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PREVIOUS YEAR PAPER · 2026

OLYMPIAD · STAGE I

NSEP

National Standard Examination in Physics

2026

Question paper, answer key and Zigyan solutions

60	216	120 min	61
Questions	Maximum marks	Time	Paper code

Question paper and TENTATIVE answer key: Indian Association of Physics Teachers (IAPT), NSEP 2026, paper code 61.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

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Sulokya Bibhuty

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- Sulokya Bibhuty — 3 Years Classroom
- Saksham Bishnoi — 4 Years Classroom

ASTRONOMY

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MATHEMATICS (IOQM)

- Priyanshi — 4 Years Classroom

Saksham Bishnoi qualified the Chemistry Olympiad twice and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai.

16 selections	16 of 35	AIR 168
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Given in the question paper

Physical constants **you may need....**

Magnitude of charge on electron $e = 1.60\times10^{-19}$ C	Avogadro's constant $N = 6.02\times10^{23}\,mol^{-1}$
Mass of electron $m_e = 9.11\times10^{-31}$ kg $= 0.511$ MeV	Speed of light in free space $c = 3\times10^{8}\,ms^{-1}$
1 u = 931.5 MeV	Speed of sound in dry air at 0°C $v = 332\,ms^{-1}$
Mass of proton $m_p = 1.67\times10^{-27}$ kg	Permittivity of free space $\epsilon_0 = 8.85\times10^{-12}\,C^2/Nm^2$
Acceleration due to gravity $g = 9.80\,ms^{-2}$	Permeability of free space $\mu_0 = 4\pi\times10^{-7}\,Hm^{-1}$
Universal gravitational constant $G = 6.67\times10^{-11}\,Nm^2/kg^2$	Planck's constant $h = 6.63\times10^{-34}$ Js
Universal gas constant $R = 8.31\,J/mol\,K$	Faraday constant $= 96,500\,C\,mol^{-1}$
Boltzmann constant $k = 1.38\times10^{-23}\,J/K$	Rydberg constant $R = 1.097\times10^{7}\,m^{-1}$
Stefan's constant $\sigma = 5.67\times10^{-8}\,W/m^2\,K^4$	Astronomical unit (AU) $= 1.50\times10^{11}$ m
Atmospheric pressure (at STP) = $1.01\times10^{5}\,Nm^{-2}$	

PART A-1 · ONE CORRECT OPTION

Q. 1 – 48 · +3 for a correct answer, –1 for a wrong one

1. The Earth is revolving around the Sun in a circular orbit with a period of revolution equal to 1 year. Suppose that during its motion around the Sun, the mass of the Sun doubles suddenly, the time period of revolution of the Earth will then become

(A) $\frac{1}{\sqrt{2}}$ year (B) $\frac{2\sqrt{2}}{3\sqrt{3}}$ year

(C) $\frac{2}{3\sqrt{3}}$ year (D) $\frac{1}{2\sqrt{2}}$ year

Solution · Q1 **Answer: (C)**

When the mass becomes 2M, the distance r and speed v remain the same.

$$v^2 = \frac{GM}{r}$$

For the new orbit of semi-major axis a,

$$\frac{1}{2}mv^2 - \frac{2GMm}{r} = -\frac{GMm}{a}$$

$$\Rightarrow a = \frac{2r}{3}$$

By Kepler's third law, with central mass M_c,

$$T \propto \sqrt{\frac{a^3}{M_c}}$$

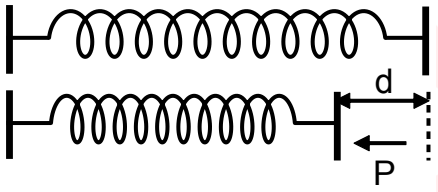
$$\frac{T'}{T} = \sqrt{\left(\frac{2}{3}\right)^3 \times \frac{1}{2}}$$

$$\Rightarrow \frac{T'}{T} = \frac{2}{3\sqrt{3}}$$

$$\therefore T' = \frac{2}{3\sqrt{3}} \text{ year}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

2. A spring is in a compressed state under the action of a constant force P. Compression of the spring is d. Suppose direction of the force is reversed suddenly with its magnitude changed to 2P; the maximum extension of the spring will now be



(A) 2d (B) 3d (C) 4d (D) 5d

Solution · Q2 **Answer: (D)**

Initially,

$$kd = P$$

Under 2P, the end starts from rest at compression d and comes to rest at extension X.

By work–energy theorem,

$$2P(X + d) = \frac{1}{2}k\left(X^2 - d^2\right)$$

$$\Rightarrow 4P = k(X - d)$$

$$\Rightarrow 4d = X - d$$

$$\Rightarrow X = 5d$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

3. In a process, one mole of a monoatomic gas is heated from initial temperature 27 °C, in such a way that its molar heat capacity is constant equal to 2R. During the process, volume of the gas is doubled. The final temperature of the gas becomes

(A) 108 °C (B) 927 °C (C) 527 °C (D) 2127 °C

Solution · Q3 **Answer: (B)**

By the first law of thermodynamics,

$$dQ = dU + P\,dV$$

$$2RdT = \frac{3}{2}RdT + PdV$$

$$\Rightarrow PdV = \frac{1}{2}RdT$$

Using the ideal gas equation,

$$P = \frac{RT}{V}$$

$$\Rightarrow \frac{dV}{V} = \frac{dT}{2T}$$

$$\Rightarrow T \propto V^2$$

The volume is doubled.

$$T_1 = 300\ K$$

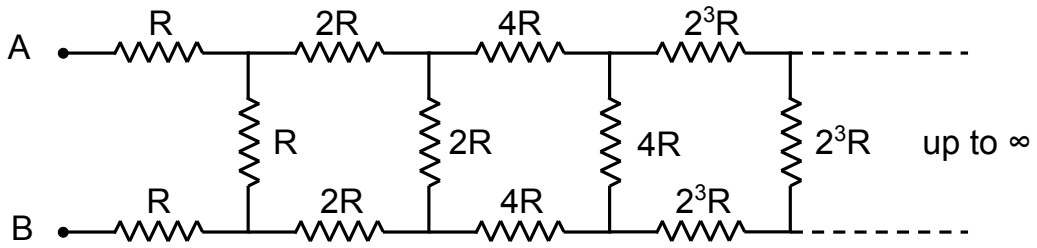
$$\Rightarrow T_2 = 4 \times 300$$

$$\Rightarrow T_2 = 1200\ K$$

$$\therefore T_2 = 927\ °C$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

4. The resistance between the points A and B in the infinite circuit shown, in terms of R, is



(A) $\frac{5+\sqrt{41}}{4}R$

(B) $\frac{-5+\sqrt{41}}{4}R$

(C) $\frac{5+\sqrt{41}}{2}R$

(D) $\left(\sqrt{3}+1\right)R$

Solution · Q4 **Answer: (A)**

Let the resistance between A and B be X.

Each stage has double the resistances of the previous one, so the ladder beyond the first vertical R has resistance 2X.

$$X = 2R + \frac{R \times 2X}{R + 2X}$$

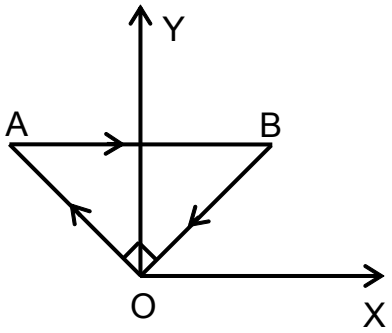
$$\Rightarrow 2X^2 - 5RX - 2R^2 = 0$$

Taking the positive root,

$$X = \frac{5+\sqrt{41}}{4}R$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

5. Three metallic wires form an isosceles right angled triangle AOB with wire AB parallel to x-axis and the vertex O at the origin. The length of the wire OA = length $OB = 2\sqrt{2}$ m. A current of 10 A flows in the loop along OABO. A magnetic field $\vec{B} = 2.5\left(\hat{i} - \hat{k}\right)$ T exists in the region y ≥ 1. The force acting on the triangle due to this field is



(A) $50\hat{j}$ N

(B) $50\left(\hat{i} + \hat{k}\right)$ N

(C) $50\left(\hat{j} + \hat{i}\right)$ N

(D) zero

Solution · Q5 **Answer: (A)**

AB = 4 m

A is at (−2, 2) and B is at (2, 2).

Only part DABC lies in the field, with D(−1, 1) on OA and C(1, 1) on OB. Current goes from D to C along this part.

So the effective length vector is

$$\vec{L} = \vec{DC}$$

$$\Rightarrow \vec{L} = 2\hat{i}\ \text{m}$$

$$\vec{F} = I\left(\vec{L} \times \vec{B}\right)$$

$$\Rightarrow \vec{F} = 10\left[2\hat{i} \times 2.5\left(\hat{i} - \hat{k}\right)\right]\ \text{N}$$

$$\therefore \vec{F} = 50\hat{j}\ \text{N}$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

6. When placed in a liquid of density d_1, a solid sphere sinks displacing a volume V of the liquid. When placed in a second liquid of density d_2, the same sphere floats with half of its volume appearing over the surface of the liquid. When placed in a third liquid of density d_3, the same sphere floats with $\frac{1}{4}$th of its volume over the surface of the liquid. The buoyant force exerted by the liquid of density d_3 on the sphere is

(A) $V d_3 g$

(B) $\frac{1}{2}Vd_1g$

(C) $\frac{1}{2}Vd_2g$

(D) $\frac{1}{4}Vd_3g$

Solution · Q6 **Answer: (C)**

The sphere sinks in the first liquid, so its volume is V.

It floats in the other two liquids, so in both the buoyant force equals its weight W.

For the liquid of density d_2,

$$W = \frac{V}{2} d_2 g$$

For the liquid of density d_3,

$$F_3 = \frac{3V}{4} d_3 g$$

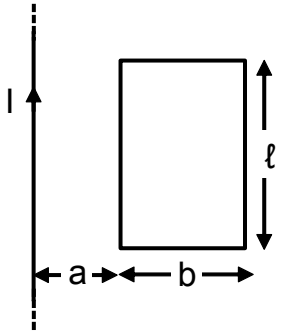
$$F_3 = W$$

$$\therefore F_3 = \frac{1}{2} V d_2 g$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

7. A flat rectangular $\ell \times b$ loop and a long straight wire lie in the same plane (see figure). Current in the wire varies according to $I = I_0 \sin \omega t$. The amplitude of emf induced in the loop is

(Given b = 2a)



(A) $\left[\frac{\mu_0 \omega I_0 \ell}{2\pi} \ln 3\right]$

(B) $\left[\frac{\mu_0 \omega I_0 \ell}{2\pi} \ln 2\right]$

(C) $\left[\frac{3\mu_0 \omega I_0 \ell}{2\pi}\right]$

(D) $\left[\frac{\mu_0 \omega I_0 \ell}{\pi}\right]$

Solution · Q7 **Answer: (A)**

Field at distance x from the wire:

$$B = \frac{\mu_0 I}{2\pi x}$$

From the figure, x goes from a to a + b.

$$\Phi = \int_a^{a+b} \frac{\mu_0 I \ell}{2\pi x} dx$$

$$\Rightarrow \Phi = \frac{\mu_0 I \ell}{2\pi} \ln \frac{a+b}{a}$$

b = 2a and $I = I_0 \sin \omega t$

$$\Rightarrow \Phi = \frac{\mu_0 I_0 \ell \ln 3}{2\pi} \sin \omega t$$

$$e = -\frac{d\Phi}{dt}$$

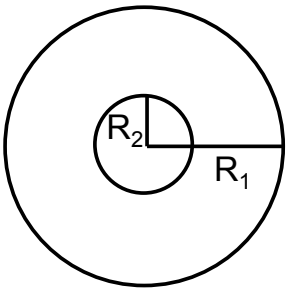
$$\Rightarrow e = -\frac{\mu_0 \omega I_0 \ell}{2\pi} \ln 3 \cos \omega t$$

Amplitude of the induced emf:

$$e_0 = \frac{\mu_0 \omega I_0 \ell}{2\pi} \ln 3$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

8. There are two concentric and coplanar coils of radii R_1 and R_2 ($R_1 >> R_2$), and number of turns N_1 and N_2 respectively. The current in the second (smaller) coil is changing at a constant rate $\frac{dI_2}{dt} = k$. The magnitude of induced emf in the first (larger) coil will be



(A) $\frac{\mu_0 \pi N_1 N_2}{2} \sqrt{R_1 R_2}\ k$

(B) $\mu_0 \pi N_1^2 N_2 \frac{R_2^2}{2R_1} k$

(C) $\mu_0 \pi N_1 N_2 \frac{R_1^2}{2R_2} k$

(D) $\mu_0 \pi N_1 N_2 \frac{R_2^2}{2R_1} k$

Solution · Q8 **Answer: (D)**

By reciprocity theorem, pass current I_1 through the larger coil.

As R_1 is much larger than R_2, its field is uniform over the small coil.

$$B_1 = \frac{\mu_0 N_1 I_1}{2R_1}$$

$$M = \frac{N_2 B_1 \pi R_2^2}{I_1}$$

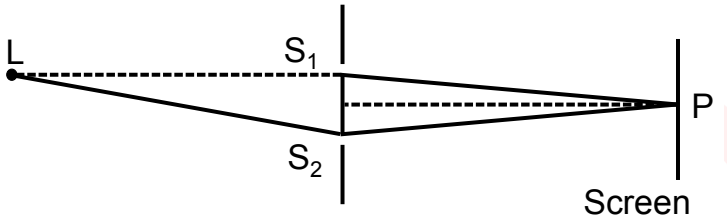
$$\Rightarrow M = \frac{\mu_0 \pi N_1 N_2 R_2^2}{2R_1}$$

$$|e_1| = Mk$$

$$\therefore |e_1| = \frac{\mu_0 \pi N_1 N_2 R_2^2}{2R_1} k$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

9. A line source L (perpendicular to the plane of the paper) emitting light of wavelength 5625 Å is placed 1.00 m away directly in front of the slit S_1 in an opaque wall (see figure). A second slit S_2 in the same wall is parallel to slit S_1 and at distance d from it; both the slits are parallel to each other and to the line source L. Intensity of light is measured at the position P, equidistant from each of the slits S_1 and S_2 on the screen, for three different conditions. When S_2 is covered it is I_1, when S_1 is covered it is I_2. When both slits are open it is I. If $I = I_1 + I_2$, the distance d between the two slits is



(A) 0.75 mm (B) 0.53 mm (C) 1.06 mm (D) 1.50 mm

Solution · Q9 **Answer: (B)**

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\varphi$$

For the given condition,

$$I = I_1 + I_2$$

$$\Rightarrow \cos\phi = 0$$

P is equidistant from S_1 and S_2, so the path difference arises between L and the slits. Let D be the distance of L from the wall.

$$\Delta = \sqrt{D^2 + d^2} - D$$

$$\Rightarrow \Delta \approx \frac{d^2}{2D}$$

For minimum d,

$$\frac{d^2}{2D} = \frac{\lambda}{4}$$

$$\Rightarrow d = \sqrt{\frac{D\lambda}{2}}$$

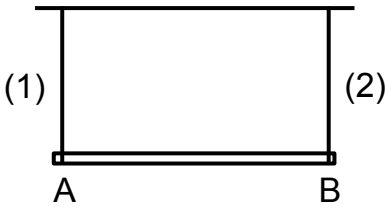
$$d = \sqrt{\frac{1.00 \times 5.625 \times 10^{-7}}{2}}$$

$$\Rightarrow d = 5.30 \times 10^{-4}\ \text{m}$$

$$\therefore d = 0.53\ \text{mm}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

10. A uniform rod AB of weight W is symmetrically suspended with the help of two identical un-stretchable light strings (1) and (2) of equal length from a rigid horizontal support. The rod is horizontal. The tension in the string (1), immediately after the string (2) is burnt, would be



(A) W

(B) $\frac{3W}{4}$

(C) $\frac{W}{2}$

(D) $\frac{W}{4}$

Solution · Q10 **Answer: (D)**

Just after string (2) is burnt, let T be the tension in string (1) and a the downward acceleration of the centre of the rod (mass m, length L).

$$W - T = ma$$

Torque equation about the centre:

$$T\frac{L}{2} = \frac{mL^2}{12}\alpha$$

$$\Rightarrow \alpha = \frac{6T}{mL}$$

At this instant, end A has no vertical acceleration.

$$a = \alpha\frac{L}{2}$$

$$\Rightarrow a = \frac{3T}{m}$$

$$\Rightarrow W - T = 3T$$

$$\therefore T = \frac{W}{4}$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

11. Speed of sound is measured in a confined gas and found to be 0.632 times the RMS velocity (V_{rms}) of the gas molecules as determined from the temperature. The degree of freedom f and molar heat capacity C_v at constant volume of the gas are

(A) f = 10, $C_V = 5R$

(B) f = 6, $C_V = 3R$

(C) f = 5, $C_V = \frac{5}{2}R$

(D) f = 3, $C_V = \frac{3}{2}R$

Solution · Q11 **Answer: (A)**

$$v = \sqrt{\frac{\gamma RT}{M}}$$

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{v}{V_{rms}} = \sqrt{\frac{\gamma}{3}}$$

$$\Rightarrow \sqrt{\frac{\gamma}{3}} = 0.632$$

$$\Rightarrow \gamma \approx 1.20$$

$$\gamma = 1 + \frac{2}{f}$$

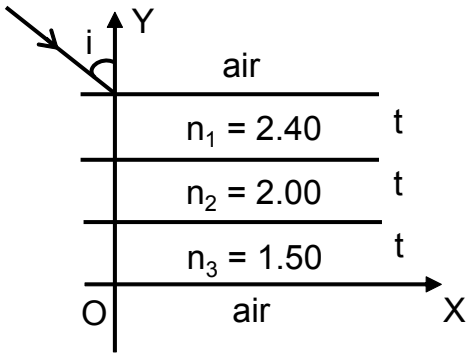
$$\Rightarrow f = 10$$

$$C_V = \frac{f}{2}R$$

$$\therefore C_V = 5R$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

12. A beam of light in air is incident at an angle of incidence i = 75° on a large block made of three parallel layers of different transparent materials stacked on top of each other, as shown. The thickness of each layer is t = 10.0 cm. Refractive indices of the three successive layers with respect to air are $n_1 = 2.40$, $n_2 = 2.00$ and $n_3 = 1.50$ respectively. The beam of light emerges from the third medium on the X axis at a distance ξ from O. The value of ξ is



(A) 30.3 cm (B) 23.4 cm (C) 18.3 cm (D) 9.02 cm

Solution · Q12 **Answer: (C)**

By Snell's law,

$$\sin 75° = n_1 \sin r_1 = n_2 \sin r_2 = n_3 \sin r_3$$

$$\Rightarrow \sin r_1 = 0.4025$$

$$\Rightarrow \sin r_2 = 0.4830$$

$$\Rightarrow \sin r_3 = 0.6440$$

$$\Rightarrow \tan r_1 = 0.4396$$

$$\Rightarrow \tan r_2 = 0.5516$$

$$\Rightarrow \tan r_3 = 0.8417$$

The sideways shifts in the three layers add up.

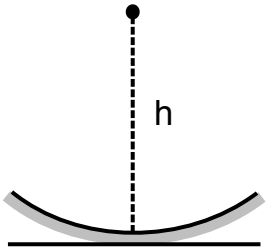
$$\xi = t(\tan r_1 + \tan r_2 + \tan r_3)$$

$$\xi = 10.0 \times 1.833$$

$$\therefore \xi = 18.3 \text{ cm}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

13. A concave mirror of radius of curvature R = 1.00 m is placed on the floor as shown. A small, light-weight ball falls from a height h = 1.20 m vertically along the principal axis towards the mirror. If the ball loses 16% of its energy after each collision with the mirror, the distance between the ball and its image formed by the mirror, when the ball reaches its maximum height after the 2nd collision, is nearly



(A) 0.75 m (B) 0.66 m (C) 0.55 m (D) 0.37 m

Solution · Q13 **Answer: (D)**

After each collision, 84% of the energy remains, so each maximum height is 0.84 times the previous one (no air resistance).

After the second collision,

$$u = 1.20 \times (0.84)^2$$

$$\Rightarrow u \approx 0.847 \text{ m}$$

$$f = 0.50 \text{ m}$$

Mirror formula, taking distances in front of the mirror as positive:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow v = \frac{uf}{u - f}$$

$$\Rightarrow v = \frac{0.847 \times 0.50}{0.847 - 0.50}$$

$$\Rightarrow v \approx 1.221 \text{ m}$$

Distance between the ball and its image:

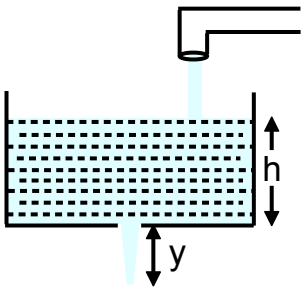
$$v - u = 1.221 - 0.847$$

$$\therefore v - u \approx 0.37 \text{ m}$$

Check: by Newton's formula, the ball is about 0.347 m beyond the focus, so its image is 0.25 divided by 0.347, about 0.721 m, beyond the focus. The gap between them is about 0.374 m.

IAPT tentative answer: (D) | **Zigyan answer:** (D)

14. In a wide container, water is always filled up to a height h. There is a nozzle (hole) of radius r_0 at its bottom. For some distance below the nozzle, water falls in a laminar stream. Radius r of stream as a function of y below the nozzle is expressed as [ignore the viscosity of water]



(A) $r = \dfrac{r_0}{\left(1+\frac{y}{h}\right)^{1/2}}$

(B) $r = \dfrac{r_0}{\left(1+\frac{y}{h}\right)^{1/4}}$

(C) $r = r_0\left(1+\dfrac{y}{h}\right)^{1/2}$

(D) $r = \dfrac{r_0}{\left(1+\frac{h}{y}\right)^{1/4}}$

Solution · Q14 **Answer: (B)**

The container is wide, so the free surface is practically at rest. By Bernoulli's theorem, at the nozzle and at depth y below it,

$$v_0 = \sqrt{2gh}$$

$$v = \sqrt{2g(h+y)}$$

By the equation of continuity,

$$\pi r_0^2 v_0 = \pi r^2 v$$

$$\Rightarrow r^2 = r_0^2\sqrt{\frac{h}{h+y}}$$

$$\therefore r = \frac{r_0}{\left(1+\frac{y}{h}\right)^{1/4}}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

15. A point object of mass m starts moving from rest along x axis from the origin, under the action of a force which delivers a constant power P. The position x of the object at time t is

(A) $x = \left(\dfrac{8Pt^3}{9m}\right)^{1/2}$

(B) $x = \left(\dfrac{9Pt^3}{8m}\right)^{1/2}$

(C) $x = \left(\dfrac{8Pt^4}{27m}\right)^{1/3}$

(D) $x = \dfrac{2}{3}\left(\dfrac{Pt^3}{m}\right)^{1/2}$

Solution · Q15 **Answer: (A)**

By work–energy theorem,

$$\frac{1}{2}mv^2 = Pt$$

$$\Rightarrow v = \sqrt{\frac{2Pt}{m}}$$

$$x = \sqrt{\frac{2P}{m}} \int_0^t t^{1/2} dt$$

$$\Rightarrow x = \frac{2}{3}\sqrt{\frac{2P}{m}} t^{3/2}$$

$$\therefore x = \left(\frac{8Pt^3}{9m}\right)^{1/2}$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

16. A black body, maintained at absolute temperature T, is emitting radiations of wavelength λ with maximum (peak) intensity. The emitted photons are capable of exciting the electron in a Bohr-model hydrogen atom from ground state (E_g = – 13.60 eV) to the third excited state. Using Wien's constant b = 2.90×10^{-3} mK, the estimated value of temperature T is nearly

(A) 2.98×10^3 K (B) 2.98×10^4 K (C) 2.83×10^4 K (D) 2.68×10^4 K

Solution · Q16 **Answer: (B)**

The third excited state is the fourth level.

$$\Delta E = 13.60\left(1 - \frac{1}{16}\right)$$

$$\Rightarrow \Delta E = 12.75 \text{ eV}$$

$$\lambda = \frac{hc}{\Delta E}$$

$$\Rightarrow \lambda = \frac{1240}{12.75}$$

$$\Rightarrow \lambda \approx 97.25 \text{ nm}$$

By Wien's law,

$$T = \frac{b}{\lambda}$$

$$\Rightarrow T = \frac{2.90 \times 10^{-3}}{97.25 \times 10^{-9}}$$

$$\therefore T \approx 2.98 \times 10^4 \text{ K}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

17. In order to form standing waves in a medium, the following two waves are superposed

$y_1 = A \sin \pi (5x + 100\, t + 0.8)$

$y_2 = A \sin \pi (5x - 100\, t)$

the variables x and y are in meter and t in second. The correct statement is that the

(A) positions of first two displacement nodes (for x > 0) are x = 2 cm and x = 22 cm respectively

(B) velocity amplitude is maximum at both the positions (for x > 0) x = 12 cm and x = 22 cm

(C) pressure variation is maximum at both the positions (for x > 0) x = 22 cm and x = 32 cm

(D) positions of first two displacement antinodes (for x > 0) are x = 2 cm and x = 22 cm respectively

Solution · Q17 **Answer: (D)**

Adding the two waves,

$$y = 2A \sin(5\pi x + 0.4\pi) \cos(100\pi t + 0.4\pi)$$

Displacement nodes:

$$\sin(5\pi x + 0.4\pi) = 0$$

$$\Rightarrow x = \frac{N - 0.4}{5}\ m$$

$$\Rightarrow x = 12\ cm, 32\ cm, \ldots$$

Displacement antinodes:

$$|\sin(5\pi x + 0.4\pi)| = 1$$

$$\Rightarrow x = \frac{N + 0.1}{5}\ m$$

$$\Rightarrow x = 2\ cm, 22\ cm, \ldots$$

(A) is false, as these two points are antinodes.

(B) is false, as the point at 12 cm is a node and stays at rest.

(C) Pressure variation follows the slope of the wave.

$$\frac{\partial y}{\partial x} \propto \cos(5\pi x + 0.4\pi)$$

It is zero at 22 cm, so (C) is false.

$\therefore$ (D) is true.

IAPT tentative answer: (D) | **Zigyan answer:** (D)

18. The density ρ of a solid sphere, of mass M and radius R, varies radially according to $\rho = \rho_0\left(1 - \frac{r}{2R}\right)$, where ρ_0 is a constant. The moment of inertia of this sphere about a diameter is $I = \alpha MR^2$ with α equal to

(A) $\frac{28}{125}$ (B) $\frac{28}{75}$

(C) $\frac{7}{25}$ (D) $\frac{7}{50}$

Solution · Q18 **Answer: (B)**

For a thin shell of radius r and thickness dr,

$$dm = 4\pi\rho_0\left(r^2 - \frac{r^3}{2R}\right)dr$$

$$M = \int_0^R dm$$

$$\Rightarrow M = \frac{5\pi\rho_0 R^3}{6}$$

For the thin shell,

$$dI = \frac{2}{3}r^2 dm$$

$$I = \frac{8\pi\rho_0}{3}\int_0^R \left(r^4 - \frac{r^5}{2R}\right)dr$$

$$\Rightarrow I = \frac{14\pi\rho_0 R^5}{45}$$

$$\alpha = \frac{I}{MR^2}$$

$$\Rightarrow \alpha = \frac{14}{45} \times \frac{6}{5}$$

$$\therefore \alpha = \frac{28}{75}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

19. The magnetic field vector in a plane electromagnetic wave is given by $\vec{B} = 2 \times 10^{-7} \sin(kx + \omega t)\hat{j}$ T. It is given that speed of wave is c = 3.00 × 10^8 ms^{-1} and ω = 1.50 × 10^{11} s^{-1}.

(A) The wavelength of the wave is 2 mm

(B) The frequency of the wave is nearly 2.39 GHz

(C) The electric field of the wave is $\vec{E} = 60\sin(kx - \omega t)\hat{k}$ Vm^{-1}

(D) The electric field of the wave is $\vec{E} = 60\sin(\omega t + kx)\hat{k}$ Vm^{-1}

Solution · Q19 **Answer: (D)**

$$k = \frac{\omega}{c}$$

$$\Rightarrow k = \frac{1.50 \times 10^{11}}{3.00 \times 10^8}$$

$$\Rightarrow k = 500 \text{ m}^{-1}$$

$$\lambda = \frac{2\pi}{k}$$

$$\Rightarrow \lambda \approx 12.6 \text{ mm}$$

So (A) is wrong.

$$f = \frac{\omega}{2\pi}$$

$$\Rightarrow f \approx 23.9 \text{ GHz}$$

So (B) is wrong.

$$E_0 = cB_0$$

$$\Rightarrow E_0 = 3.00 \times 10^8 \times 2 \times 10^{-7}$$

$$\Rightarrow E_0 = 60 \text{ V m}^{-1}$$

The phase of the given field shows travel along the negative x axis. E has the same phase, so (C) is wrong.

In (D), when the sine is positive, the direction of E × B is

$$\hat{k} \times \hat{j} = -\hat{i}$$

This is the direction of travel, so (D) is correct.

IAPT tentative answer: (D) | **Zigyan answer:** (D)

20. An astronomical telescope is used to view an object of size 4 cm kept at a distance of 20 m. The focal lengths of the objective and the eyepiece are 80 cm and 5 cm respectively. The final image is 25 cm from the eyepiece (with the eye close to the eyepiece).

Statement 1: The size of the final image is 1.0 cm

Statement 2: The angular magnification is numerically 20

(A) Both statements 1 and 2 are wrong

(B) Statement 1 is correct but statement 2 is wrong

(C) Statement 1 is wrong but statement 2 is correct

(D) Both statements 1 and 2 are correct

Solution · Q20 **Answer: (D)**

For the objective,

$$u = -2000 \text{ cm}, f = +80 \text{ cm}$$

$$\frac{1}{v} = \frac{1}{80} - \frac{1}{2000}$$

$$\Rightarrow v = \frac{250}{3} \text{ cm}$$

Height of the first image:

$$h_1 = \frac{4}{24}$$

$$\Rightarrow h_1 = \frac{1}{6} \text{ cm}$$

For the eyepiece,

$$v = -25 \text{ cm}, f = +5 \text{ cm}$$

$$\frac{1}{u} = -\frac{1}{25} - \frac{1}{5}$$

$$\Rightarrow u = -\frac{25}{6} \text{ cm}$$

The eyepiece magnifies 6 times. Final image size:

$$h_2 = 6 \times \frac{1}{6}$$

$$\Rightarrow h_2 = 1.0 \text{ cm}$$

So statement 1 is correct.

Neglecting the tube length compared with the object distance,

$$\beta = \frac{1.0}{25}$$

$$\Rightarrow \beta = 0.040 \text{ rad}$$

$$\alpha = \frac{4}{2000}$$

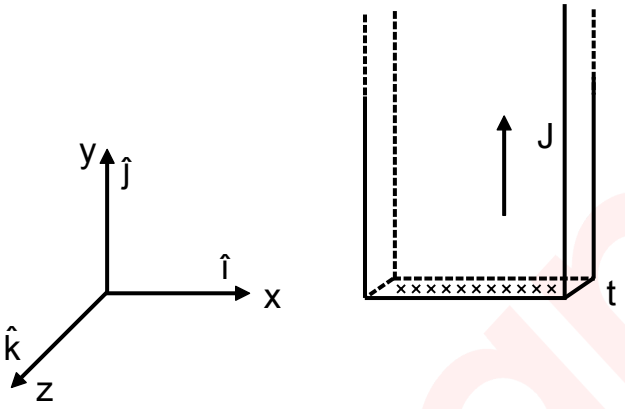
$$\Rightarrow \alpha = 0.002 \text{ rad}$$

$$\therefore \frac{\beta}{\alpha} = 20$$

So statement 2 is also correct.

IAPT tentative answer: (D) | **Zigyan answer:** (D)

21. A thin metal plate of infinite length extending in positive y direction carries a current of current density J all along its length as shown. The very small thickness of the plate is t. The breadth (much larger than thickness) of the plate lies exactly along the x axis. The magnetic field produced at a small distance 'a' above and very close to the surface of the plate is



(A) $-\frac{\mu_0 Jt}{2}\hat{i}$ (B) $+\frac{\mu_0 Jt}{2}\hat{i}$

(C) $+\frac{\mu_0 Jt}{2a}\hat{k}$ (D) $+\frac{\mu_0 Jt}{a}\hat{i}$

Solution · Q21 **Answer: (B)**

Very close to the wide plate and away from its edges, it acts as an infinite current sheet. Its current per unit width is Jt, and its field is along the x axis, opposite on the two faces.

By Ampère's law, for a rectangular loop of side w in the xz plane,

$$2Bw = \mu_0 Jwt$$

$$\Rightarrow B = \frac{\mu_0 Jt}{2}$$

The face towards positive z is taken as the upper surface. By the right-hand rule, the direction is

$$\hat{j} \times \hat{k} = \hat{i}$$

$$\therefore \vec{B} = +\frac{\mu_0 Jt}{2}\hat{i}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

22. A uniform rod of mass M and length L is hinged freely on a horizontal peg at a variable distance ξ from one of its ends, so as to execute SHM with small angular amplitude in a vertical plane about the horizontal axis with time period T. If the minimum value of its time period T_{min} = 1.0 second, the approximate value of L is

(A) 24.8 cm (B) 43.0 cm (C) 56.8 cm (D) 99.2 cm

Solution · Q22 **Answer: (B)**

Let the hinge be at distance d from the centre of the rod.

$$I = \frac{ML^2}{12} + Md^2$$

$$T = 2\pi\sqrt{\frac{I}{Mgd}}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{1}{g}\left(d + \frac{L^2}{12d}\right)}$$

For minimum T,

$$d = \frac{L}{\sqrt{12}}$$

$$\Rightarrow T_{min} = 2\pi\sqrt{\frac{L}{\sqrt{3}\ g}}$$

$$\Rightarrow L = \frac{\sqrt{3}\ g T_{min}^2}{4\pi^2}$$

$g = 9.8\ m\ s^{-2}$ and $T_{min} = 1.0\ s$

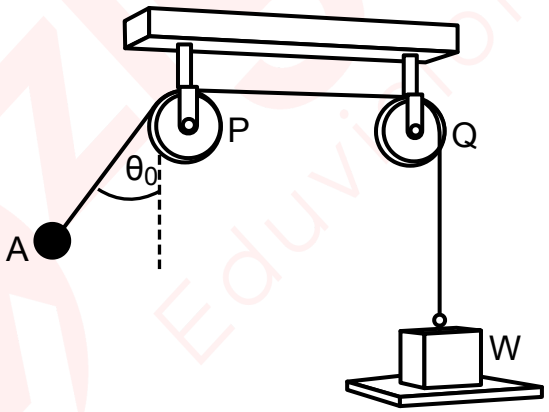
$$\Rightarrow L = \frac{1.732 \times 9.8}{39.48}$$

$$\Rightarrow L \approx 0.430\ m$$

$$\therefore L \approx 43.0\ cm$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

23. P and Q are two smooth weightless pulleys attached to the ceiling as shown. An un-stretchable, light string passes over both the pulleys. A weight W = 40 kg, resting on the floor, is tied to one end of the string. A ball of mass 20 kg is attached, at the other end A. The string PA is deflected by angle θ_0 when the ball A is released from rest. The ball at the end A is capable of just lifting up the weight W for the value of θ_0



(A) = 30° (B) = 45° (C) ≤ 53° (D) ≥ 60°

Solution · Q23 **Answer: (D)**

W just leaves the floor when the largest string tension equals its weight. The tension is largest at the lowest point of the swing. By energy conservation, with string length PA taken as ℓ,

$$v^2 = 2g\ell\ (1 - \cos\theta_0)$$

$$T_{max} = mg + \frac{mv^2}{\ell}$$

$$\Rightarrow T_{max} = mg\ (3 - 2\cos\theta_0)$$

To lift W,

$$20g\ (3 - 2\cos\theta_0) \geq 40g$$

$$\Rightarrow \cos\theta_0 \le 0.5$$

$$\therefore \theta_0 \ge 60°$$

(for release angles up to 90°)

IAPT tentative answer: (D) | **Zigyan answer:** (D)

24. The position vector $\vec{r}$ of a particle of mass m moving in XY plane is given as a function of time by $\vec{r} = R(\omega t - \sin\omega t)\hat{i} + R(1 - \cos\omega t)\hat{j}$ where R and ω are positive constants. The particle is momentarily at rest when

(A) $t = \frac{n\pi}{\omega}$ where n = 1, 3, 5.....

(B) y component of $\vec{r}$ is $= 2R\hat{j}$

(C) the acceleration $\vec{a} = \omega^2 R\hat{j}$

(D) the acceleration $\vec{a} = -\omega^2 R\hat{j}$

Solution · Q24 **Answer: (C)**

$$\vec{v} = R\omega(1 - \cos\omega t)\hat{i} + R\omega\sin\omega t\hat{j}$$

At rest, both components vanish.

$$\cos\omega t = 1 \text{ and } \sin\omega t = 0$$

$$\Rightarrow \omega t = 2n\pi$$

So (A) is false. At these instants,

$$y = R(1 - \cos\omega t)$$

$$\Rightarrow y = 0$$

So (B) is false.

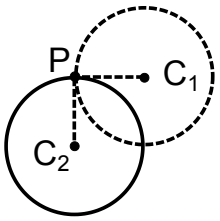
$$\vec{a} = R\omega^2\sin\omega t\hat{i} + R\omega^2\cos\omega t\hat{j}$$

$$\therefore \vec{a} = \omega^2 R\hat{j}$$

So (C) is true and (D) is false.

IAPT tentative answer: (C) | **Zigyan answer:** (C)

25. A thin circular disk of mass m and radius R can rotate freely in a vertical plane about a pivot P on its rim (as in the figure). It is released when its centre is at C_1 at the level of the pivot in a vertical plane. The speed of the lowest point of the disk when the centre is vertically below the pivot P at C_2 is



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

(B) $\sqrt{4gR}$

(C) $\sqrt{2gR}$

(D) $\sqrt{\frac{16gR}{3}}$

Solution · Q25 **Answer: (D)**

Moment of inertia of the disk about the axis through P:

$$I_P = \frac{mR^2}{2} + mR^2$$

$$\Rightarrow I_P = \frac{3mR^2}{2}$$

The centre of mass comes down by R. By energy conservation,

$$mgR = \frac{1}{2} I_P \omega^2$$

$$\Rightarrow \omega^2 = \frac{4g}{3R}$$

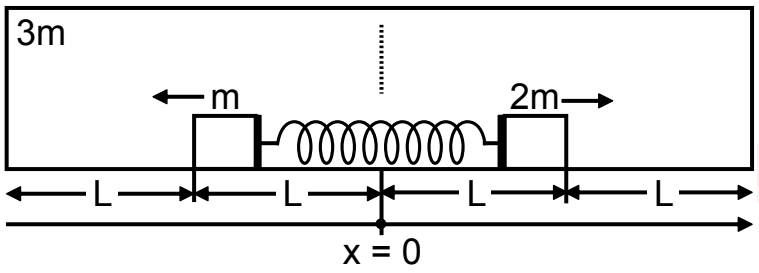
The lowest point is at a distance 2R from P.

$$v = 2R\omega$$

$$\Rightarrow v = \sqrt{\frac{16gR}{3}}$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

26. Two rectangular blocks of masses m and 2m are held against a massless compressed spring within a box of mass 3m and length 4L. The box as well as the two blocks are free to move on a horizontal frictionless surface along the x-axis. Just when the blocks leave contact with the spring, each block is at a distance L from the wall of the box in front of it and the centre of the box is at origin x = 0 (see figure). When released, each block moves its own way, collides with the front wall and immediately sticks to it. The position of the centre of the box in the process shifts to



(A) $x = -\frac{L}{2}$

(B) $x = +\frac{L}{3}$

(C) $x = +\frac{L}{6}$

(D) $x = -\frac{L}{6}$

Solution · Q26 **Answer: (D)**

There is no external horizontal force and the initial momentum is zero, so the centre of mass of the system does not move.

Let the box shift by X, taking rightward as positive. Relative to the ground, m moves X − L and 2m moves X + L.

$$3mX + m(X - L) + 2m(X + L) = 0$$

$$\Rightarrow 6mX + mL = 0$$

$$\therefore X = -\frac{L}{6}$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

27. A charge q is uniformly distributed over the surface of a thin circular disk of radius R. The disk rotates about its own axis with an angular velocity ω rad/s, maintaining its axis normal to a uniform magnetic field B. The magnitude of the torque acting on the charged disk is

(A) Zero

(B) $\frac{q\omega R^4 B}{4}$

(C) $\frac{q\omega R^2 B}{4}$

(D) $\frac{q\omega R^2 B}{2}$

Solution · Q27 **Answer: (C)**

For a ring of radius r and width dr,

$$\sigma = \frac{q}{\pi R^2}$$

$$dq = \sigma\, 2\pi r\, dr$$

$$dI = \frac{\omega}{2\pi} dq$$

$$\Rightarrow dI = \sigma\omega r\, dr$$

$$dM = \pi r^2\, dI$$

$$M = \pi\sigma\omega \int_0^R r^3\, dr$$

$$\Rightarrow M = \frac{\pi\sigma\omega R^4}{4}$$

$$\Rightarrow M = \frac{q\omega R^2}{4}$$

The axis of the disk, and so M, is perpendicular to B.

$$\tau = MB \sin 90°$$

$$\therefore \tau = \frac{q\omega R^2 B}{4}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

28. $_1H^3$ and $_2He^3$ have almost same atomic mass. $_1H^3$ contains one proton, one electron and 2 neutrons while $_2He^3$ has two protons, two electrons and one neutron. Knowing that the mass of a neutron is slightly greater than that of the proton, the estimation of the nuclear binding energy in the two cases reveals that

(A) the binding energy of the nucleus of $_1H^3$ is equal to that of $_2He^3$ nucleus

(B) the binding energy of the nucleus of $_1H^3$ is less than that of $_2He^3$ nucleus

(C) the binding energy of the nucleus of $_1H^3$ is greater than that of $_2He^3$ nucleus

(D) the data is insufficient to predict any information about the binding energy

Solution · Q28 **Answer: (C)**

Using atomic masses and neglecting electronic binding energies,

$$B = (Zm_H + Nm_n - M)\, c^2$$

For $_1H^3$ and then $_2He^3$,

$$B_1 = (m_H + 2m_n - M_1)\, c^2$$

$$B_2 = (2m_H + m_n - M_2)\, c^2$$

The two atomic masses are almost equal.

$$\Rightarrow B_1 - B_2 = (m_n - m_H)\, c^2$$

The rest energies of a neutron and of a proton with an electron are

$$m_n c^2 = 939.57 \text{ MeV}$$

$$m_H c^2 = 938.27 + 0.51$$

$$\Rightarrow m_H c^2 = 938.78 \text{ MeV}$$

$$\Rightarrow B_1 - B_2 \approx 0.8 \text{ MeV}$$

So the $_1H^3$ nucleus has the greater binding energy.

IAPT tentative answer: (C) | **Zigyan answer:** (C)

29. A spherical bob of mass 0.20 kg and diameter 2.0 cm, having uniform density, is attached to the end of a string of length 100 cm. This pendulum so formed is suspended from the ceiling of an elevator. The elevator is moving upward with an acceleration of 5.4 ms^{-2} along an incline which makes an angle of 60 degree with vertical. The pendulum is made to oscillate about its mean position. Assuming that there is no aerial friction, the time period of oscillation of the pendulum is (given that acceleration due to gravity is 9.8 ms^{-2})

(A) 1.28 s (B) 1.26 s (C) 1.59 s (D) 1.79 s

Solution · Q29 **As per Zigyan: no option is correct**

Components of the lift's acceleration, vertical and horizontal:

$$5.4 \cos 60° = 2.70 \text{ m s}^{-2}$$

$$5.4 \sin 60° = 4.68 \text{ m s}^{-2}$$

In the lift frame,

$$g_{eff} = \sqrt{(9.8 + 2.70)^2 + (4.68)^2}$$

$$\Rightarrow g_{eff} \approx 13.35 \text{ m s}^{-2}$$

Length up to the centre of the bob:

$$d = 100 \text{ cm} + 1.0 \text{ cm}$$

$$\Rightarrow d = 1.01 \text{ m}$$

For the bob as a compound pendulum, with r its radius,

$$T = 2\pi\sqrt{\frac{d^2 + \frac{2}{5}r^2}{g_{eff} d}}$$

The r^2 term is negligible.

$$T \approx 2\pi\sqrt{\frac{1.01}{13.35}}$$

$$\Rightarrow T \approx 1.73 \text{ s}$$

No option matches this period.

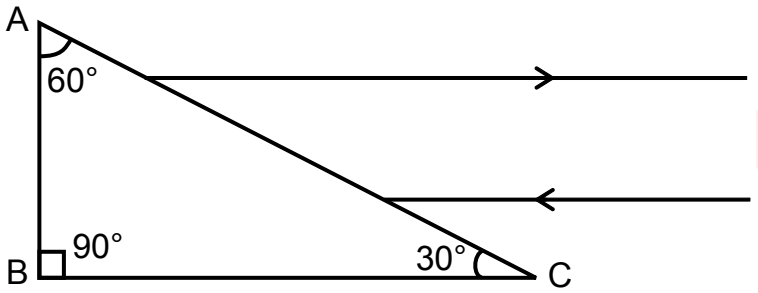
Why Zigyan differs from IAPT: the period works out to about 1.73 s. Option (D), 1.79 s, is not this value, so none of the options matches.

Check: at rest in the lift, the string makes about 20.5° with the vertical, since the tangent of this angle is 4.68 divided by 12.5. Balancing forces along the string gives g_{eff} as 12.5 divided by cos 20.5°, again about 13.35 m s^{-2}.

IAPT tentative answer: (D) | **Zigyan answer:** none of the options is correct

30. When light is incident on an interface between two media at an angle greater than $\theta_c \equiv \sin^{-1}\frac{1}{\mu}$ (where μ is the relative refractive index of the two media), it is totally reflected - a phenomenon known as total internal reflection. If the angle of incidence is smaller than θ_c light is partly reflected and partly refracted.

A ray of light incident, parallel to the base, on a 30° – 90° – 60° prism, as shown, suffers two total internal reflections before emerging parallel but reversed in direction.



The condition on the critical angle for this to be possible is:

(A) $\tan\theta_c < \frac{\sqrt{3}}{1+\sqrt{3}}$

(B) $\tan\theta_c > \frac{\sqrt{3}}{1+\sqrt{3}}$

(C) $\sin\theta_c = \frac{\sqrt{3}}{1+\sqrt{3}}$

(D) $\sin\theta_c > \frac{\sqrt{3}}{1+\sqrt{3}}$

Solution · Q30 **Answer: (A)**

The angle of incidence on face AC is 60°. By Snell's law,

$$\sin 60° = \mu \sin r$$

$$\mu = \frac{1}{\sin\theta_c}$$

$$\Rightarrow \sin r = \frac{\sqrt{3}}{2}\sin\theta_c$$

The angles of incidence on faces AB and BC are, in turn,

60° – r and 30° + r

On BC, the following always holds for an acute critical angle:

$$30° + r > \theta_c$$

On AB, total reflection needs

$$60° - r > \theta_c$$

$$\Rightarrow r < 60° - \theta_c$$

$$\Rightarrow \frac{\sqrt{3}}{2}\sin\theta_c < \frac{\sqrt{3}}{2}\cos\theta_c - \frac{1}{2}\sin\theta_c$$

$$\therefore \tan\theta_c < \frac{\sqrt{3}}{1+\sqrt{3}}$$

The ray then meets AC at angle r, below the critical angle, and emerges antiparallel.

IAPT tentative answer: (A) | **Zigyan answer:** (A)

31. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} Nm/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1 mA. The value of the magnetic field B (in Tesla) is approximately

(A) 10^{-2} (B) 10^{-3} (C) 10^{-1} (D) 10^{-4}

Solution · Q31 **Answer: (B)**

B is parallel to the plane of the coil and the deflection is only 1°. For equilibrium,

$$NIAB = k\theta$$

$$\theta = \frac{\pi}{180}$$

$$\Rightarrow \theta \approx 1.745 \times 10^{-2} \text{ rad}$$

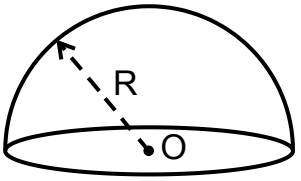
$$B = \frac{k\theta}{NIA}$$

$$\Rightarrow B = \frac{10^{-6} \times 1.745 \times 10^{-2}}{175 \times 10^{-3} \times 10^{-4}}$$

$$\therefore B \approx 10^{-3} \text{ T}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

32. Charge Q coulomb is uniformly distributed throughout the volume of a solid hemisphere of radius R meter. The potential at the centre 'O' of the hemisphere in volts is



(A) $\frac{1}{4\pi\epsilon_0}\frac{3Q}{2R}$ (B) $\frac{1}{4\pi\epsilon_0}\frac{3Q}{4R}$

(C) $\frac{1}{4\pi\epsilon_0}\frac{Q}{4R}$ (D) $\frac{1}{4\pi\epsilon_0}\frac{Q}{8R}$

Solution · Q32 **Answer: (A)**

Complete the sphere with an identical hemisphere; the total charge becomes 2Q.

For a uniformly charged solid sphere of charge q, the potential at its centre is

$$V = \frac{3}{2}\frac{1}{4\pi\varepsilon_0}\frac{q}{R}$$

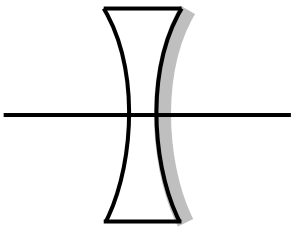
Both halves give equal potentials at O.

$$V_O = \frac{1}{2}\left(\frac{3}{2}\frac{1}{4\pi\varepsilon_0}\frac{2Q}{R}\right)$$

$$\therefore V_O = \frac{1}{4\pi\varepsilon_0}\frac{3Q}{2R}$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

33. The rear surface of an equi-concave lens of radius of curvature R and refractive index μ has been silvered; the lens behaves as a mirror. The focal length and the nature of the resulting mirror are



(A) $\frac{R}{2(2\mu-3)}$ converging

(B) $\frac{R}{2(2\mu-1)}$ converging

(C) $\frac{R}{2(2\mu+1)}$ diverging

(D) $\frac{R}{2(2\mu-1)}$ diverging

Solution · Q33 **Answer: (D)**

Taking converging power as positive, the power of the equivalent mirror is

$$P = 2P_L + P_M$$

For the lens,

$$R_1 = -R,\ R_2 = +R$$

$$P_L = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow P_L = -\frac{2(\mu-1)}{R}$$

The silvered rear face is a convex mirror.

$$P_M = -\frac{2}{R}$$

$$P = -\frac{4(\mu-1)}{R} - \frac{2}{R}$$

$$\Rightarrow P = -\frac{2(2\mu-1)}{R}$$

As P is negative, the mirror is diverging (convex).

$$\therefore |f| = \frac{R}{2(2\mu-1)}$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

34. In Millikan's oil drop experiment, a charged drop falls vertically down with a terminal velocity v. If an electric field E is applied vertically upward, it moves with terminal velocity 2v in the upward direction. If the electric field reduces to $\frac{E}{2}$ then the terminal velocity of the drop becomes

(A) v

(B) 2v

(C) $\frac{3}{2}v$

(D) $\frac{v}{2}$

Solution · Q34 **Answer: (D)**

Let W be the weight of the drop minus the buoyant force, and kv the viscous drag.

Without the field,

$$W = kv$$

With field E, the drop rises with speed 2v.

$$qE = W + k\,(2v)$$

$$\Rightarrow qE = 3kv$$

With the field reduced to half, let u be the upward speed.

$$\frac{qE}{2} = \frac{3kv}{2}$$

$$\Rightarrow \frac{3kv}{2} = kv + ku$$

$$\therefore u = \frac{v}{2}$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

35. Seven equal positive charges of magnitude q each are placed at the seven corners of a cube of side ℓ. The force experienced by a charge Q placed at the centre of the cube is $\left(\text{given } K = \frac{1}{4\pi\epsilon_0}\right)$

(A) Zero

(B) $\frac{2KQq}{3\ell^2}$

(C) $\frac{4KQq}{3\ell^2}$

(D) $\frac{7KQq}{3\ell^2}$

Solution · Q35 **Answer: (C)**

With an eighth charge q at the empty corner, the net force on Q is zero by symmetry.

So the force due to the seven charges equals that of the single charge diagonally opposite the empty corner. Its distance from the centre is

$$d = \frac{\sqrt{3}\,\ell}{2}$$

By Coulomb's law,

$$F = \frac{KQq}{d^2}$$

$$\Rightarrow F = \frac{4KQq}{3\ell^2}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

36. The magnetic moment (p_m) and the moment of inertia (I) of a magnetic needle are $p_m = 8.7 \times 10^{-2}$ A.m^2 and I = 11.5×10^{-6} kg.m^2 respectively. The magnetic needle performs 10 complete oscillations in 6.70 s when suspended in a uniform horizontal magnetic field **B**. The magnitude of the magnetic field is

(A) 2.10 mT (B) 11.6 mT (C) 11.6 T (D) 1.5 T

Solution · Q36 **Answer: (B)**

For small oscillations,

$$T = 2\pi\sqrt{\frac{I}{p_m B}}$$

$$T = \frac{6.70}{10}$$

$$\Rightarrow T = 0.670\ \text{s}$$

$$B = \frac{4\pi^2 I}{p_m T^2}$$

$$\Rightarrow B = \frac{4\pi^2 \times 11.5 \times 10^{-6}}{8.7 \times 10^{-2} \times (0.670)^2}$$

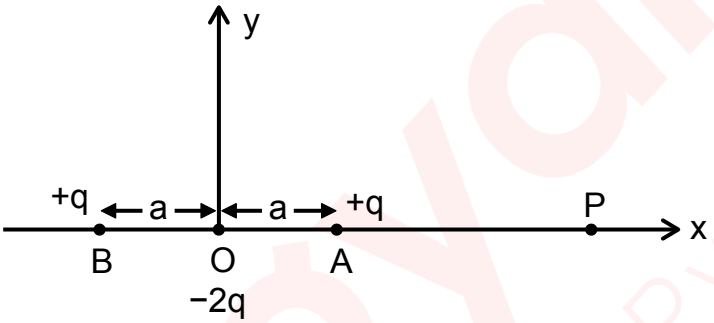
$$\Rightarrow B = 1.16 \times 10^{-2}\ T$$

$$\therefore B = 11.6\ mT$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

37. The figure shows an arrangement of charges [– 2q at O (0, 0), +q at A (a, 0) and +q at B (–a, 0)]. The electric field E at point P (r, 0) can be expressed as (for r >> a) $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{\alpha Q}{r^n}\hat{r}$ (where Q = qa^2)

Choose the correct option



(A) α = 3, n = 3 (B) α = 3, n = 4 (C) α = 6, n = 3 (D) α = 6, n = 4

Solution · Q37 **Answer: (D)**

All the fields at P lie along the x axis. Taking the direction from O to P as positive,

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$E = kq\left[\frac{1}{(r-a)^2} + \frac{1}{(r+a)^2} - \frac{2}{r^2}\right]$$

As r is much larger than a, expanding up to second order,

$$\frac{1}{(r-a)^2} + \frac{1}{(r+a)^2} \approx \frac{1}{r^2}\left(2 + \frac{6a^2}{r^2}\right)$$

$$\Rightarrow E \approx \frac{6kqa^2}{r^4}$$

$$\Rightarrow E \approx \frac{1}{4\pi\varepsilon_0}\frac{6Q}{r^4}$$

$$\therefore \alpha = 6, n = 4$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

38. Work function of metal A is equal to the ionisation energy of the hydrogen atom in the first excited state. Work function of metal B is equal to the ionisation energy of singly-ionised helium atom in the second orbit. Photons of the same energy E are incident on the two metals A and B. Maximum kinetic energy of photoelectrons emitted from metal A is twice that of the photoelectrons emitted from metal B. The value of the photon energy E is

(A) 20.8 eV (B) 32.2 eV (C) 24.6 eV (D) 23.8 eV

Solution · Q38 **Answer: (D)**

Ionisation energy from the n-th orbit of a one-electron atom:

$$E_n = \frac{13.6Z^2}{n^2}\ eV$$

For hydrogen in the first excited state,

$$\varphi_A = \frac{13.6}{2^2}$$

$$\Rightarrow \Phi_A = 3.4\ eV$$

For He^+ in the second orbit,

$$\varphi_B = \frac{13.6 \times 2^2}{2^2}$$

$$\Rightarrow \Phi_B = 13.6\ eV$$

Maximum kinetic energy from A is twice that from B.

$$E - 3.4 = 2\,(E - 13.6)$$

$$\therefore E = 23.8\ eV$$

IAPT tentative answer: (D) | **Zigyan answer:** (D)

39. During an excavation in the ancient volcanic caves, an archaeologist discovered a sample of a rare mineral trapped inside a sealed rock chamber. Laboratory analysis of the sample showed that the mineral originally contained a radioactive isotope X, which decays into a stable element Y. The radioactive isotope has a half-life T = 10^4 year. Due to contamination from underground water, 20 % of the stable element got washed away before the sample was analysed. At the time of the analysis, the ratio of remaining (undecayed) radioactive isotope X to stable element Y in the sample is found to be 1: 5.6. Assuming that no radioactive material X was lost from the sample, the archaeologist claimed that the actual age of the rock is

(A) 1×10^4 year (B) $\sqrt{3} \times 10^4$ year

(C) 3×10^4 year (D) $2\sqrt{3} \times 10^4$ year

Solution · Q39 **Answer: (C)**

Take N_0 nuclei of X and no Y at the start, with N nuclei of X left now. Only 80% of the Y produced remains.

$$0.8\,(N_0 - N) = 5.6\,N$$

$$\Rightarrow N_0 = 8N$$

$$\frac{N}{N_0} = \frac{1}{8}$$

$$\Rightarrow \frac{N}{N_0} = \left(\frac{1}{2}\right)^3$$

$$\Rightarrow \frac{t}{T} = 3$$

$$\Rightarrow t = 3T$$

So the age of the rock is 3×10^4 year.

IAPT tentative answer: (C) | **Zigyan answer:** (C)

40. Two identical particles of mass m each are moving in circular orbits under a central potential given by $V(r) = \frac{K}{r^n}$, where K is a constant. If the radii of their orbits are r_1 and r_2 while the time periods are T_1 and T_2 respectively, the correct mathematical relation is

(A) $T_1^2 r_1^{-(n+2)} = T_2^2 r_2^{-(n+2)}$

(B) $T_1^2 r_1^{-3} = T_2^2 r_2^{-3}$

(C) $T_1^2 r_1^{-(2n-1)} = T_2^2 r_2^{-(2n-1)}$

(D) $T_1^2 r_1^{-(n+1)} = T_2^2 r_2^{-(n+1)}$

Solution · Q40 **Answer: (A)**

Taking V(r) as the potential energy, the force is

$$F = -\frac{dV}{dr}$$

$$\Rightarrow F = \frac{nK}{r^{n+1}}$$

For a circular orbit this force acts towards the centre.

$$\frac{mv^2}{r} = \frac{|nK|}{r^{n+1}}$$

$$\Rightarrow v \propto r^{-n/2}$$

$$T = \frac{2\pi r}{v}$$

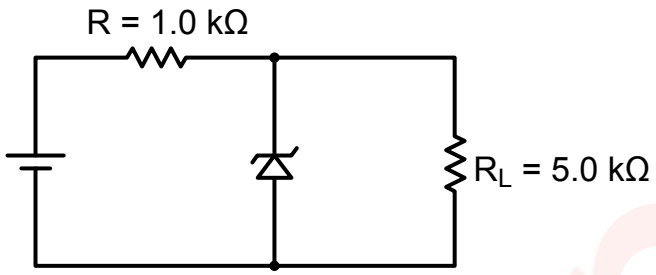
$$\Rightarrow T \propto r^{(n+2)/2}$$

$$\Rightarrow T^2 \propto r^{n+2}$$

$$\therefore T_1^2 r_1^{-(n+2)} = T_2^2 r_2^{-(n+2)}$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

41. The figure represents a voltage regulator circuit using a zener diode. The breakdown voltage of the zener diode is 5.5 V and the load resistance is 5 kilo ohm. The series resistance R is 1 kilo ohm. If the battery voltage varies from 8 V to 14 V then what is the minimum and maximum value of current through the zener diode?



(A) 2.5 mA, 8.5 mA (B) 1.4 mA, 7.4 mA (C) 1.1 mA, 1.1 mA (D) 0.5 mA, 1.5 mA

Solution · Q41 **Answer: (B)**

Without the zener, the load voltage at the lowest input would be

$$8 \times \frac{5}{1+5} \approx 6.7\ \text{V}$$

This exceeds the breakdown voltage, so the zener keeps the load at 5.5 V over the whole range.

$$I_L = \frac{5.5}{5}$$

$$\Rightarrow I_L = 1.1\ \text{mA}$$

Series current:

$$I = \frac{V - 5.5}{1.0}\ \text{mA}$$

At 8 V and 14 V,

$$I = 2.5\ \text{mA and } 8.5\ \text{mA}$$

$$I_Z = I - I_L$$

Minimum zener current:

$$2.5 - 1.1 = 1.4\ \text{mA}$$

Maximum zener current:

$$8.5 - 1.1 = 7.4\ \text{mA}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

42. Two coherent electromagnetic plane waves, of exactly equal amplitude, propagating with a very small angle of divergence ψ, fall almost normally on a distant screen to produce interference fringes with a separation (fringe width) $\bar{x} = 1.0\ \text{mm}$ between neighbouring maxima. The wavelength of light is λ = 6000 Å. The angle of divergence ψ

(A) is estimated to be ψ = 6.0 milliradians (B) is estimated to be ψ = 0.6 milliradians
(C) is estimated to be ψ = 1.2 milliradians (D) cannot be estimated from this data

Solution · Q42 **Answer: (B)**

For two plane waves at a small angle ψ, the fringe width is

$$\bar{x} = \frac{\lambda}{2\sin\left(\frac{\psi}{2}\right)}$$

$$\Rightarrow \bar{x} \approx \frac{\lambda}{\psi}$$

$$\Rightarrow \psi = \frac{\lambda}{\bar{x}}$$

$$\Rightarrow \psi = \frac{6.0 \times 10^{-7}}{1.0 \times 10^{-3}}$$

$$\Rightarrow \psi = 6.0 \times 10^{-4} \text{ rad}$$

$$\therefore \psi = 0.6 \text{ milliradians}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

43. In a line-of-sight radio communication, there is a distance of about 50 km between transmitting and receiving antennas. If the height of the receiving antenna is 70 m, then the minimum height of the transmitting antenna should be (Radius of the Earth = 6400 km)

(A) 20 m (B) 51 m (C) 32 m (D) 40 m

Solution · Q43 **Answer: (C)**

Distance up to the horizon from height h:

$$d = \sqrt{2Rh}$$

For the receiving antenna,

$$d_R = \sqrt{2 \times 6.4 \times 10^6 \times 70}$$

$$\Rightarrow d_R \approx 2.99 \times 10^4 \text{ m}$$

$$d_T = 50 - 29.93$$

$$\Rightarrow d_T = 20.07 \text{ km}$$

$$h_T = \frac{d_T^2}{2R}$$

$$\Rightarrow h_T = \frac{\left(2.007 \times 10^4\right)^2}{1.28 \times 10^7}$$

$$\Rightarrow h_T \approx 31.5 \text{ m}$$

So the minimum height among the options is 32 m.

IAPT tentative answer: (C) | **Zigyan answer:** (C)

44. In an arrangement, three polarisers P, Q and S have been set up in sequence such that transmission axis of S is crossed with respect to that of P. The transmission axis of Q is inclined at 60° to the transmission axis of S. When a beam of unpolarised light of intensity I_0 is incident on P, the intensity of light transmitted by the three polarisers in succession is I. The ratio $I : I_0$ is equal to

(A) 1 : 16 (B) 3 : 16 (C) 3 : 32 (D) 10 : 18

Solution · Q44 **Answer: (C)**

Polariser S is crossed with P and Q is at 60° to S, so the axis of Q is at 30° to that of P.

Intensity after P:

$$\frac{I_0}{2}$$

After Q:

$$I_1 = \frac{I_0}{2}\cos^2 30°$$

$$\Rightarrow I_1 = \frac{3I_0}{8}$$

After S:

$$I = I_1 \cos^2 60°$$

$$\Rightarrow I = \frac{3I_0}{32}$$

$$\therefore I : I_0 = 3 : 32$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

45. A solid sphere of mass m and radius R rolls without slipping on a horizontal surface. It collides with a light spring of stiffness constant K with kinetic energy E. If the surface under the spring is smooth (frictionless), then the maximum compression of the spring is

(A) $\sqrt{\frac{2E}{K}}$ (B) $\sqrt{\frac{10E}{7K}}$

(C) $\sqrt{\frac{E}{K}}$ (D) $\sqrt{\frac{7E}{10K}}$

Solution · Q45 **Answer: (B)**

For rolling without slipping,

$$v = \omega R$$

$$E = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mR^2\right)\omega^2$$

$$\Rightarrow E = \frac{7}{10}mv^2$$

On the smooth surface there is no torque about the centre, so the spin does not change. Only the translational energy goes into the spring.

$$\frac{1}{2}Kx^2 = \frac{1}{2}mv^2$$

$$\Rightarrow \frac{1}{2}Kx^2 = \frac{5}{7}E$$

$$\therefore x = \sqrt{\frac{10E}{7K}}$$

IAPT tentative answer: (B) | **Zigyan answer:** (B)

46. When a mass of 9.0 kg is suspended vertically from the free end of the wire of a sonometer, it resonates with a given tuning fork forming standing waves with five antinodes between the two bridges. When the 9.0 kg mass is replaced by another unknown mass M, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The mass M is

(A) 5.4 kg (B) 15 kg (C) 25 kg (D) 35 kg

Solution · Q46 **Answer: (C)**

For p loops between the bridges and tension F,

$$f = \frac{p}{2L}\sqrt{\frac{F}{\mu}}$$

The fork, length and wire are the same.

$$5\sqrt{9.0g} = 3\sqrt{Mg}$$

$$\Rightarrow 25 \times 9.0 = 9M$$

$$\therefore M = 25 \text{ kg}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

47. A thin rectangular metal plate of surface area 0.1 m^2 is placed on a large horizontal table. There are a few drops of a liquid between the metal plate and the table forming a thin liquid layer of 0.3 mm thickness. The plate is pulled horizontally with the help of a string passing over a massless and frictionless fixed pulley. When a mass of 10 g is attached to the vertically hanging free end of the string, the plate is observed to move gently towards the pulley with a constant speed of 8.5 cms^{-1}. The coefficient of viscosity of the liquid is approximately

(A) 3.5 Pascal-s (B) 0.035 Pascal-s (C) 0.0035 Pascal-s (D) 0.0025 Pascal-s

Solution · Q47 **Answer: (C)**

At constant speed, the viscous force equals the tension, which is the weight of the hanging mass.

$$F = 0.010 \times 9.8$$

$$\Rightarrow F = 0.098 \text{ N}$$

By Newton's law of viscosity,

$$F = \eta A\frac{v}{d}$$

$$\Rightarrow \eta = \frac{Fd}{Av}$$

$$\Rightarrow \eta = \frac{0.098 \times 3 \times 10^{-4}}{0.1 \times 0.085}$$

$$\Rightarrow \eta \approx 3.46 \times 10^{-3} \text{ Pa s}$$

$$\therefore \eta \approx 0.0035 \text{ Pa s}$$

IAPT tentative answer: (C) | **Zigyan answer:** (C)

48. In an experiment for determination of the focal length of a thin convex lens, the object distance is measured as 15 cm with 1% error and the image distance is measured as 30 cm with 2% error. From the given data, the focal length of the lens is estimated with n% error. The value of n is

(A) 1.33 (B) 3 (C) 0 (D) 2

Solution · Q48 **Answer: (A)**

For a real image, using magnitudes of u and v,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{15} + \frac{1}{30}$$

$$\Rightarrow f = 10 \text{ cm}$$

For the maximum error,

$$\frac{\Delta f}{f^2} = \frac{\Delta u}{u^2} + \frac{\Delta v}{v^2}$$

$$\Rightarrow \frac{\Delta f}{f} = \frac{f}{u} \times \frac{\Delta u}{u} + \frac{f}{v} \times \frac{\Delta v}{v}$$

$$n = \frac{10}{15} \times 1 + \frac{10}{30} \times 2$$

$$\Rightarrow n = \frac{4}{3}$$

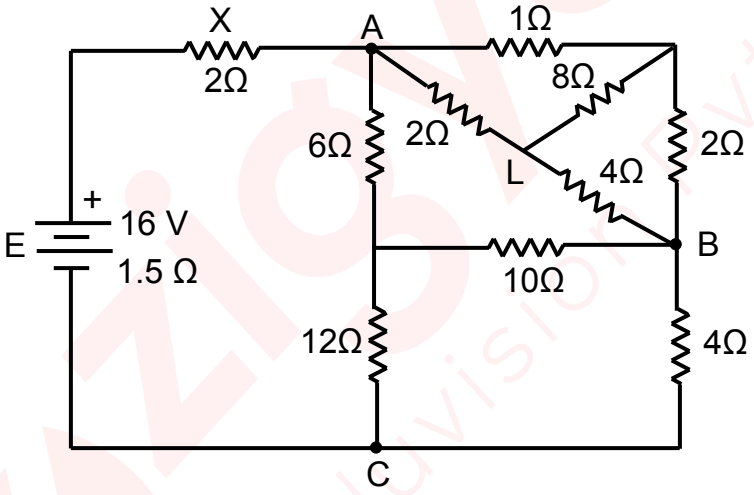
$$\therefore n \approx 1.33$$

IAPT tentative answer: (A) | **Zigyan answer:** (A)

PART A-2 · ONE OR MORE CORRECT OPTIONS

Q. 49 – 60 · 6 marks only if all correct options are marked · no negative marking

49. In the given circuit, the emf E of the battery is 16 V and its internal resistance is r = 1.5 Ω. The correct option(s) is/are



(A) The potential difference across terminals of battery is 3 V

(B) The power dissipated in the resistance X (= 2 Ω) is 8 W

(C) The power dissipated in 12 Ω resistance is 3 W

(D) The potential difference across junctions A and B is 3 V

Solution · Q49 **Answer: (B), (C), (D)**

Both bridges are balanced, so the 8 Ω and 10 Ω resistors carry no current.

$$R_{AB} = \frac{3 \times 6}{3 + 6}$$

$$\Rightarrow R_{AB} = 2\ \Omega$$

$$R_{AC} = \frac{18 \times 6}{18 + 6}$$

$$\Rightarrow R_{AC} = 4.5\ \Omega$$

$$I = \frac{16}{1.5 + 2 + 4.5}$$

$$\Rightarrow I = 2\ A$$

(A) Terminal potential difference:

$$V = 16 - 2 \times 1.5$$

$$\Rightarrow V = 13 \text{ V}$$

So (A) is false.

For (B),

$$P_X = 2^2 \times 2$$

$$\Rightarrow P_X = 8 \text{ W}$$

(C) Current through 12 Ω:

$$I_{12} = \frac{2 \times 4.5}{18}$$

$$\Rightarrow I_{12} = 0.5 \text{ A}$$

$$P = (0.5)^2 \times 12$$

$$\Rightarrow P = 3 \text{ W}$$

For (D),

$$V_{AB} = (2 - 0.5) \times 2$$

$$\Rightarrow V_{AB} = 3 \text{ V}$$

So (B), (C) and (D) are true.

IAPT tentative answer: (B), (C), (D) | **Zigyan answer:** (B), (C), (D)

50. A train, moving in a straight line with an initial speed u ms^{-1} at t = 0, is given a constant acceleration 'a' ms^{-2} to attain a maximum speed $V_m = \frac{7}{3}u$. The driver runs the train at that maximum speed for some duration and then decelerates at a rate of 'a' ms^{-2} to attain the same initial speed u ms^{-1} at t = T. The average speed of the train for the entire journey (from time t = 0 to t = T) is 2u. Choose the correct statement(s)

(A) The train runs at the maximum speed for a duration of $T\sqrt{1 - \frac{4u}{aT}}$

(B) The train runs at the maximum speed for a duration of $T\sqrt{1 - \frac{2u}{aT}}$

(C) The train runs at the maximum speed for a duration of $\frac{T}{2}$

(D) The acceleration $a = \frac{16u}{3T}$

Solution · Q50 **Answer: (A), (C), (D)**

Let each speed change take time t_1, and let τ be the time at maximum speed.

$$T = 2t_1 + \tau$$

The distance covered is

$$2uT = (u + V_m)\, t_1 + V_m \tau$$

$$\Rightarrow 2uT = \frac{10u}{3} t_1 + \frac{7u}{3}(T - 2t_1)$$

$$\Rightarrow t_1 = \frac{T}{4}$$

$$\therefore \tau = \frac{T}{2}$$

So (C) is true.

$$at_1 = V_m - u$$

$$\Rightarrow at_1 = \frac{4u}{3}$$

$$\Rightarrow a = \frac{16u}{3T}$$

So (D) is true.

With this value of a,

$$T\sqrt{1 - \frac{4u}{aT}} = \frac{T}{2}$$

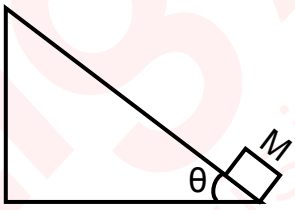
So (A) is true.

$$T\sqrt{1 - \frac{2u}{aT}} = T\sqrt{\frac{5}{8}}$$

So (B) is false.

IAPT tentative answer: (A), (C), (D) | **Zigyan answer:** (A), (C), (D)

51. A rectangular block of mass M projected up an inclined plane, set at an angle θ with the horizontal, comes to a stop at a certain height and slides back down the incline. The down trip takes exactly twice as long as the up trip. The observations reveal that



(A) coefficient of sliding friction between the block and the surface of the incline is 0.6 tan θ

(B) coefficient of sliding friction between the block and the surface of the incline is 0.6 sin θ

(C) about 75% of the original energy of projection has been lost to friction during the entire trip

(D) the acceleration of the block during its sliding down is 0.4 g sin θ

Solution · Q51 **Answer: (A), (C), (D)**

Retardation going up and acceleration coming down are

$$a_1 = g(\sin\theta + \mu\cos\theta)$$

$$a_2 = g(\sin\theta - \mu\cos\theta)$$

For the same distance, with times t and 2t,

$$\frac{1}{2}a_1 t^2 = \frac{1}{2}a_2 (2t)^2$$

$$\Rightarrow a_1 = 4a_2$$

$$\Rightarrow \mu = 0.6\tan\theta$$

So (A) is true and (B) is false.

$$\Rightarrow a_2 = 0.4g\sin\theta$$

So (D) is true, and

$$a_1 = 1.6g \sin\theta$$

Energy lost in the round trip, over slant distance s:

$$2\mu Mgs\cos\theta = 1.2Mgs\sin\theta$$

Initial kinetic energy:

$$Ma_1 s = 1.6Mgs\sin\theta$$

$$\therefore \frac{1.2}{1.6} = 0.75$$

So (C) is true.

IAPT tentative answer: (A), (C), (D) | **Zigyan answer:** (A), (C), (D)

52. A rocket is fired from Earth at 60° to the local vertical with an initial speed $v_0 = \sqrt{gR}$ where R is radius of the Earth and g is the acceleration due to gravity at the surface of the Earth. Choose correct option(s) [Assume the Earth to be a uniform solid sphere. Also ignore the rotation of the Earth]

(A) The maximum distance reached by the rocket from the Earth's centre is 2R

(B) The maximum distance reached by the rocket from the Earth's centre is $\frac{3R}{2}$

(C) The minimum velocity of the rocket during the motion is $\sqrt{\frac{gR}{3}}$

(D) The maximum height attained by the rocket above the Earth's surface is $\frac{R}{3}$

Solution · Q52 **Answer: (B), (C)**

$$v_0^2 = gR$$

$$\Rightarrow v_0^2 = \frac{GM}{R}$$

Energy per unit mass:

$$\frac{1}{2}v_0^2 - \frac{GM}{R} = -\frac{GM}{2R}$$

Angular momentum per unit mass:

$$h = Rv_0 \sin 60°$$

$$\Rightarrow h = \frac{\sqrt{3}}{2}Rv_0$$

At the farthest point the radial velocity is zero.

$$\frac{h^2}{2r^2} - \frac{GM}{r} = -\frac{GM}{2R}$$

$$\Rightarrow 4r^2 - 8Rr + 3R^2 = 0$$

$$\Rightarrow r = \frac{3R}{2}$$

The other root lies inside the Earth. So (B) is true and (A) is false. The maximum height is half of R, so (D) is false.

Speed is least at the farthest point.

$$v_{min} = \frac{2h}{3R}$$

$$\Rightarrow v_{min} = \sqrt{\frac{gR}{3}}$$

So (C) is true.

IAPT tentative answer: (B), (C) | **Zigyan answer:** (B), (C)

53. Charge Q is distributed in non-uniform but spherically symmetric manner with charge density ρ(r) such that

$\rho(r) = \rho_0\left(1 - \frac{r}{R}\right)$ for $r \le R$

$\rho(r) = 0$ for $r \ge R$

The correct statement(s) is/are

(A) The value of the constant ρ_0 is $\frac{3Q}{2\pi R^3}$

(B) The electric field produced by the given charge has maximum value at $r = \frac{2R}{3}$

(C) The maximum electric field produced by this charge distribution is $E = \frac{1}{3\pi\epsilon_0}\frac{Q}{R^2}$

(D) The maximum electric field produced is $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{R^2}$ at $r = R$

Solution · Q53 **Answer: (B), (C)**

$$q(r) = \int_0^r \rho(x)\, 4\pi x^2\, dx$$

$$\Rightarrow q(r) = 4\pi\rho_0\left(\frac{r^3}{3} - \frac{r^4}{4R}\right)$$

Putting the total charge Q at the surface,

$$\rho_0 = \frac{3Q}{\pi R^3}$$

So (A) is false.

By Gauss's law, inside the sphere,

$$E = \frac{\rho_0}{\varepsilon_0}\left(\frac{r}{3} - \frac{r^2}{4R}\right)$$

For maximum E,

$$\frac{dE}{dr} = 0$$

$$\Rightarrow r = \frac{2R}{3}$$

Outside, E only decreases, so (B) is true.

$$E_{max} = \frac{\rho_0 R}{9\varepsilon_0}$$

$$\Rightarrow E_{max} = \frac{Q}{3\pi\varepsilon_0 R^2}$$

So (C) is true.

(D) gives the surface field, which is smaller than this, so it is false.

IAPT tentative answer: (B), (C) | **Zigyan answer:** (B), (C)

54. A proton of mass m is released from rest at $x_0 = \frac{\alpha}{\beta}$ and starts moving along x axis under the influence of a conservative force F(x). Its potential energy function is $U(x) = \frac{\alpha}{x^2} - \frac{\beta}{x}$, where α and β are positive constants. Rigorous calculations predict that

(A) the speed of the proton is maximum at $x = 2x_0$

(B) the maximum speed of the proton is $v = \sqrt{\frac{\alpha}{mx_0^2}}$

(C) the force on the proton is zero at $x = 2x_0$

(D) during its motion the proton can move in a region $x_0 \le x \le \infty$

Solution · Q54 **Answer: (A), (C), (D)**

At release, U is zero and the proton is at rest, so total energy is zero.

$$K = -U$$

$$\Rightarrow K = \frac{\beta}{x} - \frac{\alpha}{x^2}$$

$$F = -\frac{dU}{dx}$$

$$\Rightarrow F = \frac{2\alpha}{x^3} - \frac{\beta}{x^2}$$

The force is zero at the point

$$x = 2x_0$$

So (C) is true. The force changes from positive to negative there, so (A) is true.

At this point,

$$\frac{1}{2}mv^2 = \frac{\alpha}{4x_0^2}$$

$$\Rightarrow v = \sqrt{\frac{\alpha}{2mx_0^2}}$$

So (B) is false.

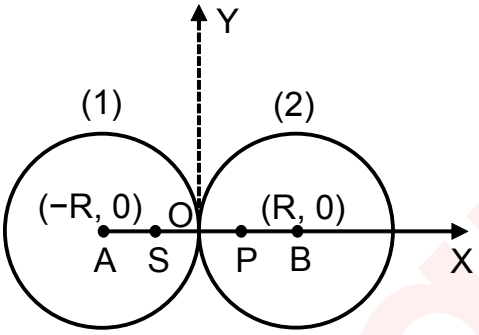
Motion needs K to be non-negative.

$$\Rightarrow x \ge x_0$$

K stays positive beyond the start, so (D) is true.

IAPT tentative answer: (A), (C), (D) | **Zigyan answer:** (A), (C), (D)

55. Two non-conducting solid spheres (1) and (2), with uniformly distributed charge throughout their volumes, are held at positions A and B, as shown in the figure. Each sphere has radius R. The centers A and B of the spheres (1) and (2) lie on x axis with the point of contact O at the origin. Given that the total charge on sphere (1) is Q and the electric field E at point $P\left(\frac{R}{2}, 0\right)$ is zero. The correct statement(s) is/are



(A) The charge on sphere (2) is $Q_2 = \frac{8Q}{9}$

(B) The ratio of the magnitudes of the electric fields at O and at B is 4 : 9

(C) The electric potential at B is $V_B = \frac{1}{8\pi\epsilon_0}\frac{Q}{R}$ [taking V = 0 at infinity]

(D) The electric field at the point $S\left(-\frac{R}{2}, 0\right)$ is in positive x-direction

Solution · Q55 **Answer: (A), (B), (D)**

Taking Q as positive, let q be the charge on sphere (2).

$$k = \frac{1}{4\pi\varepsilon_0}$$

At P, the two fields cancel.

$$\frac{kq}{2R^2} = \frac{4kQ}{9R^2}$$

$$\Rightarrow q = \frac{8Q}{9}$$

So (A) is true.

$$E_O = \frac{k}{R^2}\left(Q - \frac{8Q}{9}\right)$$

$$\Rightarrow E_O = \frac{kQ}{9R^2}$$

$$E_B = \frac{kQ}{4R^2}$$

$$\Rightarrow E_O : E_B = 4 : 9$$

So (B) is true.

$$V_B = \frac{kQ}{2R} + \frac{3kq}{2R}$$

$$\Rightarrow V_B = \frac{11kQ}{6R}$$

So (C) is false.

At S, net field along +x:

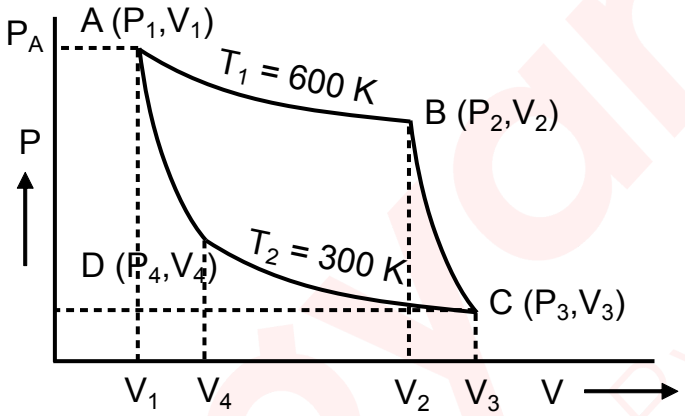
$$E_S = \frac{kQ}{R^2}\left(\frac{1}{2} - \frac{32}{81}\right)$$

$$\Rightarrow E_S = \frac{17kQ}{162R^2}$$

So (D) is true.

IAPT tentative answer: (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

56. Two moles of a mixture of a monoatomic gas and a diatomic gas are being used as the working substance in a reversible Carnot cycle as shown in figure. For the mixture of gasses, the value of $\gamma_{mixture} = \frac{C_P}{C_V} = \frac{3}{2}$. The cycle operates between the source temperature 600 K and the sink temperature 300 K. The highest and lowest pressures during the cycle are 1600 kPa and 100 kPa. The correct statement(s) is/are



(A) If the minimum volume in the cycle is V, then the maximum volume is 8 V

(B) The working substance consists of one mole of monoatomic and one mole of diatomic gas

(C) Work done per cycle by the engine is 600 R ln 2

(D) The minimum volume of working substance is 6.23 litre

Solution · Q56 **Answer: (A), (B), (C), (D)**

$$\frac{V_C}{V_A} = \frac{P_A}{P_C} \times \frac{T_2}{T_1}$$

$$\Rightarrow \frac{V_C}{V_A} = \frac{1600}{100} \times \frac{300}{600}$$

$$\Rightarrow \frac{V_C}{V_A} = 8$$

So (A) is true.

For the mixture, with n moles of monoatomic gas,

$$C_V = 2R$$

$$n\frac{3R}{2} + (2-n)\frac{5R}{2} = 4R$$

$$\Rightarrow n = 1$$

So (B) is true.

Along adiabatic BC,

$$600\sqrt{V_B} = 300\sqrt{V_C}$$

$$\Rightarrow V_B = 2V$$

$$W = nR(T_1 - T_2)\ln 2$$

$$\Rightarrow W = 600R \ln 2$$

So (C) is true.

$$V = \frac{nRT_1}{P_A}$$

$$\Rightarrow V = \frac{2 \times 8.31 \times 600}{1.6 \times 10^6}$$

$$\Rightarrow V = 6.23 \times 10^{-3}\ m^3$$

So (D) is true. The sketch is not to scale, but no option depends on it.

IAPT tentative answer: (A), (B), (C), (D) | **Zigyan answer:** (A), (B), (C), (D)

57. A long horizontal thin metal wire under tension is attached at one end to a vibrator, which causes transverse oscillations in the wire when the other end of the wire is fastened rigidly. The vibration produces a travelling wave in the wire, which is described by $y = y_0 \sin \pi(\alpha t - \beta x)$, where x is measured in meter along the wire from the vibrator end. Here α and β are known positive constants. The linear density of the wire is μ kg/m. Then

(A) the tension in the wire is $T = \mu\frac{\alpha^2}{\beta^2}$

(B) the transverse wave propagates in the negative x direction with a speed $v = \frac{\alpha}{\beta}$

(C) the power supplied by the vibrator is $P = \frac{\mu\pi^2\alpha^3 y_0^2}{2\beta}$

(D) if the vibrator vibrates with double the frequency, delivering double power to the same wire under the same tension, the amplitude of the wave will reduce to half of the original value.

Solution · Q57 **Answer: (A), (C)**

$$\omega = \pi\alpha \text{ and } K = \pi\beta$$

$$v = \frac{\omega}{K}$$

$$\Rightarrow v = \frac{\alpha}{\beta}$$

$$v = \sqrt{\frac{T}{\mu}}$$

$$\Rightarrow T = \frac{\mu\alpha^2}{\beta^2}$$

So (A) is true.

The phase shows travel along +x, so (B) is false.

Average power supplied:

$$P = \frac{1}{2}\mu\omega^2 y_0^2 v$$

$$\Rightarrow P = \frac{\mu\pi^2\alpha^3 y_0^2}{2\beta}$$

So (C) is true.

For the same wire and tension, power varies as the square of frequency times amplitude.

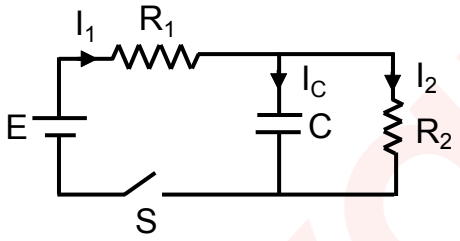
$$2 = 4\left(\frac{A'}{A}\right)^2$$

$$\Rightarrow A' = \frac{A}{\sqrt{2}}$$

So (D) is false.

IAPT tentative answer: (A), (C) | **Zigyan answer:** (A), (C)

58. In the circuit shown, E is the emf of an ideal battery. Capacitor C is initially uncharged. Switch S is closed at time t = 0. The time dependent current through the resistances R_1 and R_2 are I_1 and I_2 respectively. At any moment t, the charging current through the capacitor is $I_C(t)$. Choose correct option(s)



(A) Current I_C charging the capacitor is given by $I_C = \frac{E}{R_1}e^{-t/CR}$ where $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

(B) Current I_C charging the capacitor is given by $I_C = \frac{E}{R}e^{-t/CR}$ where $R = R_1 + R_2$

(C) Soon after the switch S is closed (at t = 0), the currents are $I_1 = \frac{E}{R_1}$ and $I_2 = 0$

(D) Long time after the switch S is closed ($t \to \infty$), charge on the capacitor is q = CE

Solution · Q58 **Answer: (A), (C)**

Let q be the charge on C at time t.

$$E = I_1R_1 + \frac{q}{C}$$

$$I_1 = I_C + \frac{q}{CR_2}$$

$$\Rightarrow \frac{dq}{dt} = \frac{E}{R_1} - \frac{q}{C}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\Rightarrow I_C = \frac{E}{R_1}e^{-t/CR}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

So (A) is true and (B) is false.

At the start the uncharged capacitor acts as a short circuit.

$$I_1 = \frac{E}{R_1}$$

$$I_2 = 0$$

So (C) is true.

After a long time the capacitor current is zero.

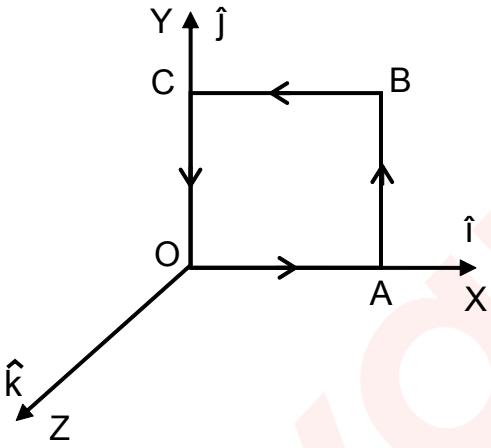
$$q = \frac{CER_2}{R_1 + R_2}$$

This is less than CE, so (D) is false.

IAPT tentative answer: (A), (C) | **Zigyan answer:** (A), (C)

59. A wire loop OABC, with corners at O (0, 0), A (L, 0), B (L, L) and C (0, L) lying in XY plane, carries a current I in anti-clock wise direction as shown.

The correct statement(s) is/are



(A) The magnetic field produced at the centre of the loop is $\vec{B}_1 = \frac{2\sqrt{2}\,\mu_0 I}{\pi L}\hat{k}$

(B) The magnetic moment of the current loop is $\mu_0 I L^2 \hat{k}$

(C) If a non-uniform magnetic field $\vec{B}_2 = \left(\frac{B_0 z}{L}\right)\hat{j} + \left(\frac{B_0 y}{L}\right)\hat{k}$ is switched on, the magnetic force on the loop is $B_0 I L \hat{j}$

(D) The magnetic force on the current carrying loop due to the magnetic field $\vec{B}_2$ is zero

Solution · Q59 **Answer: (A), (C)**

Field at the centre due to one side:

$$B = \frac{\mu_0 I}{2\pi L}\sqrt{2}$$

All four sides give fields along +z.

$$\vec{B}_1 = \frac{2\sqrt{2}\,\mu_0 I}{\pi L}\hat{k}$$

So (A) is true.

The magnetic moment is

$$\vec{m} = I L^2 \hat{k}$$

So (B) is false.

On the loop the z coordinate is zero.

$$\vec{B}_2 = \frac{B_0 y}{L}\hat{k}$$

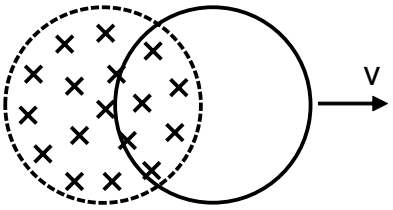
Side OA lies in zero field, and the forces on AB and CO cancel. The net force is that on BC.

$$\vec{F} = B_0 I L \hat{j}$$

So (C) is true and (D) is false.

IAPT tentative answer: (A), (C) | **Zigyan answer:** (A), (C)

60. A uniform magnetic field B = 0.5 T exists in a circular region of radius R = 5 m. A wire loop of radius R = 5 m completely encloses the magnetic field at t = 0. The loop is pulled at uniform speed v = 2 ms^{-1} in the plane of the paper as shown.



(A) The emf induced in the loop at time t = 3 s will be 8 V

(B) The maximum emf induced in the loop will be 10 V

(C) The emf induced in the loop will be minimum at time t = 4 s

(D) The emf induced in the loop will be maximum just at start at the time t = 0 s

Solution · Q60 **Answer: (A), (B), (D)**

The emf equals Bcv, where c is the common chord of the two circles.

$$c = 2\sqrt{25 - t^2}$$

$$\varepsilon = 0.5 \times 2\sqrt{25 - t^2} \times 2$$

$$\Rightarrow \varepsilon = 2\sqrt{25 - t^2}$$

(A) At 3 s,

$$\varepsilon = 8 \text{ V}$$

So (A) is true.

(B), (D) The emf falls steadily, so it is maximum at the start.

$$\varepsilon = 10 \text{ V}$$

So both are true.

(C) At 4 s,

$$\varepsilon = 6 \text{ V}$$

It is still falling and becomes zero at 5 s, so (C) is false.

IAPT tentative answer: (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

ANSWER KEY

NSEP 2026 · PAPER CODE 61 · IAPT TENTATIVE KEY

60
QUESTIONS · 216 MARKS

IAPT's TENTATIVE answer key for paper code 61; the final key may differ. ★ marks an answer given as per Zigyan.

1	(C)	2	(D)	3	(B)	4	(A)	5	(A)
6	(C)	7	(A)	8	(D)	9	(B)	10	(D)
11	(A)	12	(C)	13	(D)	14	(B)	15	(A)
16	(B)	17	(D)	18	(B)	19	(D)	20	(D)
21	(B)	22	(B)	23	(D)	24	(C)	25	(D)
26	(D)	27	(C)	28	(C)	29	–★	30	(A)
31	(B)	32	(A)	33	(D)	34	(D)	35	(C)
36	(B)	37	(D)	38	(D)	39	(C)	40	(A)
41	(B)	42	(B)	43	(C)	44	(C)	45	(B)
46	(C)	47	(C)	48	(A)	49	(B), (C), (D)	50	(A), (C), (D)
51	(A), (C), (D)	52	(B), (C)	53	(B), (C)	54	(A), (C), (D)	55	(A), (B), (D)
56	(A), (B), (C), (D)	57	(A), (C)	58	(A), (C)	59	(A), (C)	60	(A), (B), (D)

★ Answers as per Zigyan

- **Q29** — As per Zigyan: no option is correct; IAPT tentative key (D).

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OLYMPIADS · 2026

Olympiad results



TOP ACHIEVEMENT · CHEMISTRY

Qualified the Chemistry Olympiad twice, and selected for the HBCSE camp.

Saksham Bishnoi reached the national stage of the Chemistry Olympiad in two consecutive years and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai. 4 Years Classroom - the same student who took AIR 168 in JEE Advanced 2026.

Qualified twice | HBCSE selection camp | Only student from Faridabad

Above MAS means above the **Minimum Admissible Score**: clearing it puts a student in the national band for their subject. It is a real threshold, not a participation marker.

CHEMISTRY · ABOVE MAS



Sulokya Bibhuty
Class XII
3 Years Classroom
Above MAS



Anay Gupta
Class XI
3 Years Classroom
Above MAS



Akshat Khator
Class XI
3 Years Classroom
Above MAS



Harshit Goyal
Class XII
4 Years Classroom
Above MAS



Hardik Sharma
Class XI
3 Years Classroom
Above MAS



Aarush Kumar
Class XII
1 Year Classroom
Above MAS

PHYSICS · ASTRONOMY · MATHEMATICS

PHYSICS



Sulokya Bibhuty
Class XII
3 Years Classroom
Above MAS

PHYSICS



Saksham Bishnoi
Class XII
4 Years Classroom
Above MAS

ASTRONOMY



Sulokya Bibhuty
Class XI
3 Years Classroom
Above MAS

MATHEMATICS · IOQM



Priyanshi
Class XI
4 Years Classroom
IOQM Qualifier

OLYMPIADS WE PREPARE STUDENTS FOR

NSEP	NSEC	NSEB	NSEA	IOQM	NSEJS
Physics	Chemistry	Biology	Astronomy	Mathematics	Class X and below

The olympiad pathway starts in Class 8.

NSEJS is open to Class 10 and below - the habit of staying with one hard problem is the one JEE Advanced rewards.

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RESULTS · 2021 – 2026

Our toppers, year by year

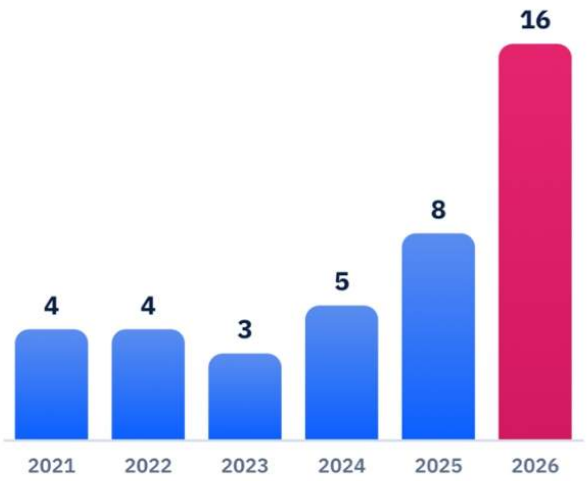
40
JEE Advanced selections in 6 years

AIR 168
best rank — Saksham Bishnoi, 2026

16 of 35
students selected, JEE Advanced 2026

14 of 35
above 98 percentile, JEE Main 2026

JEE ADVANCED SELECTIONS PER YEAR



BEST RANK EACH YEAR

YEAR	JEE ADVANCED	JEE MAIN
2026	**Saksham Bishnoi** AIR 168 · 4 Years Classroom	**Saksham Bishnoi** AIR 811 · 99.95 %ile
2025	**Chakshu** AIR 4,233 · 2 Years Classroom	**Chakshu** AIR 8,538 · 99.44 %ile
2024	**Harshit** AIR 777 · 2 Years Classroom	**Harshit** AIR 1,473 · 99.91 %ile
2023	**Aditya Jain** AIR 2,373 · 2 Years Classroom	**Aditya Jain** AIR 2,503 · 99.79 %ile
2022	**Rachit Sharma** AIR 698 · 1 Year Classroom	**Rachit Sharma** AIR 1,016 · 99.90 %ile
2021	**Sparsh Mittal** AIR 2,237 · 1 Year Classroom	**Sparsh Mittal** AIR 1,562

JEE ADVANCED 2026 — THIRTEEN NAMED SELECTIONS



Saksham Bishnoi
AIR 168
4 Years Classroom



Sulokya Bibhuty
AIR 1,315
3 Years Classroom



Aarush
AIR 2,699
1 Year Classroom



Manishka
AIR 2,869
4 Years Classroom



Oojit Kumar
AIR 5,765
4 Years Classroom



Harshit Goyal
AIR 6,407
4 Years Classroom



Pranab Sharma
AIR 6,750
3 Years Classroom



Aditya Dhar
AIR 15,183
3 Years Classroom



Arpit Anshuman
AIR 19,308
4 Years Classroom



Lokesh
AIR 22,857
3 Years Classroom



Arjun
AIR 24,674
3 Years Classroom



Sanyam Gulyani
AIR 25,123
1 Year Classroom



Saket
AIR 27,628
3 Years Classroom

Sixteen students of the 2026 batch were selected in JEE Advanced; the thirteen above are named with their All India Rank.

JEE MAIN 2026 — TOP SIX, WITH PERCENTILE



Saksham Bishnoi
AIR 811
99.95 %ile
4 Years Classroom



Sulokya Bibhuty
AIR 1,095
99.94 %ile
3 Years Classroom



Harshit Goyal
AIR 2,662
99.83 %ile
4 Years Classroom



Manishka
AIR 4,817
99.70 %ile
4 Years Classroom



Oojit Kumar
AIR 5,040
99.69 %ile
4 Years Classroom



Aarush
AIR 5,276
99.67 %ile
1 Year Classroom

14 of the 35 students in the 2026 batch scored above the 98th percentile in JEE Main.

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