $U = \frac{1}{2}kr^2$

Force, $F = -\frac{dU}{dr} = -kr$

For circular motion $\frac{mv^2}{r} = kr$ …(i)

And $mvr = \frac{nh}{2\pi}$ …(ii)

$$\Rightarrow \quad r^2 = \frac{nh}{2\pi\sqrt{km}} \Rightarrow r \propto \sqrt{n}$$

Total energy,

$E = k + U$

$= \frac{1}{2}mv^2 + \frac{1}{2}kr^2$

$= \frac{1}{2}kr^2 + \frac{1}{2}kr^2$

[From equation (i)]

$E = kr^2 \Rightarrow E \propto n$

**14.** **(1)**

**Sol:** The wavelengths of the hydrogen spectrum could be arranged in a formula or series named after its discoverer. For ultraviolet spectrum the series is called Lyman series, for visible spectrum the Balmer series, and for infrared region we have the Paschen series.

The ultraviolet series is obtained when the energy of the atom falls from higher states to the energy level corresponding to $n = 1$. Thus, ultraviolet radiation can only be possible with transition from $E_2$ to $E_1$ out of the given transitions

**15.** **(1)**

**Sol:** $E_n = -3.4$ eV, $E_n \propto \frac{1}{n^2}$

$E_1 = -13.6$ eV

Clearly, $n = 2$

Angular momentum

$= \frac{nh}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi} = 2.11 \times 10^{-34}$ Js

**16.** **(4)**

**Sol:** As we know the atomic number, $He^+, Z_{He^+} = 2$

And the atomic number Hydrogen, $H^+, Z_{H^+} = 1$

Since, $v \propto \frac{Z}{n} \propto Z$ ($n$ = constant)

We have;

$v_{He^+} \propto Z_{He^+}$

Now, On dividing equation (i) and equation (ii) we have;

$$\frac{v_{He^+}}{v_H^+} = \frac{Z_{He^+}}{Z_H^+} \Rightarrow \frac{v_{He^+}}{v_H^+} = \frac{2}{1}$$

**17.** **(1)**

**Sol:** $\frac{1}{\lambda_2} = R\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$

$\frac{1}{\lambda_2} = R\left[\frac{1}{4} - \frac{1}{16}\right]$

$\frac{1}{\lambda_2} = R\left[\frac{3}{16}\right]$ or $\lambda_2 = \frac{16}{3R}$

Again, $\frac{1}{\lambda_1} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$\frac{1}{\lambda_1} = R\left[\frac{1}{4} - \frac{1}{9}\right]$

$\frac{1}{\lambda_1} = \frac{5R}{36}$ or $\lambda_1 = \frac{36}{5R}$

$\therefore \frac{\lambda_1}{\lambda_2} = \frac{36}{5R} \times \frac{3R}{16} = \frac{27}{20}$

or $\lambda_1 = \frac{27}{20} \times 4861$ Å

**18.** **(2)**

**Sol:** Given $\Delta E = 10.2$ eV

For atom in ground state, $n_1 = 1$.

$$\therefore \quad \Delta E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$10.2 = 13.6\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{10.2}{13.6} = 1 - \frac{1}{n_2^2}$$

$$n_2 = 2$$

Increase in Angular Momentum,

$\Delta L = L_f - L_i$

$$= \frac{n_2 h}{2\pi} - \frac{n_1 h}{2\pi}$$

$$= \frac{2h}{2\pi} - \frac{nh}{2\pi}$$

$$= \frac{h}{2\pi}$$

$$\Delta L = \frac{6.6 \times 10^{-34}}{2 \times 3.14} = 1.05 \times 10^{-34} \text{ J-sec}$$

**19.** **(1)**

**Sol:** We know that, $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$;

$$\frac{1}{\lambda_1} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) \Rightarrow \frac{1}{\lambda_1} = R\left(\frac{7}{9 \times 16}\right)$$

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \frac{1}{\lambda_2} = R\left(\frac{5}{4 \times 9}\right)$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{5}{36}}{\frac{7}{9 \times 16}} = \frac{5 \times 9 \times 16}{7 \times 36} = \frac{20}{7}$$

**20. (2)**

**Sol:** $KE \propto \frac{1}{n^2}$ and $PE \propto \frac{1}{n^2}$

**21. (1)**

**Sol:** $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\therefore \quad \frac{1}{\lambda} = 109677.6 \text{ cm}^{-1} \times \left[\frac{1}{1} - \frac{1}{2^2}\right]$

$\Rightarrow \quad \lambda = \frac{1}{82258.2} \text{cm} = 121.8 \text{ nm}$

**22. (3)**

**Sol:** This is Bohr' postulate

**23. (4)**

**Sol:** $\frac{1}{\lambda} = Z^2 R\left(\frac{1}{1^2} - \frac{1}{5^2}\right)$

Hence, $\lambda$ is minimum when $Z$ is maximum

**24. (3)**

**Sol:** Energy supplied

$E = \frac{12500}{980} = 12.75 \text{eV}$

$\therefore \quad E_n - E_1 = 12.75$

$\Rightarrow \quad (13.6)\left(1 - \frac{1}{n^2}\right) = 12.75$

$\Rightarrow \quad n^2 \approx 14.3 \Rightarrow n \approx 4$

Now radius = 16 $a_0$

**25. (3)**

**Sol:** Potential energy $= -C/r^2$ and total energy $= -Rhc/n^2$. With higher orbit, both $r$ and $n$ increase. So, both become less negative; hence both increase

**26. (3)**

**Sol:** $\frac{1}{660} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36} \quad \ldots(i)$

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16} \quad \ldots(ii)$

Equation (i) ÷ (ii)

$\frac{\lambda}{660} = \frac{5 \times 16}{36 \times 3} \Rightarrow \lambda = \frac{660 \times 5 \times 16}{36 \times 3} = 488.9 \text{ nm}$

**27. (2)**

**Sol:** $U = -\frac{ke^2}{2R^3}, F = -\frac{dU}{dR} = -\frac{3ke^2}{2R^4}$

But, $F = \frac{mv^2}{R} \Rightarrow \frac{mv^2}{R} = \frac{3ke^2}{2R^4}$

Also, $mvR = \frac{nh}{2\pi}$

Solve to get: $R = \frac{6\pi^2 ke^2 m}{n^2 h^2}$

**28. (3)**

**Sol:** We know that, $\Delta E \propto \left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

If $n_1 = 3$ and $n_2 = 2$

$\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{9-4}{36} = \frac{5}{36}$

If $n_1 = 4$ and $n_2 = 3$

$\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{16-9}{144} = \frac{7}{144}$

If $n_1 = 2$ and $n_2 = 1$

$\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{4-1}{4} = \frac{3}{4}$

If $n_1 = 5$ and $n_2 = 4$

$\left(\frac{1}{4^2} - \frac{1}{5^2}\right) = \frac{25-16}{400} = \frac{9}{400}$

Since, $\Delta E = hv$.

**29. (2)**

**Sol:** Balmer series lies in the visible region.

**30. (2)**

**Sol:** The series in U-V region is Lyman series. Longest wavelength corresponds to, minimum energy which occurs in transition from $n$=2 to $n$=1.

$\therefore \quad 122 = \frac{\frac{1}{R}}{\left(\frac{1}{1^2} - \frac{1}{2^2}\right)} \quad \ldots (i)$

The smallest wavelength in the infrared region corresponds to maximum energy of Paschen series.

$\therefore \quad \lambda = \frac{\frac{1}{R}}{\left(\frac{1}{3^2} - \frac{1}{\infty}\right)} \quad \ldots (ii)$

Solving Eqs.(i) and (ii) , we get

$\lambda = 823.5$ nm

**31. (3)**

**Sol:** $E = -E_0 \times \frac{1}{n^2}$

$\Rightarrow \quad \Delta E = -E_0 \times \frac{2}{n^3} \times (\Delta n)$

$\Rightarrow \quad hv = 2E_0 \times 1 \times \frac{1}{n^3}$

$\Rightarrow \quad v \propto \frac{1}{n^3}$

**32. (2)**

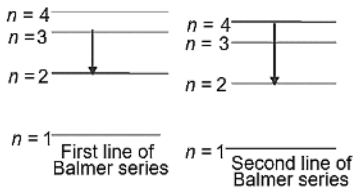
**Sol:** For third excited state, $n = 4$

$r_n = r_0 \frac{n^2}{2}$

or $r_1 = 0.5 \times \frac{4\times4}{2}$ Å $= 4$ Å

**33. (1)**

**Sol:**




For hydrogen or hydrogen type atoms

$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

In the transition from $ni \rightarrow nf$

$\therefore \quad \lambda \propto \frac{1}{Z^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)}$

$\therefore \quad \frac{\lambda_2}{\lambda_1} = \frac{Z_1^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)_1}{Z_2^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)_2}$

$\lambda_2 = \frac{\lambda_1 Z_1^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)_1}{Z_2^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)_2}$

Substituting the values, we have

$= \frac{(6561)(1)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)}{(2)^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right)} = 1215$ Å

**34. (1)**

**Sol:** $k = qV$

$\frac{1}{2}mv^2 - qV$

$\Rightarrow \quad v = \sqrt{\frac{2qV}{m}}$

$\frac{V_H}{V_{He}} = \sqrt{\frac{q_H m_{He}}{m_H q_{He}}} = 2:1$

**35. (2)**

**Sol:** $f = cZ^2R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\Rightarrow 2.7 \times 10^{15} = cz^2R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$f' = cZ^2R\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

Divide and solve to get: $f = 3.2 \times 10^{15}$ Hz

**36. (3)**

**Sol:** $L_1 = (1)\frac{h}{2\pi} \quad \ldots$(i)

(Using Bohr' Quantization Rule)

In the first excited state of Li,

$L_2 = (2)\frac{h}{2\pi} \quad \ldots$(ii)

$\therefore \quad \frac{L_2}{L_1} = 2$

**37. (4)**

**Sol:** $V_n \propto \frac{Z}{n}$

$\therefore \quad \frac{V_3}{V_7} = \frac{7}{3}$

$\therefore \quad V_3 = \frac{7}{3}V_7$

$= \frac{7}{3} \times 3.6 \times 10^6$ m/s

$= 8.4 \times 10^6$ m/s

**38. (3)**

**Sol:** Using Bohr's theory, $\frac{mv^2}{r} = \frac{ke^2}{r^2}$

$v^2 = \frac{ke^2}{mr} \Rightarrow L = mvr$

$\therefore \quad L = m\sqrt{\frac{ke^2}{mr}}\,r \Rightarrow L = \sqrt{mke^2\,r}$

$\Rightarrow \quad L \propto \sqrt{r}$

**39.** **(1)**

**Sol:** $h\nu_1 = R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = \frac{8R}{9}$

$h\nu_2 = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3R}{4}$

$\frac{\nu_1}{\nu_2} = \frac{8/9}{3/4} = \frac{32}{27}$

$= (2.92 \times 10^{15}) \times \left(\frac{27}{32}\right)$

$= 2.46 \times 10^{15}$ Hz

**40.** **(1)**

**Sol:** $13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ eV $= 1.9$ eV

**41.** **(3)**

**Sol:** For the first transition,

$\frac{hc}{\lambda} = 13.6Z^2\left(\frac{1}{n_1^2} - \frac{1}{n^2}\right)$

$\Rightarrow \frac{1240}{108.5} = 13.6 \times 4\left(\frac{1}{n_1^2} - \frac{1}{n^2}\right) \quad \ldots(1)$

For second transition

$\frac{hc}{\lambda} = 13.6Z^2\left(1 - \frac{1}{n_1^2}\right)$

$\Rightarrow \frac{1240}{30.4} = 13.6 \times 4\left(1 - \frac{1}{n_1^2}\right) \quad \ldots(2)$

Adding (1) and (2)

$1240\left(\frac{1}{108.5} + \frac{1}{30.4}\right) = 13.6 \times 4\left(1 - \frac{1}{n^2}\right)$

on solving,

$n = 5$

**42.** **(3)**

**Sol:** $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For longest wavelength, $n_1 = 2, n_2 = 3$

$\therefore \quad \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$ or $\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{9}\right]$

$\Rightarrow \quad \lambda = \frac{36}{5R}$ for electron,

But $\lambda \propto \frac{1}{m}$

So $\lambda' = \frac{1}{2} \times \frac{36}{5R} = \frac{18}{5R}$

**43.** **(3)**

**Sol:** $T \propto \frac{r}{v} \propto \frac{n^2}{z} \times \frac{n}{z} \propto \frac{n^3}{z^2}, \frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1}{8}$

$T_2 = 8T_1 = 8 \times 1.6 \times 10^{-16} = 12.8 \times 10^{-16}$

$f_2 = \frac{1}{12.8 \times 10^{-6}} \approx 7.8 \times 10^{14}$

**44.** **(3)**

**Sol:** $E_{max} = 13.6 \text{ eV}; E_{min} = 13.6\left(1 - \frac{1}{2^2}\right)$

$= \frac{3}{4} \times 13.6$ eV

$\Rightarrow \quad \frac{E_{max}}{E_{min}} = \frac{4}{3}$

**45.** **(4)**

**Sol:** For $M \to L$ shell

$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K \times 5}{36}$

For $N \to L$

$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K \times 3}{16}$

$\lambda' = \frac{20}{27}\lambda$

**46.** **(3)**

**Sol:** Required energy

$= \left[\left(\frac{-13.6}{9}\right) - \left(\frac{-13.6}{1}\right)\right] \times 9$

$= \left[13.6 - \frac{13.6}{9}\right]9 = 8 \times 13.6$ eV

Wavelength $= \frac{12375}{8 \times 13.6} = 113.7$Å

**47.** **(4)**

**Sol:** The wavelength of spectral line of the third member of Lyman series;

$$\frac{1}{\lambda_1} = RZ^2\left(\frac{1}{1^2} - \frac{1}{4^2}\right)$$

The wavelength of spectral line of the first member of paschen series;

$$\frac{1}{\lambda_2} = RZ^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\frac{1/\lambda_1}{1/\lambda_2} = \frac{1-\frac{1}{16}}{\frac{1}{9}-\frac{1}{16}} \Rightarrow \frac{\lambda_2}{\lambda_1} = \frac{\frac{15}{16}}{\frac{7}{9\times16}} = \frac{15\times9}{7}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{7}{135}$$

**48. (4)**

**Sol:** For Lyman series, the series limit wavelength is given by

$$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = R \text{ or } \lambda = \frac{1}{R}$$

For Balmer series, the series limit wavelength is given by

$$\frac{1}{\lambda''} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{R}{4} \text{ or } \lambda'' = \frac{4}{R}$$

Clearly,

$$\lambda'' = 4\left[\frac{1}{R}\right] \text{ or } \lambda'' = 4\lambda$$

**49. (1)**

**Sol:** $$\frac{hc}{\lambda} = (13.6\text{ eV})z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\frac{hc}{\lambda} = (13.6\text{ eV})(3^2)\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$$

$$\Rightarrow \frac{hc}{\lambda} = (13.6\text{ eV})(9)\left(\frac{8}{9}\right)$$

$$\text{Wavelength} = \frac{1240}{8\times13.6}\text{nm} = 11.39\text{ nm}$$

**50. (3)**

**Sol:** $E_n = -\frac{13.6}{n^2} \Rightarrow n^2 = -\frac{13.6}{-0.54}$

or $n^2 = 25.2$ or $n = 5$(nearly)

As $v \propto 1/n$, so $v_n = \frac{v}{5}$

**51. (2)**

**Sol:** $$\lambda_{\min} = \frac{hc}{\Delta E_{\max}}$$

For shortest wavelength, energy gap should be maximum.

So, correct choice is transition from $n = 3$ to $n = 1$.

**52. (1)**

**Sol:** Number of possible emission lines are $n(n-1)/2$ when an electron jumps from $n^{\text{th}}$ state to ground state. In this question, this value should be $(n-1)(n-2)/2$

Hence, $10 = \frac{(n-1)(n-2)}{2}$

Solving this, we get $n = 6$

**53. (1)**

**Sol:** Radius of first orbit, $r \propto 1/Z$. For doubly ionized lithium, $Z$ will be maximum. Hence, for doubly ionized lithium $r$ will be minimum

**54. (1)**

**Sol:** As $n = 5$ to $n = 1$

$\therefore\ \Delta E = 13.6 - 0.54$

$\Delta E = 13.06$ eV ... (i)

Using conservation of linear momentum

$$\frac{h}{\lambda} = m_H v_H \Rightarrow \frac{hc}{\lambda} = cm_H v_H = \frac{\frac{hc}{\lambda}}{cm_H}$$

$$= \frac{\Delta E}{cm_H} = \frac{13.06\times1.6\times10^{-19}}{3\times10^8\times1.67\times10^{-27}}$$

$$= 4.17\text{ m/s}$$

**55. (4)**

**Sol:** $T^2 \propto R^3$

$$\frac{T_R}{T_{4R}} = \left(\frac{R}{4R}\right)^{3/2} = \left(\frac{1}{4}\right)^{3/2} = \frac{1}{8}$$

**56.** **(2)**

**Sol:** Energy released for transition

($n = 2$ to $n = 1$)

$$E = 13.6Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$Z = 1$, $n_1 = 1$, $n_2 = 2$

$$E_H = 13.6\times 1\times\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$= 13.6\times\frac{3}{4}\times \text{eV}$$

For $He^+$ ions $Z = 2$

Using option

(1) $n = 1$ to $n = 4$

$$E = 13.6\times 2^2\times\left(\frac{1}{1^2} - \frac{1}{4^2}\right)$$

$$= 13.6\times\frac{15}{4}\text{eV}$$

(2) $n = 2$ to $n = 4$

$$E = 13.6\times 2^2\times\left(\frac{1}{1^2} - \frac{1}{4^2}\right)$$

$$= 13.6\times\frac{3}{4}\text{eV}$$

(3) $n = 2$ to $n = 5$

$$E = 13.6\times 2^2\times\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$= 13.6\times\frac{21}{25}\text{eV}$$

(4) $n = 2$ to $n = 3$

$$E = 13.6\times 2^2\times\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 13.6\times\frac{5}{9}\text{eV}$$

Hence the possible transition is

$n = 2 \rightarrow n = 4$

**57.** **(1)**

**Sol:** Ground state energy of the ($H$–atom)

$E_{\text{ground}} = -13.6$ eV

$E_{\text{Carbon}} = E_{\text{Ground}}$ of $H_{\text{atom}}$

$$\Rightarrow\ 13.6\times\frac{6^2}{n^2} = -13.6\text{ eV}\ \Rightarrow n = 6$$

## Integer Type Questions (58 to 71)

**58.** **(3)**

**Sol:** Energy used to Bombard gaseous hydrogen,

$E = 12.5$ eV

Energy of excited state = The energy of gaseous hydrogen after bombardment

$E_n = -13.6$ eV + 12.5

eV = – 1.1 eV

$\therefore$ Orbital no of excited state,

$$n = \sqrt{\frac{-13.6eV}{E_n}} = \sqrt{\frac{-13.6}{-1.1}} \simeq 3.5 \approx 3$$

So, number of spectral lines is $\dfrac{3(3-1)}{2} = 3$

**59.** **(27)**

**Sol:** For hydrogen atom, $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$

For balmer series, $n_1 = 2$

And for $H_\alpha$, $n_2 = 3$, $H_\beta$, $n_2 = 4$

$$\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{\lambda_\alpha} = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36}$$

$$\lambda_\alpha = \frac{36}{5R}$$

$$\frac{1}{\lambda_\beta} = R\left[\frac{1}{4} - \frac{1}{16}\right] = \frac{3R}{16} \Rightarrow \lambda_\beta = \frac{16}{3R}$$

$$\frac{\lambda_\alpha}{\lambda_\beta} = \frac{36}{5R}\times\frac{3R}{16}$$

$$\frac{\lambda_\alpha}{\lambda_\beta} = \frac{27}{20} = \frac{x}{20}$$

$x = 27$

**60. (5)**

**Sol:** As, $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For $A$ to $B$, $n_1 = 2$, $n_2 = 3$

$$\frac{1}{\lambda_1} = R(1)^2\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = R\left(\frac{5}{36}\right) \quad \ldots\text{(i)}$$

For $B$ to $C$, $n_1 = 3$, $n_2 = 4$

$$\& \ \frac{1}{\lambda_2} = R(1)^2\left[\frac{1}{(3)^2} - \frac{1}{(4)^2}\right] = R\left(\frac{7}{144}\right) \quad \text{...(ii)}$$

Dividing (ii) by (i)

$$\frac{\lambda_1}{\lambda_2} = \frac{7/144}{5/36} = \frac{7}{20} = \frac{7}{4\times 5}$$

$\therefore \quad n = 5$

**61. (27)**

**Sol:** $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\Rightarrow \quad \frac{1}{\lambda_1} = RZ^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8}{9}RZ^2 \quad \ldots\text{(i)}$$

$$\text{and, } \frac{1}{\lambda_2} = RZ^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}RZ^2 \quad \ldots\text{(ii)}$$

Dividing eqn (ii) by (i)

$$\frac{\lambda_1}{\lambda_2} = \frac{27}{32}$$

$\Rightarrow \quad x = 27$

**62. (114)**

**Sol:** $Z = 3$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

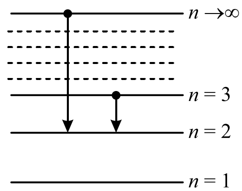
$n_1 = 1$, $n_2 = 3$

$$\lambda = \frac{1}{8R} = 114\times 10^{-10}\,\text{m}$$

**63. (5)**

**Sol:** Formula of atomic energy of $n^{\text{th}}$ level,

$$E_n = \frac{-13.6z^2}{n^2}$$




$$\Delta E_1 = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5\times 13.6}{36} \quad \text{and}$$

$$\Delta E_2 = 13.6\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$

$$\frac{\Delta E_1}{\Delta E_2} = \frac{5}{9}$$

$$\frac{x}{x+4} = \frac{5}{5+4}$$

$$x = 5$$

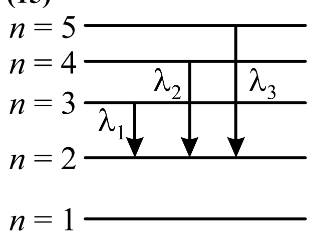
**64. (15)**

**Sol:** No. of different wavelengths

$$= \frac{n\times(n-1)}{2} = \frac{6\times 5}{2} = 15$$

**65. (15)**

**Sol:**




The ratio of wavelength of first and third spectral lines

$$\frac{\lambda_1}{\lambda_3} = \frac{R\left(\frac{1}{2^2} - \frac{1}{5^2}\right)}{R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)}$$

$$= \frac{21}{100}\times\frac{36}{5} = 1.512 \approx 15\times 10^{-1}$$

**66.** **(136)**

**Sol:** $E_B = 13.6\dfrac{Z^2}{n^2}$

For $Li^{2+}$,

$Z = 3$, $n = 3$

$$E_{Li^{2+}} = 13.6\left(\frac{3^2}{3^2}\right) = 13.6\ eV$$

Comparing above result with $x \times 10^{-1}$ eV we get

$x = 136$

**67.** **(828)**

**Sol:** Ground state energy = –13.6 eV

$$\therefore \quad \frac{-13.6eV}{n^2} = -13.6 + 12.75$$

$$\Rightarrow \quad \frac{-13.6eV}{n^2} = -0.85$$

$\Rightarrow \quad n = 4$

Angular momentum $= \dfrac{nh}{2\pi} = \dfrac{4h}{2\pi} = \dfrac{2h}{\pi}$

$\Rightarrow$ Angular momentum

$$= \frac{2}{\pi} \times 4.14 \times 10^{-15}$$

$$= \frac{828 \times 10^{-17}}{\pi} \text{eVs}$$

**68.** **(2)**

**Sol:** $r \propto \dfrac{n^2}{z} \Rightarrow \dfrac{r_{He^+}}{r_{Be^{3+}}} = \left(\dfrac{\eta_{He^+}}{\eta_{Be^{3+}}}\right)^2 \times \dfrac{z_{Be^{3+}}}{z_{He^+}}$

$$\frac{r_{He^+}}{r_{Be^{3+}}} = \left(\frac{2}{4}\right)^2 \times \left(\frac{4}{2}\right) = \frac{1}{2}$$

**69.** **(425)**

**Sol:** $r_n = r_0 = \dfrac{n^2}{z}$

$$\Rightarrow \quad r_n = 0.51 \times \frac{(5)^2}{3} \text{Å} = 4.25 \times 10^{-10}\ \text{N}$$

$= 425 \times 10^{-12}$ m

**70.** **(3)**

**Sol:** Let the number of spectral time be $n$

$$\therefore \quad \frac{n(n-1)}{2} = 6$$

$n^2 - n - 12 = 0$

$n^2 - 4n + 3n - 12 = 0$

$n(n-4) + 3(n-4)$

$n = 4$, $n = -3$ (ignore)

$\therefore \quad hv = E_4 - E_1$

$$\therefore \quad v = 13.6\left(\frac{1}{1^2} - \frac{1}{4^2}\right) \times \frac{1}{4.25 \times 10^{-15}}$$

$= 3 \times 10^{15}$ Hz

**71.** **(3)**

**Sol:** We know that,

$$d \propto \cot^2\frac{\theta}{2} \Rightarrow \sqrt{d} \propto \cot\frac{\theta}{2}$$

$$\frac{\sqrt{d_1}}{\sqrt{d_2}} = \frac{\cot\frac{\theta_1}{2}}{\cot\frac{\theta_2}{2}}$$

$$\Rightarrow \quad \sqrt{x} = \frac{\cot 30°}{\cot 45°} \Rightarrow \sqrt{x} = \sqrt{3} \Rightarrow x = 3$$

# NUCLEUS

## Single Option Correct Type Questions (01 to 39)

**1.** **(4)**

**Sol.** Experimental fact.

**2.** **(3)**

**Sol.** Nucleus is stable but neutrons and protons cannot be stable when separated. So binding energy of nucleus is greater. So mass of nucleus is smaller.

**3.** **(2)**

**Sol.** To start chain reaction mass should be greater than or equal to critical mass.

**4.** **(3)**

**Sol.** Spontaneous fission occurs to lower the binding energy of product nuclei. So statement 1 is true and statement 2 is false.

**5.** **(4)**

**Sol.** Fusion reaction is possible at high temperature because kinetic energy is high enough to overcome repulsion between nuclei.

**6.** **(3)**

**Sol.** By conservation of linear momentum

$$0 = 234\vec{v} + 4\vec{u}$$

$$\vec{v} = \frac{-4\vec{u}}{234} \Rightarrow \text{speed } v = \frac{4u}{234}$$

**7.** **(3)**

**Sol.** Energy of proton = $(8 \times 7.06 - 7 \times 5.60)$ MeV = 17.28 MeV

**8.** **(4)**

**Sol.** Law of conservation of momentum gives

$m_1v_1 = m_2v_2$

$$\Rightarrow \frac{m_1}{m_2} = \frac{v_2}{v_1}$$

But $m = \frac{4}{3}\pi r^3\rho$

or $m \propto r^3$

$$\therefore \frac{m_1}{m_2} = \frac{r_1^3}{r_2^3} = \frac{v_2}{v_1}$$

$$\Rightarrow \frac{r_1}{r_2} = \left(\frac{1}{2}\right)^{1/3}$$

$\therefore$ $r_1 : r_2 = 1 : 2^{1/3}$

**9.** **(4)**

**10.** **(2)**

**Sol.** Nuclear binding energy = (mass of nucleons − mass of nucleus) $C^2$

$= (8M_P + 9M_N - M_o)C^2$

**11.** **(4)**

**Sol.** For hydrogen nucleus mass number is equal to atomic number, else mass number is more than atomic number.

**12.** **(3)**

**13.** **(2)**

**Sol.** Gamma ray is electromagnetic radiation which does not involve any change in proton number or neutron number

**14.** **(3)**

**Sol.** Energy released $Q = BE_{\text{product}} - BE_{\text{reactant}}$

$= y - 2x = -(2x - y)$

**15.** **(4)**

**Sol.** $A + P \rightarrow B + b$

$Q = K_B + K_b - K_P$

$\Rightarrow Q + K_P = K_B + K_b$

$\Rightarrow Q + K_P > 0$

**16.** **(1)**

**17.** **(4)**

**Sol.** The binding energy per nucleon in a nucleus varies in a way that depends on the actual value of $A$.

**18.** **(1)**

**Sol.** $\because \quad A \propto r^3 \Rightarrow r \propto A^{1/3}$

$\therefore \quad \propto \frac{r^2}{A} \propto \frac{1}{A^{1/3}}$

A is incorrect Coulomb contribution to the binding energy is $b_c = \frac{-a_2 Z(Z-1)}{A^{1/3}} \Rightarrow B$ is incorrect

Volume energy $\propto A \Rightarrow C$ is correct

As we consider only surface energy contribution then option is correct. $\Rightarrow$ D is correct. In case of surface energy, only 3 interactions contribute to surface energy. $\Rightarrow E$ is incorrect.

**19.** **(3)**

**Sol.** For heavy nucleus binding energy per nucleon decreases with increasing $Z$ while for light nuclei it increases with increasing $Z$.

**20.** **(4)**

**Sol.** $_{92}U^{235} + \text{n} \longrightarrow {}_{54}Xe^{139} + {}_{38}Sr^{94} + 3\text{n}$

**21.** **(2)**

**Sol.** $Q = \Delta m\, c^2 = \frac{1}{2} \times \left(\frac{M}{2}\right) \text{v}^2 + \frac{1}{2} \times \left(\frac{M}{2}\right) \text{v}^2$

$\Delta mc^2 = \frac{1}{2} \times Mv^2$

$\Rightarrow v = c\sqrt{\frac{2\Delta m}{M}}$

**22.** **(1)**

**Sol.** Nuclear density is constant hence, mass $\propto$ volume or $m \propto V$

**23.** **(1)**

**Sol.** Mass densities of all nuclei are same so their ratio is 1.

**24.** **(3)**

**Sol** (1) $3^{Li^7} \rightarrow {}_2 He^4 + {}_1 H^3$

$\Delta m = [M_{Li} - M_{He} - M_{H^3}]$

$= [6.01513 - 4.002603 - 3.016050]$

$= -\ 1.003523\text{u}$

$\Delta m$ is negative so reaction is not possible.

(2) ${}^{210}_{84}Po \rightarrow {}^{209}_{83}Bi + {}^{1}_{1}P$

$\Delta m$ is negative so reaction is not possible.

(3) $1^{H^2} + 2^{He^4} \rightarrow 3^{Li6}$

$\Delta m$ is Positive so reaction is possible.

(4) $30^{Zn^{70}} + 34^{Se^{82}} \rightarrow 64^{Gd152}$

$\Delta m$ is negative so reaction is not possible.

**25.** **(2)**

**Sol.** Nuclear density of any element is independent of A

**26.** **(3)**

**Sol.** As a proton is lighter than a neutron, proton can not be converted into neutron without providing energy from outside. Reverse is possible. The weak interaction force is responsible in both the processes (i) conversion of $p$ to n and (ii) conversion of $n$ to $p$.

**27.** **(2)**

**Sol.** B.E of Helium

$= (2m_P + 2m_N - m\text{He}) \times 931.5 \text{ MeV} = 28.4 \text{ MeV}$

**28.** **(4)**

**Sol.** $Q = (m_A - m_B - m_D) \times c^2$

$= (238.05079 - 234.04363 - 4.00260)$

$= (0.00456\ c^2).u$

**29.** **(1)**

**Sol.** Radius of $Os^{189} = r_0\ A_{Os}^{1/3}$

Radius of that nucleus $= \frac{1}{3} \times \text{r}_0\ A_{Os}^{\frac{1}{3}} = r_0 \left(\frac{189}{27}\right)^{\frac{1}{3}} = r_0\ 7^{1/3}$

$\therefore$ **$A$ for that nucleus = 7**

**30. (2)**

**Sol.** $B.E. = (\Delta m)C^2$

$\Delta m = (50m_P + 70m_n) - (m_{Sn})$

$= (50 \times 1.00783 + 70 \times 1.00867) - (119.902199)$

$B.E. = \Delta m \times 931 MeV$

$\Rightarrow B.E. = 1020.5631 MeV$

$\Rightarrow \frac{B.E.}{Nucl.} = \frac{1029.5631}{120} = 8.5\ MeV$

**31. (2)**

**Sol.** Radius $R = R_0 A^{1/3} \Rightarrow R \propto A^{1/3}$

$V \propto R^3$

$\therefore V \propto A$

And mass $\propto A$

So, density is independent of $A$

**32. (2)**

**Sol.** Nuclear force is charge independent

**33. (2)**

$\Delta m$ should be positive

$(m_p + m_n) > m_d$

⇒ only (2) is possible

**34. (3)**

**Sol.** Power $= \frac{\text{Energy released}}{\text{time}}$

$= \frac{2 \times 6.023 \times 10^{26} \times 200 \times 1.6 \times 10^{-19}}{30 \times 24 \times 60 \times 60 \times 235}$

$= 60\ MW$

**35. (4)**

**Sol.** (1), (2) & (3) are correct description of binding energy of a nucleus.

**36. (4)**

**Sol.** Energy = (Binding Energy)$_{\text{Reactant}}$ – (Binding Energy)$_{\text{Product}}$

= 20 × 8.03 – (8 × 7.07 + 12 × 7.86)

= 160.6 – (56.56 + 94.32) = 160.6 – 150.88

= 9.72 MeV

**37. (4)**

**Sol.** Density of nucleus is constant .

**38. (4)**

**Sol.** The nuclei ranging from mass number 30 to 170 have binding energy per nucleon almost same

**39. (1)**

**Sol.** Using conservation of linear momentum, we can write

$Mv = \frac{h}{\lambda} = \frac{h\nu}{c} \Rightarrow v = \frac{h\nu}{Mc}$

Loss of internal energy = Gain in kinetic energy + energy of gamma ray

$= \frac{1}{2}Mv^2 + h\nu = \frac{1}{2}M\left(\frac{h\nu}{Mc}\right)^2 + h\nu$

$= h\nu\left[1 + \frac{h\nu}{2Mc^2}\right]$

## *Integer Type Questions (40 to 54)*

**40. (195)**

**Sol.** $Q = (BE_x + BE_y - BE_U)$

= (2 × 117 × 8.5 – 236 × 7.6) Mev.

= 195 MeV.

**41. (9)**

**Sol.** $\frac{3}{2}kT = 7.7 \times 10^{-14} J$

$T = \frac{2 \times 7.7 \times 10^{-14}}{3 \times 1.38 \times 10^{-23}}$

$= 3.7 \times 10^9$ K

$x = 9$

**42. (236)**

**Sol.** As given

${}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4$ + energy

The binding energy per nucleon of deuteron $({}_1H^2)$

= 1.1 MeV

∴ Total binding energy

= 2 × 1.1 = 2.2 MeV

The binding energy per nucleon of helium

∴ Total binding energy

= 4 × 7 = 28 MeV

Hence, energy released in above process

= 28 – 2 × 2.2 = 28 – 4.4 = 23.6 MeV

**43.** **(12)**

**Sol.** According to law of conservation of energy, kinetic energy of $\alpha$ – particle

= the potential energy of $\alpha$ – particle at distance of closest approach.

i.e $\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

$\therefore\quad 5\ MeV = \frac{9\times10^9\times 2e\times 92e}{r}$

$\left(\because \frac{1}{2}mv^2 = 5MeV\right)$

$\Rightarrow\quad r = \frac{9\times10^9\times2\times92\times(1.6\times10^{-19})^2}{5\times10^6\times1.6\times10^{-19}}$

$\therefore\quad r = 5.3\times10^{-14}\,m \approx 10^{-12}\,cm$

**44.** **(6)**

**Sol.** $R = R_0\ (A)^{1/3}$

$\frac{R_{Al}}{R_{Te}} = \frac{R_0\ A_{Al}^{\ 1/3}}{R_0\ A_{Te}^{\ 1/3}} = \frac{3}{5}$

$\therefore\quad R_{Te} = \frac{5}{3}\times 3.6$

$R_{Te}$ = 6 Fermi

**45.** **(176)**

**Sol.** The total binding energy of nucleus $A$ is,

$E_A = 220\times5.6 = 1232$ MeV

The total binding energy of $B$ and $C$ combined is,

$E_B + E_C = 105\times6.4 + 115\times6.4 = 1408$ MeV

Therefore, the energy released per fission is

$Q = E_B + E_C - E_A = 176$ MeV

**46.** **(3)**

**Sol.** According to conservation of momentum

$m_1v_1 = m_2v_2$

$\Rightarrow\quad \frac{m_1}{m_2} = \frac{v_2}{v_1} = \frac{27}{8}$

$\Rightarrow\quad \frac{\rho\times\frac{4}{3}\pi R_1^3}{\rho\times\frac{4}{3}\pi R_2^3} = \frac{27}{8}$

$\Rightarrow\quad \left(\frac{R_1}{R_2}\right) = \left(\frac{3}{2}\right)$

**47.** **(10)**

**Sol.** $\Delta m = 4m_{He} - m_0$

$\Delta m = 0.011$ amu

$\Delta E = \Delta MC^2 = 0.011\times931.5 = 10.24$ MeV

**48.** **(27)**

**Sol.** Mass defect,

$\Delta m = [Zm_p + (A-Z)m_n - M_{Al}]$

$= [13\times1.00726 + 14\times1.00866 - 27.18846]$

$= [(13.09438 + 14.12124) - 27.18846]\ u$

$= [27.21562 - 27.1884]u$

$= 0.02716\ u$

$= 0.02716x\ J$

$= 27.16x\times10^{-3}$

**49.** **(2)**

**Sol.** Nuclear density $= \frac{Am}{\frac{4}{3}\pi R^3}$

Where $A$ is the mass number and $m$ is mass of one nucleon

$\because\ R = R_0A^{\frac{1}{3}}$

$\Rightarrow R^3 = R_0^3A$

$\Rightarrow$ Nuclear density

$= \frac{Am}{\frac{4}{3}\pi R_0^3A}$

Nuclear density is independent of A

**50.** **[121]**

**Sol.** Initial binding energy = $242\times7.6$ MeV

Final binding energy = $(121 + 121)\times8.1$ MeV

= $242\times8.1$ MeV

Total gain in binding energy = (Final binding energy – Initial binding energy)

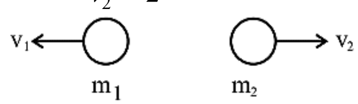
= 242 (8.1 – 7.6)

= $242\times0.5$

= 121 MeV

**51.** **(2)**

**Sol.** Given, $\frac{v_1}{v_2} = \frac{3}{2}$




Using conservation of linear momentum,

$m_1v_1 = m_2v_2$

$\Rightarrow \dfrac{m_1}{m_2} = \dfrac{2}{3}$

Since, Nuclear mass density remains constant

$\Rightarrow \dfrac{m_1}{\frac{4}{3}\pi r_1^3} = \dfrac{m_2}{\frac{4}{3}\pi r_2^3}$

$\Rightarrow \left(\dfrac{r_1}{r_2}\right)^3 = \dfrac{m_1}{m_2} \Rightarrow \dfrac{r_1}{r_2} = \left(\dfrac{2}{3}\right)^{\frac{1}{3}}$

$\left[\because \dfrac{m_1}{m_2} = \dfrac{2}{3}\right]$

$\Rightarrow x = 2$

**52.** **(6)**

**Sol.** For nucleus A mass number = 34

Total binding energy = 1.2 × 34 = 40.8MeV

For nucleus *B* mass number = 26

Total binding energy

= 1.8 × 26 MeV= 46.8 Me V

Difference of BE = 46.8 – 40.8 = 6 MeV

**53.** **(11)**

**Sol.** Density of nuclei = $= \dfrac{\text{mass of nuclei}}{\text{volume of nuclei}}$

$$\rho = \frac{1.6\times10^{-27} A}{\frac{4}{3}\pi(1.5\times10^{-15})^3 A} = 0.113\times10^{18}$$

$\rho_w = 10^3$

Hence $\dfrac{\rho}{\rho_w} = 11.31\times10^{13}$

**54.** **(1)**

**Sol.** Radius of nucleus, $R = R_0 A^{1/3}$

$$d = \frac{\text{mass}}{\text{Volume}} = \frac{mA}{\frac{4}{3}\pi R^3} = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

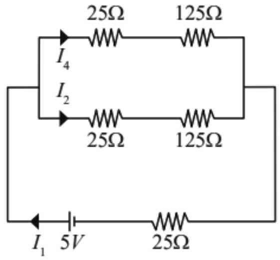
∴ Nuclear density is independent of A. (i.e., constant)

# ELECTRONIC DEVICES

*Single Option Correct Type Questions (01 to 50)*

**1.** **(4)**

**Sol:** As $D_2$ is reverse biased. So reduced circuit




$$R_{\text{Total}} = \frac{150\times150}{300} + 25 = 100\,\Omega$$

$$I_1 = \frac{5}{100} = 0.05\text{A}$$

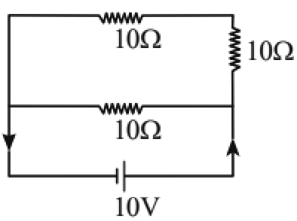
Using KCL, $I_1 = I_2 + I_4$

$$I_2 = I_4 = \frac{0.05}{2} = 0.025\text{A}$$

$$\frac{I_1}{I_2} = \frac{0.05}{0.025} = 2$$

**2.** **(1)**

**Sol:** In the circuit diode, $D_1$ and $D_3$ are forward biased and $D_2$ is reverse biased therefore $D_2$ would not allow current to pass through it.




$$R_{eq} = \frac{(10+10)\times10}{(10+10)+10} = \frac{20}{3}\,\Omega$$

$$I = \frac{V}{R_{eq}}$$

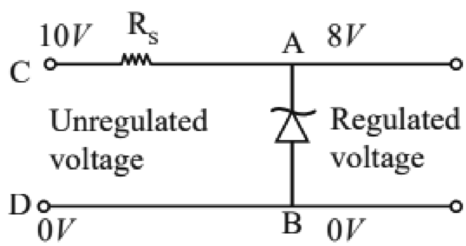
$$\therefore I = \frac{10}{20/3} = \frac{3}{2}\text{A} = 1.5\text{A}$$

**3.** **(3)**

**Sol:** Based on theory.

**4.** **(3)**

**Sol:**




$V_z = 8$ V

Current flow in Jener diode,

$$I = \frac{P}{V_z} = \frac{1.6\text{W}}{8\text{V}} = 0.2\text{A}$$

$$\therefore R_S = \frac{V_C - V_A}{i} = \frac{(10-8)\text{V}}{0.2\text{A}} = 10\,\Omega$$

[Note : A zener diode can regulate only if input voltage is ≥ zener breakdown voltage the range of input voltage should be 8 V to 10 V so that output voltage remains constant = 8 V]

**5.** **(4)**

**Sol:** When a P-N junction diode is formed an electric field is developed from N-side to P-side due to which barrier potential is created & majority charge carrier can not flow through the junction due to barrier potential so current is zero unless we apply forward bias voltage.

**6.** **(3)**

**Sol:** As temperature is increased, more electrons are excited to the conduction band and hence conductivity increases, therefore resistance decreases.

**7.** **(2)**

**Sol:** Photodiodes are operated in reverse biasing, as fractional change in current due to light is more easily measurable in reverse biasing

**8.** **(1)**

**Sol:** Works as voltage regulator in reverse bias and as simple p-n junction in forward bias.

**9.** **(3)**

**Sol:** Diffusion current takes place from *p*-side to *n*-side when *p*-*n* junction is forward bias.

**10.** **(3)**

**Sol:** A Photodiode is operated in reverse bias condition.

For a P-N junction diode current in forward bias (for $V \geq V_0$) is always greater than the current in reverse bias

Hence, Assertion is false but Reason is true.

**11.** **(3)**

**Sol:** LED works when it is forward biased.

**12.** **(4)**

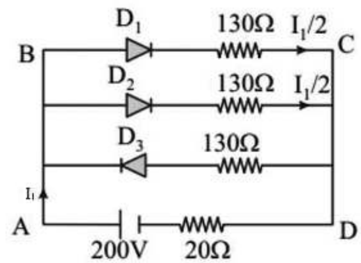
**Sol:** Photodiode are preferably operated in reverse biased mode because fractional change in minority carriers produce higher reverse bias current

**13.** **(2)**

**Sol:** I-V characteristic graph is plotted in 4th quadrant for solar cell that is, where current is negative.

**14.** **(4)**

**Sol:** Diode 1 and 2 are in forward bias with $R = 30\ \Omega$ and $D_3$ is reverse bias with $R$ infinite. $I_1$ current is flowing through 20 Ω




Applying *kVL*

$$-\left(\frac{I_1}{2}\right)\times 30-\left(\frac{I_1}{2}\right)\times 130-I_1\times 20+200=0$$

$$\Rightarrow 200-100I_1=0$$

$$\Rightarrow I_1=2$$

**15.** **(4)**

**Sol:** Zener break down occurs in *p*–*n* junction having both *p* and *n* layer heavily doped and have narrow depletion layer.

**16.** **(3)**

**Sol:** Fermi level of *p*-type semiconductors will go downward.

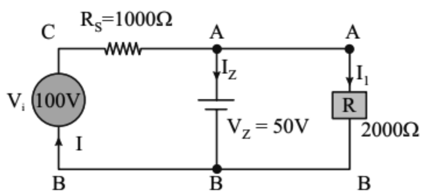
**17.** **(4)**

**Sol:** Minimum required energy, $E_{\min} = \dfrac{hc}{\lambda_{\max}}$

$$E_{\min} = \frac{1242\,\text{eV - nm}}{621\,\text{nm}} = 2\,\text{eV}$$

**18.** **(3)**

**Sol:** $I_z = \dfrac{V_i - V_z}{R_S} - \dfrac{V_Z}{R} = \dfrac{100-50}{1000} - \dfrac{50}{2000} = 25\text{ mA}$




**19.** **(4)**

**Sol:** Wavelength of emitted light,

$$\lambda = \frac{hc}{E} = \frac{6.63\times 10^{-34}\times 3\times 10^{8}}{1.9\times 1.6\times 10^{-19}} = 654\text{ nm (Red)}$$

**20. (2)**

**Sol:** Pentavalent materials have more electrons and so electron density increase. But overall semiconductor is neutral

**21. (3)**

**Sol:** For photodiode to detect $\frac{hc}{\lambda} >$ band gap energy

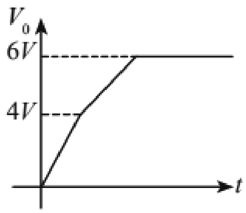
$\Rightarrow$ Band gap energy = $\frac{hc}{\lambda_{max}}$

$$\frac{6.63\times10^{-34}\times3\times10^{8}}{400\times10^{-9}} = 5\times10^{-19}\text{ J} = 3.1\text{ eV}$$

**22. (1)**

**Sol:** As input voltage varies between 0 – 4V, zener diode does not reach breakdown voltage. Hence $V_0 = V_i$.

As input voltage varies between 4 – 6 V, zener diode with 4V will break down and potential difference across this zener will become constant.




As input voltage raises beyond 6 V. Both zener diodes break down, output potential is measured across 6V diode. Hence output potential remains 6V.

**23. (2)**

**Sol:** $I = \frac{6}{300} = 0.02\text{ A}$ ($D_2$ is in reverse bias)

**24. (2)**

**Sol:** At $V_B = 8$ V

$$i_L = \frac{6\times10^{-3}}{4} = 1.5\times10^{-3}\text{ A}$$

$$i_R = \frac{(8-6)\times10^{-3}}{1} = 2\times10^{-3}\text{ A}$$

$$\therefore i_{\text{zener diode}} = i_R - i_{\text{load}} = 0.5\times10^{-3}\text{ A}$$

At $V_B = 16$ V

$$i_L = 1.5\times10^{-3}\text{ A}$$

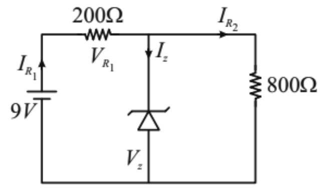
$$i_R = \frac{(16-6)\times10^{-3}}{1} = 10\times10^{-3}\text{ A}$$

$$\therefore i_{\text{zener diode}} = i_R - i_L = 8.5\times10^{-3}\text{ A}$$

**25. (1)**

**Sol:** $V_{R_1} = 9 - 5.6 = 3.4$ V

$$\therefore I_{R_1} = \frac{V_{R_1}}{R} = \frac{3.4}{200} = 17\text{ mA}$$




$$I_z = I_{R_1} - I_{R_2}$$

$$I_z = \left(17 - \frac{5.6}{800}\right)$$

$I_z$ = (17 – 7) mA = 10 mA

**26. (2)**

**Sol:** When either or both of $A$ and $B$ is closed we get current bypass from switch.

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

Hence it is "NOR" gate.

**27. (1)**

**Sol:** $\overline{A\cdot B} = \overline{A} + \overline{B}$

**28. (2)**

**Sol:** $X = \overline{A}B + A\overline{B}$

So truth table,

| $A$ | $B$ | $Y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**29. (4)**

**Sol:** $\left(\overline{A\cdot A}\right)=\overline{A}$

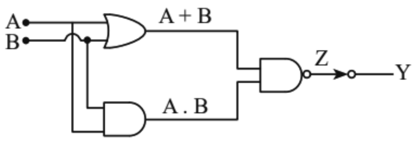
$\overline{B\cdot B}=\overline{B}$

$Y=\left(\overline{\overline{A}\cdot\overline{B}}\right)=A+B$

OR Gate

**30. (1)**

**Sol:**




$Y=\overline{\overline{(A+B)\cdot(AB)}}$

$(A+B)\cdot AB$

$AB+AB=AB$

$\therefore$ It is an AND Gate

**31. (3)**

**Sol:** $Y=\overline{\overline{A}\cdot\overline{B}}=\overline{\overline{A}}+\overline{\overline{B}}=A+B$

**32. (4)**

**Sol:** $Y=\overline{\overline{A}\cdot B}=A+\overline{B}$

**33. (1)**

**Sol:**

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |

According to the truth table the logic is AND gate.

**34. (2)**

**Sol:**

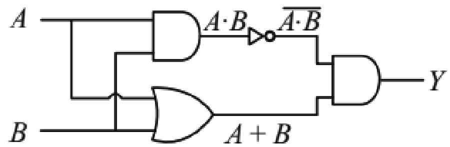
| *A* | *B* | *Y* |
|---|---|---|
| 1 | 1 | 0 |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |

NAND Gate

$Y=\overline{A\cdot B}$

**35. (1)**

**Sol:** The result of a XOR gate is high (1) just when precisely one of its bits of inputs is high (1). In the event that both of a XOR gate's bits of inputs are low (0), or then again on the off chance that both of its bits of inputs are high (1), the result of the XOR gate is low.




$Y=\overline{(A\cdot B)}\cdot(A+B)$

$=(\overline{A}+\overline{B})\cdot(A+B)$

$=\overline{A}A+\overline{A}B+A\overline{B}+\overline{B}B$

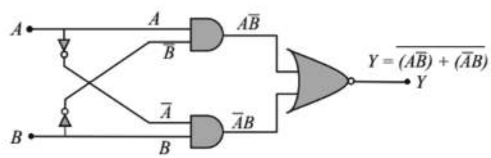
$=0+\overline{A}B+A\overline{B}+0$

$y=\overline{A}B+A\overline{B}$

Which is XOR gate

**36. (1)**

**Sol:**



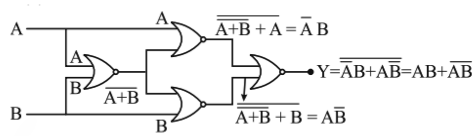

$Y=\overline{(A\overline{B})+(\overline{A}B)}=\left(\overline{(A\overline{B})}\right)\left(\overline{(\overline{A}B)}\right)$

$Y=(\overline{A}+\overline{\overline{B}})(\overline{\overline{A}}+\overline{B})=\left((\overline{A}+B)\right)\left((A+\overline{B})\right)$

$=AB+\overline{AB}$

**37. (1)**

**Sol:**




**38. (2)**

**Sol:** We have given the sequence of the inputs *A* and *B*

(0, 0); (0, 1); (1, 0); (1, 1).

Thus, the output Y is (1, 1, 1, 0)

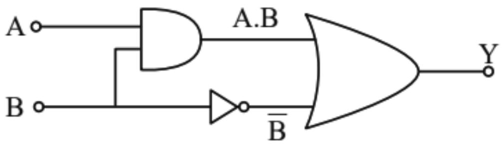
| A | B | P | Q | Y |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 |

**39.** **(2)**

**Sol:** Here $Y = AB + \overline{B}$

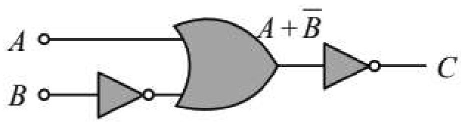
So the output will be as given in the below table

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |




**40.** **(4)**

**Sol:**




$C = \overline{A+\overline{B}} = \overline{A}\cdot\overline{\overline{B}} = \overline{A}B$

**41.** **(2)**

**Sol:**

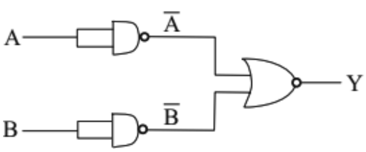
| A | B | X | Y | Z |
|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 |

**42.** **(3)**

**Sol:** $Y = \overline{\overline{A}+B} = A\cdot\overline{B}$

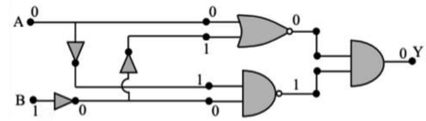
**43.** **(3)**

**Sol:** $Y = \overline{\overline{A}+\overline{B}} = \overline{\overline{A}}\cdot\overline{\overline{B}} = A\cdot B$




**44.** **(1)**

**Sol:**




**45.** **(3)**

**Sol:** $Y = \overline{\overline{A}\cdot\overline{B}} = \overline{\overline{A}}+\overline{\overline{B}} = A+B$

Truth table

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**46.** **(1)**

**Sol:** $Y = \overline{\overline{AB}\bullet A} = \overline{\overline{AB}}+\overline{A}$

$= AB + \overline{A} = 0+0 = 0$

**47.** **(1)**

**Sol:** $Y = \overline{\overline{A}\cdot\overline{B}} = \overline{\overline{A}}+\overline{\overline{B}} = A+B$

**48.** **(3)**

**Sol:** $Y = \overline{\overline{(A\cdot\overline{AB})\cdot(B+\overline{AB})}} \Rightarrow Y = A\cdot\overline{AB}+\overline{B}\cdot AB$

$Y = A\overline{A}+A\overline{B}+AB\overline{B}$

$Y = A\overline{B}$

**49.** **(3)**

**Sol:** To make output 1

$P+Q$ must be 0

$P+Q = (\overline{x}+y)+(y+\overline{x})$

So, $x = 1$, $y = 0$ will give $P+Q = 0$

**50.** **(1)**

**Sol:**

$C = A+B$ and $Y = \overline{A\cdot C}$

| A | B | C = (A + B) | A.C. | Y = $\overline{\text{A.C}}$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 |

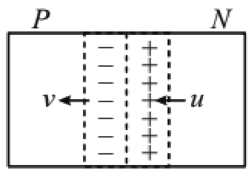
*Integer Type Questions (51 to 66)*

**51.** **(5)**

**Sol:** $I_L = \frac{5}{R_L} = \frac{5}{100} = 5\ mA$

**52.** **(14)**

**Sol:**




Work done by Electric field = $K_f - K_i$

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = -1.6\times10^{-19}\times0.4$

$\frac{1}{2}\times9\times10^{-31}(v^2-u^2) = -0.64\times10^{-19}$

$u^2 - v^2 = \frac{2\times0.64\times10^{12}}{9}$

$v^2 = \left(36-\frac{128}{9}\right)\times10^{10}$

$v = \frac{14}{3}\times10^5$ m/s

**53.** **(480)**

**Sol:** $V - I_MR - V_z = 0$

$\Rightarrow 20 - I_MR - 8 = 0$

$\Rightarrow I_MR = 12$

$\Rightarrow 25\times10^{-3}\times R = 12$

$\Rightarrow R = \frac{12}{25\times10^{-3}} = 480\ \Omega$

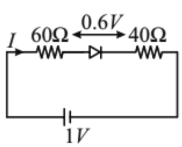
**54.** **(3)**

**Sol:** Formula of energy gap.

$E_g = \frac{hc}{\lambda} = \frac{1242}{\lambda(\text{nm})} = \frac{1242}{400} = 3.105$

**55.** **(4)**

**Sol:**




Current will flow only through diode–$D_1$ as it is forward biased.

Applying Kirchoff's law

$1 - I(60) - 0.6 - I(40) = 0$

$\frac{0.4}{100} = I$

$I = 4$ mA

**56.** **(9)**

**Sol:** Current in the load, $I_L = \frac{60}{10,000} = 0.006A$

$I = \frac{120-60}{4000} = 0.015A$

Thus, maximum zener current, $I_Z = I - I_L$

$= 0.015 - 0.006 = 0.009 = 9$ mA

**57.** **(1)**

**Sol:** As, $Ed = V_B$

$\therefore E = \frac{V_B}{d} = \frac{0.6}{6\times10^{-6}} = 1\times10^5$ N/C

**58.** **(25)**

**Sol:** Since potential difference across 2 kΩ is 5 V, therefore current through it,

$i = \frac{5}{2\times10^3} = 25\times10^{-4}$ A

**59.** **(20)**

**Sol:** $D_1$ is forward biased & $D_2$ is reverse biased.

The current through the 120 Ω resistance

$I = \frac{6}{120+130+50} = \frac{6}{300} = 2\times10^{-2}\text{ A} = 20\times10^{-3}\text{ A}$

= 20 mA

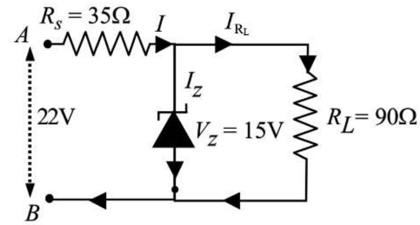
**60.** **(5)**

**Sol:** $I_z = I - I_{RL} = \left(\frac{22-15}{35}\right) - \frac{15}{90} = \frac{1}{30}$ A

Power dissipitated across zener diode, $= V_zI_z$

$= \frac{1}{30}\times15 = 5\times10^{-1}$ W

Hence, the value of $x$ is 5.




**61.** **(25)**

**Sol:** According to the graph as shown in the question,

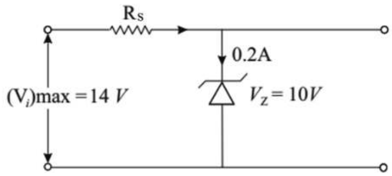
$$R = \frac{\Delta V}{\Delta I} = \frac{0.75 - 0.70}{(5-3)\times 10^{-3}} = \frac{0.05\times 1000}{2} = 25\Omega$$

**62.** **(20)**

**Sol:** We have given, $(V_i)_{max} = 14$ V, $V_Z = 10$ V

Maximum current through zener diode,

$$i = \frac{2}{10} = 0.2\,\text{A}$$



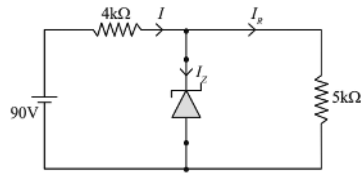

$$R = \frac{(V_i)_{\max} - V_Z}{i} = \frac{14-10}{0.2} = 20\Omega$$

**63.** **(9)**

**Sol:** $I_z = I - I_R$

$$I_z = \frac{90-30}{4000} - \frac{30}{5000}$$

$$I_z = 15\times 10^{-3} - 6\times 10^{-3} = 9 \text{ mA}$$




**64.** **(500)**

**Sol:** If $I_{z(\max)} = 90$ mA then current in $R$ should be greater than 90 mA.

$$R = \frac{V_i - V_z}{I_{z(\max)}} = \frac{50-5}{90\times 10^{-3}}$$

$R = 500\ \Omega$

**65.** **(5)**

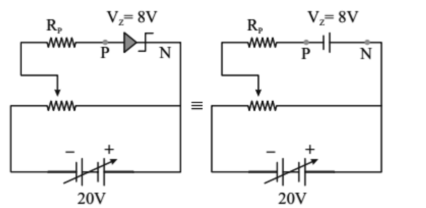
**Sol:** $n^2 = n_h \cdot n_e \Rightarrow n_e = \dfrac{n^2}{n_h}$

$$n_e = \frac{1.5\times 1.5\times 10^{32}}{4.5\times 10^{22}} = \frac{10^{10}}{2} = 0.5\times 10^{10}$$

$= 5 \times 10^9/\text{m}^3$

**66.** **(192)**

**Sol:**




$$P_z = V_z I_z \Rightarrow 0.5 = 8I_z \Rightarrow I_z = \frac{1}{16} \text{ Amp}$$

$$I_z = \frac{20 - V_z}{R_P}$$

$$\Rightarrow \frac{1}{16} = \frac{20-8}{R_P}$$

$$\Rightarrow R_P = 16\times 12 = 192\,\Omega$$