zigyan

PREVIOUS YEAR PAPER · 2025

OLYMPIAD · STAGE I

NSEP

National Standard Examination in Physics

2025

Question paper, answer key and Zigyan solutions

60	216	120 min	61
Questions	Maximum marks	Time	Paper code

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), NSEP 2025, paper code 61.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

Prepare for the Olympiads with Zigyan

www.zigyan.com

zigyan

SCO No. 107, Sector 16, Faridabad, Haryana 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com

zigyan

JEE 2026 RESULTS

OUR TOPPERS

When talent meets the right guidance.

Saksham Bishnoi and Sulokya Bibhuty - our JEE 2026 toppers from Zigyan, Sector 16 - with the programme they took and the rank they earned.



Rahul Kaushik Sir
Founder & Director, Zigyan Eduvision
23 years of teaching



Saksham Bishnoi

4 YEARS CLASSROOM

JEE ADVANCED 2026	JEE MAIN 2026
AIR 168	AIR 811
	99.95 percentile



Sulokya Bibhuty

3 YEARS CLASSROOM

JEE ADVANCED 2026	JEE MAIN 2026
AIR 1,315	AIR 1,095
	99.94 percentile

OLYMPIAD RESULTS

Above the Minimum Admissible Score - the national band for the subject

CHEMISTRY

- Sulokya Bibhuty — 3 Years Classroom
- Anay Gupta — 3 Years Classroom
- Akshat Khator — 3 Years Classroom
- Harshit Goyal — 4 Years Classroom
- Hardik Sharma — 3 Years Classroom
- Aarush Kumar — 1 Year Classroom

PHYSICS

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

ASTRONOMY

- Sulokya Bibhuty — 3 Years Classroom

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
in JEE Advanced 2026	students of the batch selected	best JEE Advanced rank

Start where they started.

Register for ZEST - ₹200 · www.zigyan.com/scholarship/zest

+91 92115 38800
info@zigyan.com

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. A point mass m moves in a straight line under a retardation kv^2 [where k is a positive constant and v is the instantaneous velocity]. The initial velocity of the point mass is u. The displacement of the point mass at time t is

(A) $\frac{1}{k}\ell n(1+kut)$ (B) $\frac{1}{k}\ell n\,kut$

(C) $k\,\ell n\,kut$ (D) $\frac{1}{k}\ell n(1-kut)$

Solution · Q1 **Answer: (A)**

$$\frac{dv}{dt} = -kv^2$$

$$\Rightarrow \int_u^v \frac{dv}{v^2} = -k\int_0^t dt$$

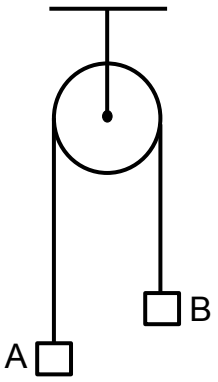
$$\Rightarrow \frac{1}{v} = \frac{1}{u} + kt$$

$$\Rightarrow v = \frac{u}{1+kut}$$

$$\therefore x = \int_0^t \frac{udt}{1+kut} = \frac{1}{k}\ln(1+kut)$$

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

2. In the arrangement shown in figure, 'a' represents the magnitude of acceleration of small blocks A and B while 'T' is the tension in the massless string passing over the frictionless and massless pulley. The sum of the masses of blocks A and B is constant. For this system, a linear relationship can be obtained between



(A) a and $\frac{1}{T}$

(B) a and T

(C) a and T^2

(D) T and a^2

Solution · Q2 **Answer: (D)**

Take the first block as the heavier one, with a constant total mass C.

$$m_1 + m_2 = C$$

$$m_1 g - T = m_1 a$$

$$T - m_2 g = m_2 a$$

$$\Rightarrow a = \frac{(m_1 - m_2)g}{C}$$

$$\Rightarrow T = \frac{2m_1 m_2 g}{C}$$

Using the identity,

$$4m_1 m_2 = C^2 - (m_1 - m_2)^2$$

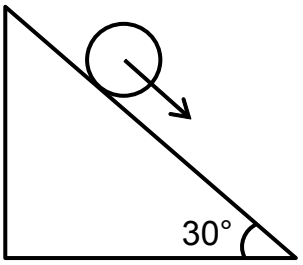
$$\Rightarrow T = \frac{gC}{2}\left(1 - \frac{a^2}{g^2}\right)$$

$$\Rightarrow T = \frac{gC}{2} - \frac{C}{2g}a^2$$

$\therefore$ The graph of T against a^2 is a straight line.

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

3. A thin uniform circular ring of mass m is rolling without slipping down an inclined plane of inclination 30° with the horizontal. The coefficient of friction between the ring and the surface is μ. The correct statement is



(A) linear acceleration of the center of the ring along the plane is $a = \frac{g}{2}$

(B) force of friction between the ring and the inclined plane is $F_{friction} = \frac{mg}{4}$

(C) the ring keeps rolling for all values of the coefficient of friction $\mu \geq \frac{1}{4}$

(D) linear acceleration of the center of the ring along the plane is $a = \frac{g}{3}$

Solution · Q3 **Answer: (B)**

Along the incline:

$$\frac{mg}{2} - f = ma$$

Torque about the centre:

$$fR = I\alpha$$

$$I = mR^2 \text{ and } a = R\alpha$$

$$\Rightarrow f = ma$$

$$\therefore a = \frac{g}{4}$$

$$\therefore f = \frac{mg}{4}$$

So (B) is true; (A) and (D) are false.

Condition for rolling:

$$f \leq \mu N$$

$$\frac{mg}{4} \leq \mu \frac{\sqrt{3}}{2} mg$$

$$\Rightarrow \mu \geq \frac{1}{2\sqrt{3}} \approx 0.289$$

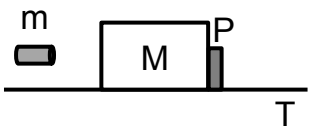
The ring slips in the range

$$0.25 \leq \mu < 0.289$$

$\therefore$ (C) is false.

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

4. A bullet of mass m can penetrate a target (a heavy block of mass M) up to a distance S, when the target M is held stationary by a stopper P (shown in figure). Up to what distance S′ the bullet will penetrate if the block of mass M is free to move (i.e. when the stopper P is removed) on the frictionless surface T.



(A) $S' = S$

(B) $S' = \frac{m}{M}S$

(C) $S' = \frac{m}{m+M}S$

(D) $S' = \frac{M}{M+m}S$

Solution · Q4 **Answer: (D)**

Take a constant resisting force F and bullet speed v.

When the block is held:

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

When the block is free, by conservation of momentum,

$$V = \frac{mv}{M+m}$$

$$FS' = \frac{1}{2}mv^2 - \frac{1}{2}(M+m)V^2$$

$$\Rightarrow FS' = \frac{1}{2}mv^2\frac{M}{M+m}$$

$$\therefore S' = \frac{M}{M+m}S$$

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

5. Knowing that the atomic masses of Al and Mg are respectively $^{25}_{13}Al = 24.990432$ u and $^{25}_{12}Mg = 24.985839$ u while electron mass is often expressed as $m_e = 0.511$ MeV, the Q value (energy liberated) of the β decay nuclear reaction $^{25}Al \rightarrow {}^{25}Mg + e^+ + \nu$ in MeV is

(A) 4.278 (B) 3.767 (C) 3.256 (D) 931.478

Solution · Q5 **Answer: (C)**

Neglecting electron binding energies, each nuclear mass is the atomic mass less Z electron masses, with atomic numbers 13 (Aℓ) and 12 (Mg).

$$Q = [(M_{A\ell} - 13m_e) - (M_{Mg} - 12m_e) - m_e]c^2$$

$$\Rightarrow Q = (M_{A\ell} - M_{Mg} - 2m_e)c^2$$

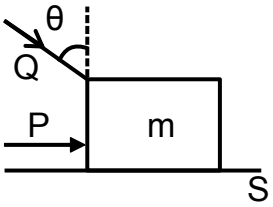
$$M_{A\ell} - M_{Mg} = 24.990432\text{ u} - 24.985839\text{ u} = 0.004593\text{ u}$$

$$\Rightarrow Q = 0.004593 \times 931.5\text{ MeV} - 2 \times 0.511\text{ MeV}$$

$$\Rightarrow Q = 4.278\text{ MeV} - 1.022\text{ MeV} = 3.256\text{ MeV}$$

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

6. A block of mass m, lying on a rough horizontal plane, is acted upon by a horizontal force P and simultaneously by another force Q acting at an angle θ from the vertical as shown. The block will remain in equilibrium if the coefficient of friction between the block and the surface S is



(A) at least $\frac{P + Q\sin\theta}{mg + Q\cos\theta}$

(B) at least $\frac{P + Q\cos\theta}{mg + Q\sin\theta}$

(C) equal to $\frac{P + Q\sin\theta}{mg - Q\cos\theta}$

(D) equal to $\frac{P + Q\cos\theta}{mg - Q\sin\theta}$

Solution · Q6 **Answer: (A)**

Resolve Q along the horizontal and the vertical (downward):

Q sin θ and Q cos θ

$$\therefore N = mg + Q\cos\theta$$

Friction needed for equilibrium:

$$f = P + Q\sin\theta$$

and

$$f \le \mu N$$

$$\Rightarrow \mu \ge \frac{P + Q\sin\theta}{mg + Q\cos\theta}$$

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

7. Knowing that the acceleration due to gravity on the Earth surface is g and the radius of the Earth is R, a small body of mass m falls on the Earth from a height $h = \frac{R}{5}$ above the Earth's surface. During the freefall, the potential energy of the falling body decreases by

(A) mgh

(B) $\frac{4}{5}mgh$

(C) $\frac{5}{6}mgh$

(D) $\frac{6}{7}mgh$

Solution · Q7 **Answer: (C)**

$$\Delta U = -\frac{GMm}{R+h} + \frac{GMm}{R}$$

$$\Rightarrow \Delta U = \frac{GMmh}{R(R+h)}$$

$$GM = gR^2$$

$$\Rightarrow \Delta U = mgh\frac{R}{R+h}$$

$$h = \frac{R}{5}$$

$$\therefore \Delta U = \frac{5}{6}mgh$$

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

8. At some instant, a motor car is moving on a circular path of radius 600 m, with a speed u = 30 ms^{-1}. If its speed is increased at a rate of 2 ms^{-2}, the magnitude of the acceleration of the car at that instant is

(A) 2.0 ms^{-2} (B) 2.5 ms^{-2} (C) 3.5 ms^{-2} (D) 1.5 ms^{-2}

Solution · Q8 **Answer: (B)**

Tangential acceleration:

$$a_t = 2\ m\ s^{-2}$$

Centripetal acceleration:

$$a_c = \frac{u^2}{R} = \frac{30^2}{600} = 1.5\ m\ s^{-2}$$

These two are perpendicular.

$$\therefore a = \sqrt{2^2 + 1.5^2} = 2.5\ m\ s^{-2}$$

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

9. A cricket ball, thrown across a field, is at heights of h_1 and h_2 above the point of projection, at time t_1 and time t_2 after the throw, respectively. It is then caught by the wicket keeper at the same height as that from which it was thrown. The Time of Flight (T) of the ball is

(A) $T = \frac{h_1 t_2^2 - h_2 t_1^2}{h_1 t_2 - h_2 t_1}$ (B) $T = \frac{h_1 t_2^2 + h_2 t_1^2}{h_2 t_1 + h_1 t_2}$

(C) $T = \frac{h_1 t_1^2 - h_2 t_2^2}{h_1 t_1 - h_2 t_2}$ (D) $T = \frac{h_1 t_1^2 + h_2 t_2^2}{h_1 t_1 + h_2 t_2}$

Solution · Q9 **Answer: (A)**

Height at time t:

$$y = u_y t - \frac{1}{2} g t^2$$

The ball returns to this level at the time of flight T.

$$\Rightarrow u_y = \frac{gT}{2}$$

$$\Rightarrow y = \frac{g}{2} t (T - t)$$

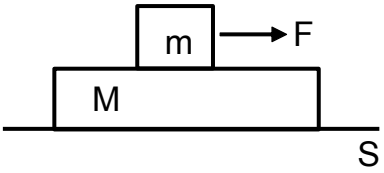
$$\frac{h_1}{h_2} = \frac{t_1 (T - t_1)}{t_2 (T - t_2)}$$

$$\Rightarrow T(h_1 t_2 - h_2 t_1) = h_1 t_2^2 - h_2 t_1^2$$

$$\therefore T = \frac{h_1 t_2^2 - h_2 t_1^2}{h_1 t_2 - h_2 t_1}$$

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

10. A plate of mass M is placed on a horizontal frictionless surface S. A block of mass m is placed on the plate. The coefficient of dynamic friction between the block and the plate is μ. If a horizontal force F = 2μmg is applied to the block (as shown), the acceleration of the plate will be



(A) $\frac{\mu mg}{M}$ (B) $\frac{\mu mg}{m+M}$

(C) $\frac{2\mu mg}{M}$ (D) $\frac{2\mu mg}{m+M}$

Solution · Q10 **As per Zigyan: (A)**

Friction between block and plate:

$$f = \mu N = \mu mg$$

For the block:

$$2\mu mg - \mu mg = ma_b$$

$$\Rightarrow a_b = \mu g$$

For the plate:

$$\mu mg = Ma_p$$

$$\Rightarrow a_p = \frac{\mu mg}{M}$$

The block slides only if

$$a_b > a_p$$

$$\Rightarrow M > m$$

This condition is assumed.

Reference: NCERT Physics Class XI (Part I), Chapter 4 'Laws of Motion', section 4.9.1: kinetic friction belongs to surfaces in relative motion.

Check: moving together would need a friction of 2μmgM divided by (m + M). This exceeds μmg only when M is greater than m, so with the static limit also μmg the block can slide only in that case.

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

11. A simple pendulum, with a bob of mass m, oscillates in a vertical plane, with an angular amplitude θ_0. The tension in its string when it passes through the mean position is 2mg. Neglecting the effect of air friction and the viscosity of air, the angular amplitude θ_0 is

(A) 30° (B) 60° (C) 90° (D) 120°

Solution · Q11 **Answer: (B)**

At the mean position:

$$T - mg = \frac{mv^2}{L}$$

$$T = 2mg$$

$$\Rightarrow v^2 = gL$$

By conservation of energy,

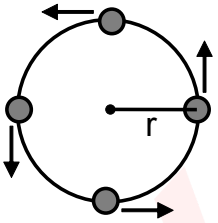
$$mgL(1-\cos\theta_0) = \frac{1}{2}mv^2$$

$$\Rightarrow \cos\theta_0 = \frac{1}{2}$$

$$\therefore \theta_0 = 60°$$

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

12. Because of their mutual gravitational attraction, four identical planets each of mass m are orbiting in a circular path of radius r in the same sense (angular direction). The magnitude of the velocity of each planet is



(A) $\left[\frac{Gm}{r}\left(\frac{1+2\sqrt{2}}{4}\right)\right]^{1/2}$

(B) $3\sqrt{\frac{Gm}{r}}$

(C) $\sqrt{\frac{Gm}{r}\left(1+2\sqrt{2}\right)}$

(D) $\left[\frac{1}{2}\frac{Gm}{r}\left(\frac{1+\sqrt{2}}{2}\right)\right]^{1/2}$

Solution · Q12 **Answer: (A)**

Distances of the two neighbours and of the opposite planet from any planet:

$$r\sqrt{2} \text{ and } 2r$$

Force due to the opposite planet:

$$F_1 = \frac{Gm^2}{4r^2}$$

Force due to each neighbour, which acts at 45° to the radius:

$$F_2 = \frac{Gm^2}{2r^2}$$

Net force towards the centre:

$$F = F_1 + 2F_2\cos 45°$$

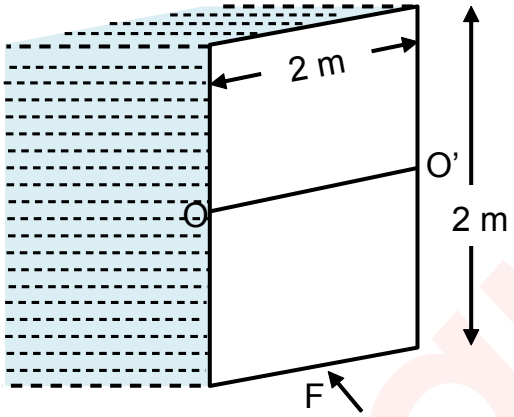
$$\Rightarrow F = \frac{Gm^2}{4r^2}\left(1+2\sqrt{2}\right)$$

$$\frac{mv^2}{r} = F$$

$$\Rightarrow v = \left[\frac{Gm}{r}\left(\frac{1+2\sqrt{2}}{4}\right)\right]^{1/2}$$

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

13. A rigid square sheet of size 2 m × 2 m is hinged at the middle of the vertical edges to serve as a door which can turn about the horizontal axis OO′. A fluid of density ρ fills the space to the left of the sheet up to its top. The horizontal force F required (to be applied at the lower edge) to hold the sheet vertical is



(A) $\frac{2}{3}\rho g$ (B) $\frac{4}{3}\rho g$

(C) $\frac{8}{3}\rho g$ (D) $\frac{1}{3}\rho g$

Solution · Q13 **Answer: (B)**

Atmospheric pressure cancels on the two faces. Force on a strip of height dh at depth h:

$$dF = \rho g h \times 2\, dh$$

Lever arm of this strip about OO′:

$h - 1$

Torque due to the fluid:

$$\tau = \int_0^2 2\rho g h(h-1)\, dh$$

$$\Rightarrow \tau = 2\rho g\left(\frac{8}{3} - 2\right) = \frac{4}{3}\rho g$$

F acts at the lower edge, 1 m below the axis.

$$F \times 1 = \tau$$

$$\therefore F = \frac{4}{3}\rho g$$

This is in newtons when ρ and g are in SI units.

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

14. A major artery in human body, with radius 0.4 cm, carries blood at a flow rate of 5.0 cubic centimeters per second. The pressure difference of blood per meter length of the artery is nearly [Given that the coefficient of viscosity (η) of blood at body temperature is 4.0×10^{-3} Pa.s and the density of mercury is 13.6 g/cm^3]

(A) 9.6 mm of Hg (B) 3.2 mm of Hg (C) 1.5 mm of Hg (D) 6.0 mm of Hg

Solution · Q14 **Answer: (C)**

By Poiseuille's law,

$$Q = \frac{\pi \Delta P r^4}{8\eta L}$$

$$\Rightarrow \Delta P = \frac{8\eta L Q}{\pi r^4}$$

$$r = 4.0 \times 10^{-3}\ \text{m},\ L = 1\ \text{m}$$

$$Q = 5.0 \times 10^{-6}\ \text{m}^3\ \text{s}^{-1}$$

$$\eta = 4.0 \times 10^{-3}\ \text{Pa s}$$

$$\Rightarrow \Delta P \approx 199\ \text{Pa}$$

For the equivalent column of mercury,

$$h = \frac{199}{13600 \times 9.8}\ \text{m}$$

$$\Rightarrow h = 1.49 \times 10^{-3}\ \text{m}$$

The nearest value is 1.5 mm of Hg per metre.

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

15. If P represents radiation pressure, E represents radiation energy striking per unit area per unit time and c represents speed of light then the possible values of non-zero integers x, y and z such that $P^x E^y c^z$ is dimensionless, may be

(A) x = 1, y = 1, z = 1 (B) x = −1, y = 1, z = 1

(C) x = 1, y = −1, z = 1 (D) x = 1, y = 1, z = −1

Solution · Q15 **Answer: (C)**

Dimensions of the three quantities:

$$[P] = [M L^{-1} T^{-2}]$$

$$[E] = [M T^{-3}]$$

$$[c] = [L T^{-1}]$$

The dimensions of the product are

$M^{x+y} L^{-x+z} T^{-2x-3y-z}$

Each power must vanish:

$$x + y = 0$$

$$z - x = 0$$

$$-2x - 3y - z = 0$$

$$\therefore x : y : z = 1 : -1 : 1$$

Hence a possible set is

$$x = 1,\ y = -1,\ z = 1$$

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

16. A large tank, open at the top, has two small holes in the vertical wall. One is a square hole of side 's' at a depth h below the top and the other is a circular hole of radius r at a depth 4h below the top (given that s << h; r << h). When the tank is completely filled up to the brim with water, the quantity of water flowing out per second from each hole is the same, then r is equal to

(A) $2\pi s$ (B) $\frac{s}{2\pi}$

(C) $\frac{s}{\sqrt{2\pi}}$ (D) $\frac{s}{2\sqrt{\pi}}$

Solution · Q16 **Answer: (C)**

By Torricelli's law, for the two holes,

$$v_1 = \sqrt{2gh}$$

$$v_2 = \sqrt{2g(4h)} = 2\sqrt{2gh}$$

Equal volumes flow out per second.

$$s^2 v_1 = \pi r^2 v_2$$

$$\Rightarrow s^2 = 2\pi r^2$$

$$\therefore r = \frac{s}{\sqrt{2\pi}}$$

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

17. A pendulum consists of a heavy but very small bob of mass M suspended at the end of a rigid rod of mass m and length L. The time period of small oscillations in the vertical plane, about a horizontal axis through the upper end of the rod is



(A) $2\pi\sqrt{\left(\frac{m+2M}{m+3M}\right)\times\left(\frac{3L}{2g}\right)}$ (B) $2\pi\sqrt{\left(\frac{m+3M}{m+2M}\right)\times\left(\frac{2L}{3g}\right)}$

(C) $2\pi\sqrt{\frac{3L}{2g}}$ (D) $2\pi\sqrt{\left(\frac{2m+M}{3m+M}\right)\times\left(\frac{3L}{2g}\right)}$

Solution · Q17 **Answer: (B)**

Moment of inertia about the upper end:

$$I = \frac{mL^2}{3} + ML^2 = \frac{(m+3M)L^2}{3}$$

Restoring torque for a small angle θ:

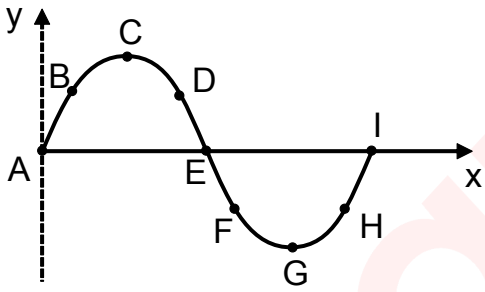
$$\tau = \frac{(m+2M)gL\theta}{2}$$

$$\Rightarrow \omega^2 = \frac{3g(m+2M)}{2L(m+3M)}$$

$$\therefore T = 2\pi\sqrt{\left(\frac{m+3M}{m+2M}\right)\times\left(\frac{2L}{3g}\right)}$$

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

18. A transverse wave is travelling along a long stretched string from left to right (along +ve x direction). The snapshot of a small part of the string at any moment t is shown in the figure. At this particular instant



(A) A and E are at rest for a moment while C and G have maximum speed

(B) B and D have upward velocity whereas F and H have downward

(C) D, E, F are moving downward at that moment

(D) B and H are moving downward at that moment

Solution · Q18 **Answer: (D)**

For a wave moving along +x, the particle velocity is

$$\frac{\partial y}{\partial t} = -v\frac{\partial y}{\partial x}$$

So points of positive slope move down and points of negative slope move up.

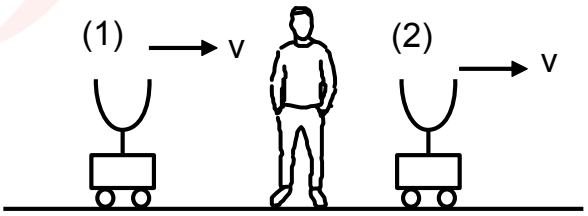
From the figure, A, B, H and I move down, while D, E and F move up.

C and G (zero slope) are momentarily at rest; A and E have maximum speed.

∴ B and H are moving downwards.

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

19. Two tuning forks, with natural frequency 700 Hz each, move relative to a stationary observer. Fork (1) moves towards the observer while the fork (2) moves away from the observer. Both the forks move with same velocity v on the same line. The observer, standing between the two forks, hears 4 beats per sec. Using the speed of sound in air as v_s = 350 ms^{-1}, the speed of each tuning fork is



(A) 2.0 ms^{-1} (B) 1.5 ms^{-1} (C) 1.0 ms^{-1} (D) 0.5 ms^{-1}

Solution · Q19 **Answer: (C)**

Approaching fork:

$$f_1 = f_0 \frac{v_s}{v_s - v}$$

Receding fork:

$$f_2 = f_0 \frac{v_s}{v_s + v}$$

Beat frequency:

$$f_1 - f_2 = \frac{2f_0 v_s v}{v_s^2 - v^2} = 4 \text{ Hz}$$

As v is much smaller than the speed of sound,

$$\frac{2f_0 v}{v_s} \approx 4$$

$$f_0 = 700 \text{ Hz}, v_s = 350 \text{ m s}^{-1}$$

$$\Rightarrow 4v = 4$$

$$\therefore v = 1.0 \text{ m s}^{-1}$$

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

20. The speed of sound in a mixture of 1 mole of Helium (molar mass = 4 g) and 2 moles of oxygen (molar mass = 32 g) at 27 °C is nearly

(A) 318 ms^{-1} (B) 332 ms^{-1} (C) 381 ms^{-1} (D) 401 ms^{-1}

Solution · Q20 **Answer: (D)**

For the mixture,

$$C_V = 1 \times 1.5R + 2 \times 2.5R = 6.5R$$

$$\Rightarrow C_P = 6.5R + 3R = 9.5R$$

$$\Rightarrow \gamma = \frac{19}{13}$$

Mean molar mass:

$$M = \frac{1 \times 4 + 2 \times 32}{3} \approx 22.67 \text{ g mol}^{-1}$$

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

$$T = 300 \text{ K}$$

$$\Rightarrow v = \sqrt{\frac{19 \times 8.31 \times 300}{13 \times 0.02267}} \text{ m s}^{-1}$$

$$\therefore v \approx 401 \text{ m s}^{-1}$$

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

21. Three identical large metal plates are kept parallel and close to each other. Each plate can be treated as an ideal black body and has very high thermal conductivity. The first and third plates are maintained at high temperature $T_1 = 3T$ and $T_3 = 2T$. The temperature T_2 of the middle (i.e. second) plate under steady state condition is

(A) $\frac{5T}{2}$ (B) $\left(\frac{65}{2}\right)^{1/4} T$

(C) $\left(\frac{97}{2}\right)^{1/4} T$ (D) $\left(\frac{65}{4}\right)^{1/4} T$

Solution · Q21 **Answer: (C)**

In the steady state, the power absorbed by the middle plate equals the power it emits from its two faces.

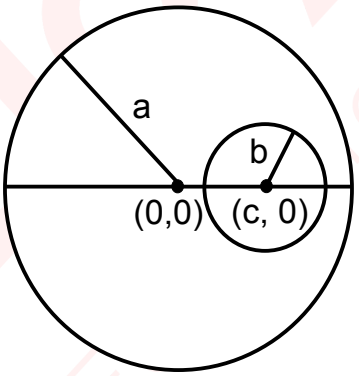
$$\sigma T_1^4 + \sigma T_3^4 = 2\sigma T_2^4$$

$$\Rightarrow 2T_2^4 = (3T)^4 + (2T)^4 = 97T^4$$

$$\therefore T_2 = \left(\frac{97}{2}\right)^{1/4} T$$

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

22. A thin uniform circular disc of radius 'a' is placed in XY plane with its center at origin (0,0). A small circular disc of radius b with center at (c, 0) is cut and taken out to create a hole. The center of mass of the remaining disc is at



(A) $-\frac{b^2}{a^2}c, 0$ (B) $-\frac{b^2}{a^2 - c^2}c, 0$

(C) $-\frac{b^2}{a^2 + b^2}c, 0$ (D) $-\frac{b^2}{a^2 - b^2}c, 0$

Solution · Q22 **Answer: (D)**

Take the cut-out disc as a negative mass. With mass per unit area σ,

$$x = \frac{\sigma\pi a^2(0) - \sigma\pi b^2 c}{\sigma\pi a^2 - \sigma\pi b^2}$$

$$\Rightarrow x = -\frac{b^2}{a^2 - b^2}c$$

By symmetry,

$$y = 0$$

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

23. One mole of an ideal monoatomic gas, contained in a cylinder fitted with movable piston, is originally at P_1, V_1 and T_1 = 27 °C. The gas is slowly heated. Initially 8.31 watt-hour of energy is added to it; at the same time it is allowed to expand at constant pressure to a new state P_1, V_2 and T_2.

The correct option is

(A) Value of T_2 is 1740 °C

(B) Work done by the gas is 2160 R joule

(C) Internal energy of the gas increases by 1440 R joule

(D) $\frac{V_2}{V_1} = 5.8$

Solution · Q23 **Answer: (D)**

Heat supplied:

$$Q = 8.31 \times 3600\ J = 3600R\ J$$

At constant pressure, for a monatomic gas,

$$3600R = \frac{5R}{2}\Delta T$$

$$\Rightarrow \Delta T = 1440\ K$$

$$\Rightarrow T_2 = 300\ K + 1440\ K = 1740\ K$$

This is 1467 °C, so (A) is false.

Work done by the gas:

$$W = nR\Delta T = 1440R\ J$$

So (B) is false.

Rise in internal energy:

$$\Delta U = \frac{3}{2}R\Delta T$$

$$\Rightarrow \Delta U = 2160R\ J$$

So (C) is false.

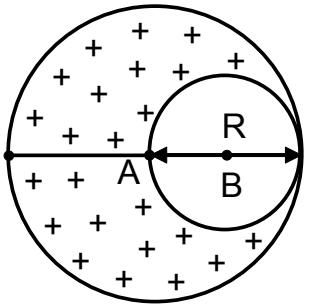
At constant pressure,

$$\frac{V_2}{V_1} = \frac{1740}{300} = 5.8$$

$\therefore$ (D) is true.

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

24. A non-conducting solid sphere, of radius R, with its center at A, has a spherical cavity of diameter R with center at B as shown. There is no charge in the cavity while the solid part has a uniform volume charge density ρ. Electric potential at the center of the sphere (at point A) is $V = \frac{k\rho R^2}{12\,\epsilon_0}$ (in SI units) where the value of k is



(A) 3 (B) 5 (C) 7 (D) 9

Solution · Q24 **Answer: (B)**

Superpose a full sphere of density ρ and a sphere of density −ρ filling the cavity.

Potential at A due to the full sphere:

$$V_1 = \frac{\rho R^2}{2\varepsilon_0}$$

Charge of the small sphere:

$$q = -\rho \times \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 = -\frac{\pi\rho R^3}{6}$$

A lies on the surface of this sphere.

$$V_2 = \frac{q}{4\pi\varepsilon_0\left(\frac{R}{2}\right)} = -\frac{\rho R^2}{12\varepsilon_0}$$

$$V = V_1 + V_2 = \frac{5\rho R^2}{12\varepsilon_0}$$

$$\therefore k = 5$$

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

25. Energy from the Sun falls on the Earth surface at the rate of 1400 W/m^2, which is known as solar constant. The respective rms values E_{rms} and B_{rms} of electric and magnetic fields in the sunlight (electromagnetic radiation) reaching Earth surface are (Take speed of light c = 3 × 10^8 ms^{-1})

(A) E_{rms} = 726.5 V/m, B_{rms} = 2.42 μT (B) E_{rms} = 7260 V/m, B_{rms} = 242 nT

(C) E_{rms} = 1030 V/m, B_{rms} = 3.42 μT (D) E_{rms} = 10300 V/m, B_{rms} = 342 nT

Solution · Q25 **Answer: (A)**

For an electromagnetic wave, the average intensity is

$$I = \varepsilon_0 c E_{rms}^2$$

$$\Rightarrow E_{rms} = \sqrt{I\mu_0 c}$$

$$E_{rms}^2 = 1400 \times (4\pi \times 10^{-7}) \times (3 \times 10^8)\ V^2/m^2$$

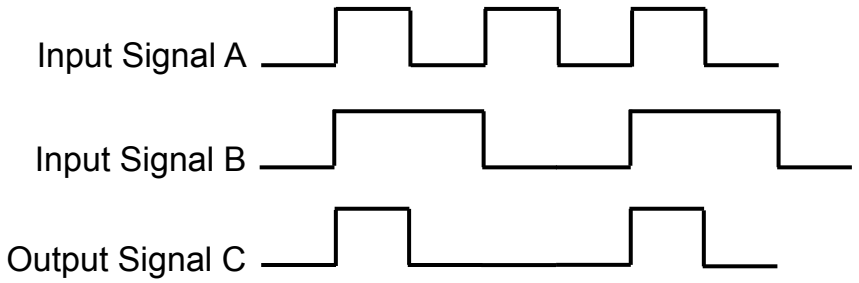
$$\Rightarrow E_{rms} \approx 726.5 \text{ V/m}$$

$$B_{rms} = \frac{E_{rms}}{c} = \frac{726.5}{3 \times 10^8} \text{ T}$$

$$\Rightarrow B_{rms} \approx 2.42 \ \mu\text{T}$$

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

26. The figure below depicts the voltage wave forms of binary input signals A and B and the output signal C of a certain logic gate.



The logic gate is

(A) AND (B) NAND (C) OR (D) XOR

Solution · Q26 **Answer: (A)**

Take a high level as 1 and a low level as 0. The successive time slots give these rows of the truth table:

$$(0, 0) \rightarrow C = 0$$

$$(1, 1) \rightarrow C = 1$$

$$(0, 1) \rightarrow C = 0$$

$$(1, 0) \rightarrow C = 0$$

The later slots repeat these results. The output is high only when both inputs are high.

$$C = A \cdot B$$

$\therefore$ It is an AND gate.

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

27. Two electric charges, +q at the origin O (0,0) and – 2q at the point A (6,0) are placed on x axis. The locus of the point P in x-y plane where the potential vanishes (V = 0) is

(A) a straight line perpendicular to x axis and passing through (2,0)

(B) only the point (2,0)

(C) a circle with center at (– 2,0) and radius 4

(D) an ellipse with foci at O and A

Solution · Q27 **Answer: (C)**

Let the distances of P from O and A be r_1 and r_2.

$$V = \frac{kq}{r_1} - \frac{2kq}{r_2} = 0$$

$$\Rightarrow r_2 = 2r_1$$

$$(x-6)^2 + y^2 = 4(x^2 + y^2)$$

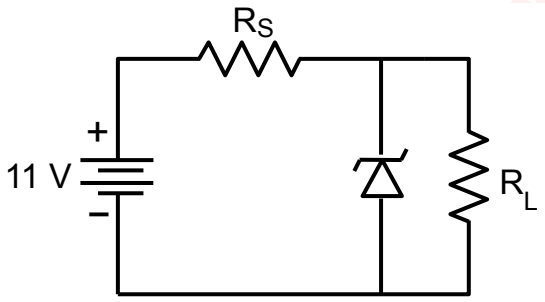
$$\Rightarrow x^2 + y^2 + 4x - 12 = 0$$

$$\Rightarrow (x+2)^2 + y^2 = 16$$

$\therefore$ The locus is a circle with centre $(-2, 0)$ and radius 4.

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

28. In the circuit shown, the Zener diode is an ideal one with breakdown voltage of 5.0 volt. The values of the resistances are $R_S = 10\ k\Omega$ and $R_L = 1\ k\Omega$. The current through the resistances, when the supply voltage is 11.0 V, is



(A) 0.6 mA through R_S and 5.0 mA through R_L

(B) 1.0 mA through R_S and 1.0 mA through R_L

(C) 1.1 mA through R_S and no current through R_L

(D) no current through R_S and 11 mA through R_L

Solution · Q28 **Answer: (B)**

First take the Zener diode as not conducting. By the potential divider rule, the load voltage is

$$V_L = 11.0 \times \frac{1}{10+1} = 1.0\ V$$

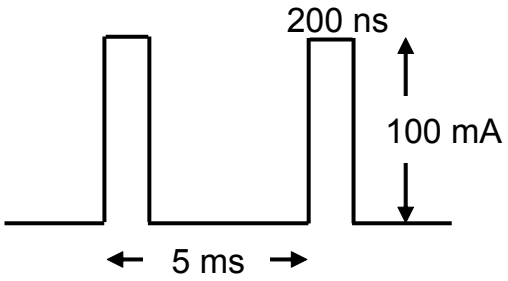
This is less than 5.0 V, so the diode draws no current.

$$I = \frac{11.0}{10+1}\ mA = 1.0\ mA$$

$\therefore$ 1.0 mA flows through both resistors.

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

29. In an accelerator the electrons are accelerated up to an energy of 50 MeV. The electrons do not emerge continuously from the accelerator rather they come in pulses at time interval of 5.0 milliseconds. Each pulse has a much shorter duration of 200 nanoseconds. Electron current during the pulse is 100 mA, while the current is zero between the two successive pulses (see figure), then



(A) the average current per pulse is 4 mA

(B) the peak value of power delivered by the electron beam is 50 MW

(C) the average power delivered by the electron beam is 200 W

(D) the average power delivered by the electron beam is 2 MW

Solution · Q29 **Answer: (C)**

Charge in one pulse:

$$Q = 0.100\ A \times 200 \times 10^{-9}\ s = 2.0 \times 10^{-8}\ C$$

Average current:

$$I_{avg} = \frac{Q}{T} = \frac{2.0 \times 10^{-8}}{5.0 \times 10^{-3}} = 4.0 \times 10^{-6}\ A$$

This is 4 μA, so (A) is false.

For an electron beam,

$$P = IV$$

$$V = 5.0 \times 10^{7}\ V$$

Peak power:

$$P_{peak} = 0.100 \times 5.0 \times 10^{7}\ W = 5\ MW$$

So (B) is false.

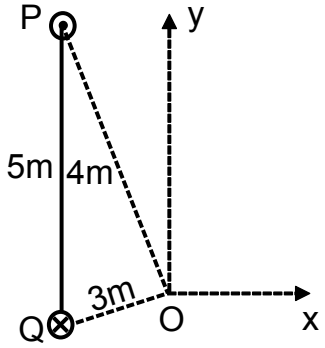
Average power:

$$P_{avg} = 4.0 \times 10^{-6} \times 5.0 \times 10^{7}\ W = 200\ W$$

∴ (C) is true and (D) is false.

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

30. Two infinitely long straight parallel wires perpendicular to the plane of the paper are 5 m apart. One of the wires, P carries current I out of the plane of the paper and the other, Q carries the current I into the plane of paper. The magnetic field B at the origin O of the coordinate system with x and y axes as perpendicular and parallel to PQ, respectively, is [Given OP = 4 m and OQ = 3 m]



(A) $\frac{\mu_0 I}{2\pi}\left(\hat{i} - \frac{3}{5}\hat{j}\right)$

(B) $\frac{\mu_0 I}{5\pi}\left(\hat{i} - \frac{7}{24}\hat{j}\right)$

(C) $\frac{\mu_0 I}{5\pi}\left(-\hat{i} + \frac{3}{8}\hat{j}\right)$

(D) $\frac{\mu_0 I}{24\pi}\left(2\hat{i} + 3\hat{j}\right)$

Solution · Q30 **Answer: (B)**

OP and OQ are perpendicular. With O as origin and the y axis parallel to PQ, the wire positions in metres are P(−2.4, 3.2), Q(−2.4, −1.8)

Field of P at O:

$$\vec{B}_1 = \frac{\mu_0 I}{2\pi \times 4}\left(\frac{4}{5}\hat{i} + \frac{3}{5}\hat{j}\right)$$

Field of Q at O:

$$\vec{B}_2 = \frac{\mu_0 I}{2\pi \times 3}\left(\frac{3}{5}\hat{i} - \frac{4}{5}\hat{j}\right)$$

Adding,

$$\vec{B} = \frac{\mu_0 I}{2\pi}\left(\frac{2}{5}\hat{i} - \frac{7}{60}\hat{j}\right)$$

$$\Rightarrow \vec{B} = \frac{\mu_0 I}{5\pi}\left(\hat{i} - \frac{7}{24}\hat{j}\right)$$

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

31. Charge q is uniformly distributed over the surface of a thin non-conducting annular disc of inner radius R_1 and outer radius R_2. The disc is made to rotate with constant frequency f, about an axis passing through the center of the annular disc and perpendicular to its plane. The magnetic moment of the disc is

(A) $\pi f q \frac{R_2^2 + R_1^2}{2}$

(B) $\pi f q \frac{R_2^2 - R_1^2}{2}$

(C) $\pi f q \frac{R_2^2 - R_1^2}{4}$

(D) $2\pi f q(R_2{}^2 - R_1{}^2)$

Solution · Q31 **Answer: (A)**

Surface charge density:

$$\sigma = \frac{q}{\pi\left(R_2^2 - R_1^2\right)}$$

A ring of radius r and width dr carries

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

It is equivalent to a current

$$dI = f\, dq$$

Its magnetic moment:

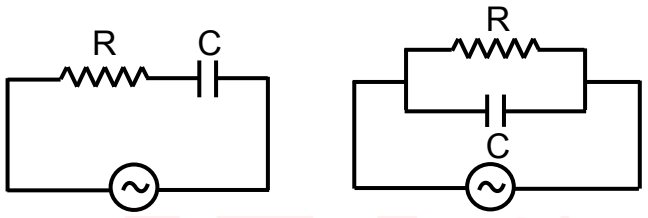
$$dM = \pi r^2\, dI = 2\pi^2 \sigma f r^3\, dr$$

$$\Rightarrow M = 2\pi^2\sigma f \int_{R_1}^{R_2} r^3 dr = \frac{\pi^2\sigma f}{2}\left(R_2^4 - R_1^4\right)$$

$$\therefore M = \pi f q \frac{R_2^2 + R_1^2}{2}$$

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

32. For a resistance R and capacitance C in series, the impedance is twice that of a parallel combination of the same elements when used with an AC voltage of frequency f. The frequency f of the applied emf is



(A) $f = 2\pi RC$

(B) $f = \frac{1}{2\pi RC}$

(C) $f = \frac{2\pi}{RC}$

(D) $f = \frac{1}{2\pi\sqrt{R^2 + C^2}}$

Solution · Q32 **Answer: (B)**

Capacitive reactance:

$$X = \frac{1}{2\pi fC}$$

For the series and parallel combinations,

$$Z_s = \sqrt{R^2 + X^2}$$

$$Z_p = \frac{RX}{\sqrt{R^2 + X^2}}$$

$$Z_s = 2Z_p$$

$$\Rightarrow R^2 + X^2 = 2RX$$

$$\Rightarrow (R - X)^2 = 0$$

$$\Rightarrow X = R$$

$$\therefore f = \frac{1}{2\pi RC}$$

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

33. In an experiment on photoelectric effect on a metal surface, one finds a stopping potential of 1.8 V for the wavelength of 300 nm and a stopping potential of 0.9 V for the wavelength of 400 nm. The cutoff wavelength λ_0 (the maximum wavelength that can produce photoelectric effect) for the metal is

(A) 500 nm (B) 550 nm (C) 600 nm (D) 750 nm

Solution · Q33 **Answer: (C)**

By Einstein's photoelectric equation,

$$eV_s = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

The two readings do not fit the accepted value of hc exactly, so it is eliminated. With wavelengths in nm, dividing their equations gives

$$\frac{1}{300} - \frac{1}{\lambda_0} = 2\left(\frac{1}{400} - \frac{1}{\lambda_0}\right)$$

$$\Rightarrow \frac{1}{\lambda_0} = \frac{2}{400} - \frac{1}{300} = \frac{1}{600}$$

$$\therefore \lambda_0 = 600 \text{ nm}$$

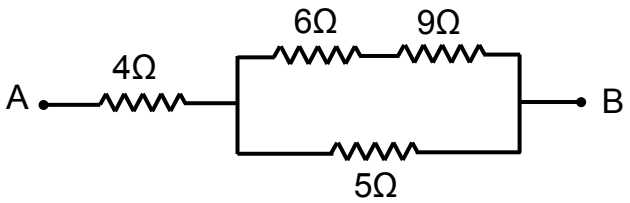
IAPT answer: (C) | **Zigyan answer:** (C)

34. Given that the power dissipated in 5 Ω resistance is 7.2 W in the circuit shown.

Statement (1): Power dissipated in 6 Ω resistance is 6 W.

Statement (2): Potential difference V_{AB} between A and B is V_{AB} = 12.4 V

Then



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

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

(C) Both statements (1) and (2) are wrong

(D) Both statements (1) and (2) are correct

Solution · Q34 **Answer: (B)**

For the 5 Ω resistor,

$$V^2 = PR = 7.2 \times 5 = 36$$

$$\Rightarrow V = 6.0 \text{ V}$$

The same voltage is across the series pair of 6 Ω and 9 Ω.

$$I = \frac{6.0}{15} = 0.40 \text{ A}$$

Power in the 6 Ω resistor:

$$P = (0.40)^2 \times 6 \text{ W} = 0.96 \text{ W}$$

So statement (1) is wrong.

Current through the 5 Ω resistor:

$$\frac{6.0}{5} = 1.2\ \text{A}$$

Current through the 4 Ω resistor:

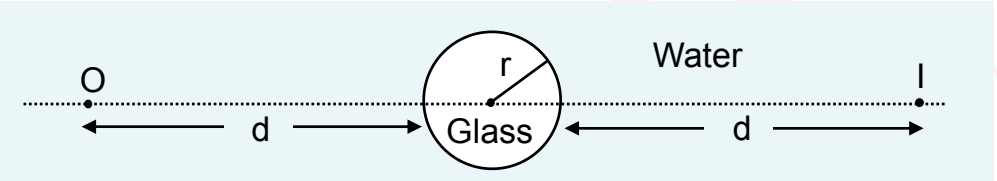
$$1.2\ \text{A} + 0.40\ \text{A} = 1.6\ \text{A}$$

$$\Rightarrow V_{AB} = 1.6 \times 4\ \text{V} + 6.0\ \text{V} = 12.4\ \text{V}$$

∴ Only statement (2) is correct.

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

35. A transparent and homogeneous sphere of glass of radius r is immersed in water (refractive indices of glass and water being ${}_a\mu_g = \frac{3}{2}$ and ${}_a\mu_w = \frac{4}{3}$). The image of a point object O, located at distance d on its axis in front of the sphere, is formed at point I at the same distance d from the sphere on the opposite side as shown.



The distance d is equal to

(A) 2r (B) 3r (C) 6r (D) 8r

Solution · Q35 **Answer: (D)**

Object and image are symmetrically placed, so by reversibility the rays inside the sphere are parallel to the axis.

For paraxial rays, at the first refraction (water to glass):

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$u = -d$, $R = r$, $v = \infty$

$$\frac{n_1}{d} = \frac{n_2 - n_1}{r}$$

$$\Rightarrow d = \frac{n_1 r}{n_2 - n_1}$$

$$\Rightarrow d = \frac{(4/3)r}{3/2 - 4/3}$$

$$\therefore d = 8r$$

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

36. A certain substance, with a dielectric constant k = 2.5 and the dielectric strength E = 1.8×10^7 N/C, completely fills the space between the plates of a parallel plate capacitor (with circular plates) of capacitance C = 72.0 nF. The minimum diameter of the circular plates, to ensure that the capacitor can withstand a potential difference of V = 4.0 kV, is

(A) 12 cm (B) 24 cm (C) 48 cm (D) 96 cm

Solution · Q36 **Answer: (D)**

The dielectric strength limits the field, so the minimum plate separation is

$$d = \frac{V}{E} = \frac{4.0 \times 10^3}{1.8 \times 10^7} \approx 2.22 \times 10^{-4}\ \text{m}$$

$$C = \frac{k\varepsilon_0 A}{d}$$

$$\Rightarrow A = \frac{Cd}{k\varepsilon_0}$$

$$\Rightarrow A = \frac{72.0 \times 10^{-9} \times 2.22 \times 10^{-4}}{2.5 \times 8.85 \times 10^{-12}} \approx 0.723\ \text{m}^2$$

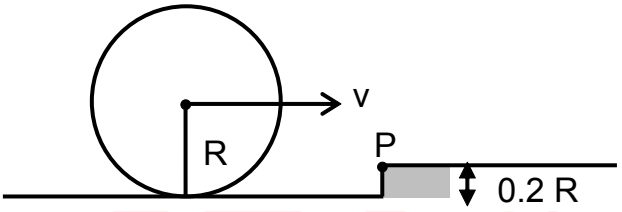
For a circular plate,

$$D = \sqrt{\frac{4A}{\pi}} \approx 0.96\ \text{m}$$

$$\therefore D \approx 96\ \text{cm}$$

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

37. A uniform solid sphere of radius R rolls without slipping on a rough horizontal surface with a forward velocity v of its center. On its way, it suddenly encounters a small step of height 0.2 R as shown. The angular velocity of the sphere just after the impact is [given that the sphere does not bounce back, rather it goes ahead up the step]



(A) $\frac{v}{7R}$ (B) $\frac{3v}{7R}$

(C) $\frac{6v}{7R}$ (D) $\frac{v}{R}$

Solution · Q37 **Answer: (C)**

The impact force acts at the edge P, and other angular impulses about P are negligible. So angular momentum about P is conserved.

Just before the impact:

$$L_i = mv(0.8R) + \frac{2}{5}mvR = \frac{6}{5}mvR$$

Just after it, the sphere turns about P.

$$I_P = \frac{2}{5}mR^2 + mR^2 = \frac{7}{5}mR^2$$

$$\frac{7}{5}mR^2\omega = \frac{6}{5}mvR$$

$$\therefore \omega = \frac{6v}{7R}$$

Check: split the impulse at P along the line from P to the centre and across it. Only the part J across that line changes the spin. J raises the centre's speed across the line from 0.8v to ωR and lowers the spin from v divided by R to ω. Eliminating J between these two changes again gives ω as 6v divided by 7R.

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

38. The magnetic field (B) produced by the current i flowing through the sides of a square loop of side ℓ, at a point P at distance x from the center of the square, on the axis perpendicular to the plane of the square loop and passing through its center, is

(A) $B = \frac{\mu_0 i}{4\pi} \frac{2\sqrt{2}\,\ell^2}{\left(4x^2+\ell^2\right)\sqrt{2x^2+\ell^2}}$

(B) $B = \frac{\mu_0 i}{4\pi} \frac{4\sqrt{2}\,\ell x}{\left(x^2+\ell^2\right)\sqrt{2x^2+\ell^2}}$

(C) $B = \frac{\mu_0 i}{4\pi} \frac{4\times 2\sqrt{2}\,\ell^2}{\left(4x^2+\ell^2\right)\sqrt{2x^2+\ell^2}}$

(D) $B = \frac{\mu_0 i}{4\pi} \frac{4\sqrt{2}\,\ell x}{\left(4x^2+\ell^2\right)\sqrt{x^2+\ell^2}}$

Solution · Q38 **Answer: (C)**

For one side, P is at this perpendicular distance:

$$d = \sqrt{x^2 + \frac{\ell^2}{4}}$$

Field of one side:

$$B_1 = \frac{\mu_0 i}{4\pi d} \frac{\ell}{\sqrt{x^2 + \ell^2/2}}$$

Only the axial parts survive. The axial part of one side is

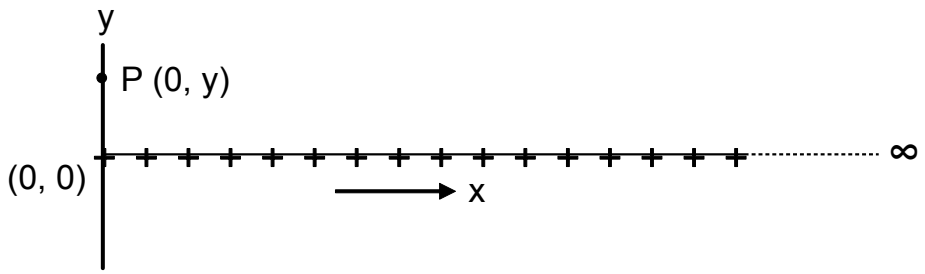
$$B_{axial} = B_1 \frac{\ell}{2d}$$

$$\Rightarrow B = 4B_{axial} = \frac{\mu_0 i}{4\pi} \frac{2\ell^2}{d^2\sqrt{x^2+\ell^2/2}}$$

$$\therefore B = \frac{\mu_0 i}{4\pi} \frac{4\times 2\sqrt{2}\,\ell^2}{\left(4x^2+\ell^2\right)\sqrt{2x^2+\ell^2}}$$

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

39. A linear positive charge distribution, with linear charge density λ coulomb per meter, extends along +x - axis from x = 0 to x = ∞.



The electric field $\vec{E}$ at any point P (0, y) on the y – axis

(A) is proportional to $\frac{\lambda}{y^2}$ irrespective of whether y is positive or negative.

(B) is always directed away and perpendicular to the line of charge.

(C) has a vanishing component parallel to the line of charge.

(D) is directed along a straight line of slope m = −1 if y is positive but along a line of slope m = +1 if y is negative.

Solution · Q39 **Answer: (D)**

For an element of charge λ dx at distance x along the line:

$$E_x = -\frac{\lambda}{4\pi\varepsilon_0}\int_0^{\infty}\frac{x\,dx}{(x^2+y^2)^{3/2}}$$

$$\Rightarrow E_x = -\frac{\lambda}{4\pi\varepsilon_0|y|}$$

$$E_y = \frac{\lambda}{4\pi\varepsilon_0}\int_0^{\infty}\frac{y\,dx}{(x^2+y^2)^{3/2}}$$

$$\Rightarrow E_y = \frac{\lambda}{4\pi\varepsilon_0 y}$$

The two components are equal in size, so the field makes 45° with the line.

The slope of the field line is therefore −1 for positive y and +1 for negative y.

∴ (D) is correct.

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

40. Imagine a situation, in which an infinite sheet with positive charge + σ per unit area lies in the xy-plane and a second infinite sheet with negative charge − σ per unit area lies in the yz-plane. The net electric field E at any point (x, y, z) [that does not lie on either of these planes xy or yz] can be expressed as

(A) $\vec{E} = \frac{\sigma}{2\epsilon_0}\left(-\hat{i}+\hat{k}\right)$

(B) $\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{j}$

(C) $\vec{E} = \frac{\sigma}{2\epsilon_0}\left[-\frac{x}{|x|}\hat{i}+\frac{z}{|z|}\hat{k}\right]$

(D) $\vec{E} = \frac{\sigma}{\epsilon_0}\left[\frac{x}{|x|}\hat{i}-\frac{z}{|z|}\hat{k}\right]$

Solution · Q40 **Answer: (C)**

Field of the positive sheet (xy-plane):

$$\vec{E}_1 = \frac{\sigma}{2\varepsilon_0}\frac{z}{|z|}\hat{k}$$

Field of the negative sheet (yz-plane):

$$\vec{E}_2 = -\frac{\sigma}{2\varepsilon_0}\frac{x}{|x|}\hat{i}$$

By superposition,

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\left[-\frac{x}{|x|}\hat{i}+\frac{z}{|z|}\hat{k}\right]$$

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

41. For the electric field E, in a region of space where a non-uniform, but spherically symmetric distribution of charge has a charge density ρ(r) as

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

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

one can say that

(A) E = 0 : both at r = 0 and r = R

(B) $E \propto r$ for $r < R$ and $E \propto \frac{1}{r^2}$ for $r \ge R$

(C) the magnitude of E increases with r and reaches its maximum at $r = \frac{2R}{3}$

(D) the maximum electric field produced by the given charge distribution is $E_{max} = \frac{\rho_0 R}{3\epsilon_0}$

Solution · Q41 **Answer: (C)**

Charge enclosed within a radius r inside the sphere:

$$Q(r) = \int_0^r \rho_0\left(1 - \frac{s}{R}\right)4\pi s^2 ds$$

By Gauss's law,

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

The field is not zero at the surface, so (A) is false. Inside, it is not proportional to the radius, so (B) is false.

For the maximum,

$$\frac{dE}{dr} = \frac{\rho_0}{\varepsilon_0}\left(\frac{1}{3} - \frac{r}{2R}\right) = 0$$

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

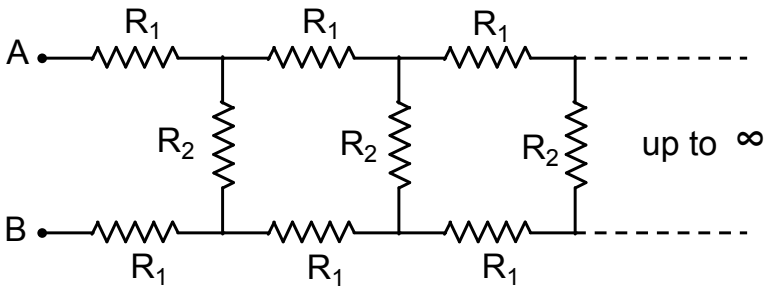
$\therefore$ (C) is true.

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

So (D) is false.

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

42. A typical network of resistances R_1 and R_2 shown below extends to infinity towards the right. The total resistance $R_{effective}$ of this network between points A and B is



(A) $R_{effective} = R_1 + \sqrt{R_1^2 + 2R_1R_2}$

(B) $R_{effective} = R_2 + \sqrt{R_1^2 + 2R_1R_2}$

(C) $R_{effective} = R_1 + \sqrt{3R_1R_2}$

(D) $R_{effective} = R_1 + \sqrt{R_2^2 + 2R_1R_2}$

Solution · Q42 **Answer: (A)**

Let the resistance between A and B be X. The infinite chain beyond the first rung also has resistance X.

$$X = 2R_1 + \frac{R_2X}{R_2 + X}$$

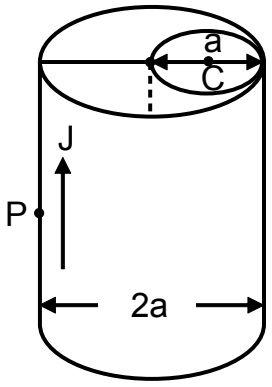
$$\Rightarrow X^2 - 2R_1X - 2R_1R_2 = 0$$

Taking the positive root,

$$X = R_1 + \sqrt{R_1^2 + 2R_1R_2}$$

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

43. A cylindrical cavity of diameter 'a' exists inside a long solid cylinder of diameter '2a' as shown in figure. Both the cylinder and the cavity are taken to be infinitely long. The axis of the cavity is parallel to the axis of the cylinder and is at a distance $\frac{a}{2}$ from it. A uniform current of current density J (Am^{-2}) flows through the cylinder along its length and not through the cavity. The magnitude of the magnetic field at a point P on the surface of the cylinder lying farthest from the axis of the cavity, is



(A) $B = \frac{3}{8}\frac{\mu_0 J}{a}$

(B) $B = \frac{3}{4}\mu_0 Ja$

(C) $B = \frac{3}{8}\mu_0 Ja$

(D) $B = \frac{5}{12}\mu_0 Ja$

Solution · Q43 **Answer: (D)**

Take a full cylinder with current density J, plus a cylinder filling the cavity with current density −J.

Field of the full cylinder at P:

$$B_1 = \frac{\mu_0 Ja}{2}$$

P is outside the cavity cylinder, at this distance from its axis:

$$\frac{3a}{2}$$

$$B_2 = \frac{\mu_0 J(a/2)^2}{2(3a/2)} = \frac{\mu_0 Ja}{12}$$

The two fields are opposite.

$$B = B_1 - B_2$$

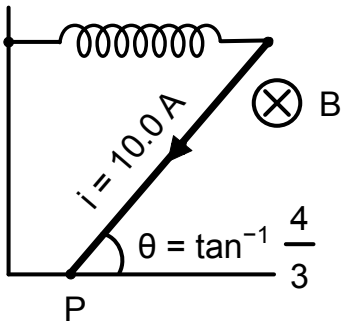
$$\therefore B = \frac{5}{12}\mu_0 Ja$$

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

44. A thin uniform rod, of length ℓ = 0.200 m with negligible mass, is attached to the floor by a frictionless hinge at a fixed point P. A horizontal spring connects the other end of the rod to a vertical wall. The rod is in a uniform magnetic field B = 0.500 tesla directed into the plane of paper. There is a current i = 10.0 A in the rod in the direction shown. Force constant of the spring is 5.00 N/m. The rod is in equilibrium at $\theta = \tan^{-1}\frac{4}{3}$

Statement (1) Torque on the rod due to magnetic force is 0.1 Nm clockwise

Statement (2) In equilibrium the energy stored in the spring is 0.039 J



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

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

(C) Both statements (1) and (2) are wrong

(D) Both statements (1) and (2) are correct

Solution · Q44 **Answer: (D)**

Magnetic force on the rod:

$$F = i\ell B = 10.0 \times 0.200 \times 0.500\ \text{N} = 1.00\ \text{N}$$

It acts at the midpoint. Its torque about P is

$$\tau = 1.00 \times 0.100\ \text{N m} = 0.100\ \text{N m}$$

This torque is clockwise, so statement (1) is correct.

Height of the upper end above P:

$$\sin\theta = 0.8$$

$$0.200 \times 0.8 \text{ m} = 0.160 \text{ m}$$

Balancing the torques,

$$kx \times 0.160 = 0.100$$

$$\Rightarrow x = 0.125 \text{ m}$$

$$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 5.00 \times (0.125)^2 \text{ J}$$

$$\Rightarrow U \approx 0.039 \text{ J}$$

$\therefore$ Both statements are correct.

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

45. The electric flux through a certain area of a dielectric medium is $\phi = (8.00 \times 10^3)\, t^4$ in SI units. The displacement current through that area is 12.5 pA at a time t = 20.0 ms. The dielectric constant of the dielectric medium is

(A) 22.1 (B) 5.52 (C) 55.2 (D) 2.76

Solution · Q45 **Answer: (B)**

Displacement current:

$$I_d = K\varepsilon_0 \frac{d\varphi}{dt}$$

$$\frac{d\varphi}{dt} = 3.20 \times 10^4 t^3$$

At the given instant,

$$t = 2.00 \times 10^{-2} \text{ s}$$

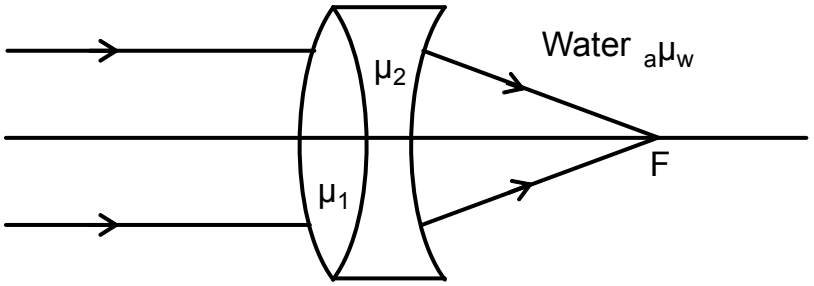
$$\frac{d\varphi}{dt} = 0.256 \text{ V m s}^{-1}$$

$$\Rightarrow K = \frac{12.5 \times 10^{-12}}{8.85 \times 10^{-12} \times 0.256}$$

$$\therefore K = 5.52$$

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

46. A thin equi-convex lens of flint glass (refractive index μ_1) is kept coaxially in contact with another thin equi-concave lens of crown glass (refractive index μ_2). The system is completely immersed in water $\left({}_a\mu_w = \frac{4}{3}\right)$.



Parallel rays of light incident parallel to the principal axis in water are focused by this system at a distance of 24 cm beyond the system. The thickness of the system is negligible. If the radius of curvature of each surface is R = 20 cm, the difference $(\mu_1 - \mu_2)$ is

(A) $\frac{2}{9}$ (B) $\frac{3}{9}$
(C) $\frac{4}{9}$ (D) $\frac{5}{9}$

Solution · Q46 **Answer: (D)**

Focal lengths of the two lenses in water:

$$\frac{1}{f_1} = \left(\frac{\mu_1}{\mu_w} - 1\right)\frac{2}{R}$$

$$\frac{1}{f_2} = -\left(\frac{\mu_2}{\mu_w} - 1\right)\frac{2}{R}$$

For lenses in contact,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{2}{R}\frac{\mu_1 - \mu_2}{\mu_w}$$

$$\frac{1}{24} = \frac{2}{20} \times \frac{3}{4}(\mu_1 - \mu_2)$$

$$\therefore \mu_1 - \mu_2 = \frac{5}{9}$$

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

47. Two identical large thin metal plates carrying charges $+q_1$ and $+q_2$ $(q_1 > q_2)$, respectively, are kept close at a distance d apart and parallel to each other to form a parallel plate capacitor of capacitance C. The potential difference between the plates is

(A) $\frac{q_1 - q_2}{C}$ (B) $\frac{q_1 - q_2}{2C}$
(C) $\frac{q_1 - q_2}{4C}$ (D) $\frac{q_1 + q_2}{2C}$

Solution · Q47 **Answer: (B)**

Let the inner faces carry +q and −q. The outer faces then carry

$q_1 - q$ and $q_2 + q$

The field inside the metal of a plate is zero, which requires

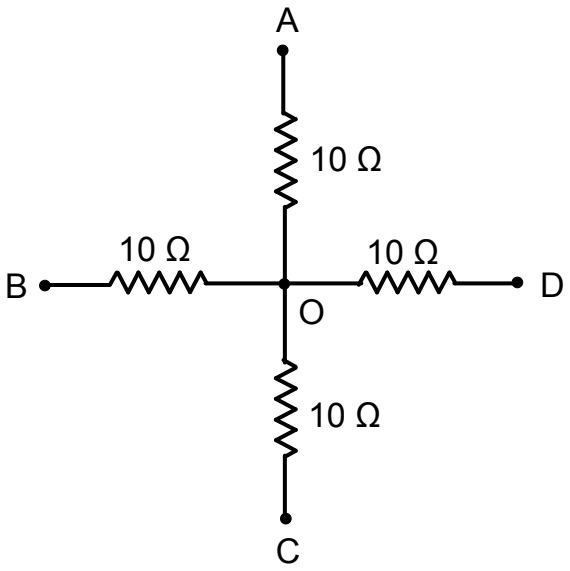
$$q_1 - q = q_2 + q$$

$$\Rightarrow q = \frac{q_1 - q_2}{2}$$

$$\therefore V = \frac{q}{C} = \frac{q_1 - q_2}{2C}$$

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

48. In a certain electrical network, the three nodes A, B and C are each at a potential of 1.0 volt while the node D is at a potential 2.0 volt. The potential at the Node O in volt is



(A) $\frac{3}{2}$ (B) $\frac{4}{3}$

(C) $\frac{5}{4}$ (D) $\frac{6}{5}$

Solution · Q48 **Answer: (C)**

Let the potential of O be V. By Kirchhoff's current law,

$$3 \times \frac{V-1}{10} + \frac{V-2}{10} = 0$$

$$\Rightarrow 4V = 5$$

$$\therefore V = \frac{5}{4} \text{ volt}$$

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

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

49. A thin uniform metallic rod, of length ℓ = 1.0 m and area of cross section A = 2 mm^2, is made to rotate with angular velocity ω = 400 rad/s in a horizontal plane about a vertical axis through one of its ends. The density and the Young's modulus of the material of the rod are $\rho = 10^4$ kg m^{-3} and Y = 2.0 × 10^{11} Nm^{-2}. Taking r as the distance of a point on the rod from the axis of rotation, the

(A) tension at midpoint of the rod is T = 1200 N.

(B) tension in the rod varies with distance r from the axis of rotation as T = 1600 r^2 N

(C) stress in the rod at r = 0.5 m is 3.0 × 10^8 Nm^{-2}

(D) elongation of the rod is $\frac{8}{3}$ mm

Solution · Q49 **Answer: (A), (D)**

$$T = \int_r^{\ell} \rho A \omega^2 x dx = \frac{1}{2}\rho A \omega^2 \left(\ell^2 - r^2\right)$$

$$\Rightarrow T = 1600(1 - r^2)\ \text{N}$$

(A) At the midpoint,

$$T = 1600 \times 0.75\ \text{N} = 1200\ \text{N}$$

$\therefore$ (A) is true and (B) is false.

(C) Stress at that point:

$$\sigma = \frac{1200}{2 \times 10^{-6}} = 6.0 \times 10^8\ \text{N m}^{-2}$$

$\therefore$ (C) is false.

(D) Elongation:

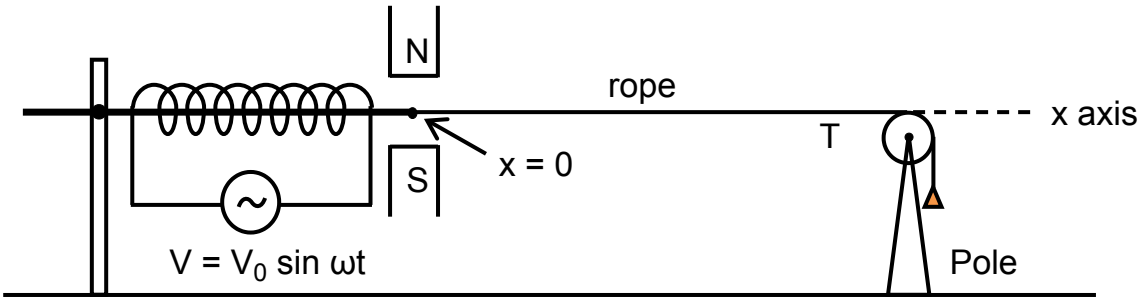
$$\Delta\ell = \frac{1}{AY}\int_0^{\ell} T dr = \frac{\rho\omega^2\ell^3}{3Y}$$

$$\Rightarrow \Delta\ell = \frac{8}{3} \times 10^{-3}\ \text{m}$$

$\therefore$ (D) is true.

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

50. One end of a long and thin rope, stretched horizontally with a tension T = 8 N, along x axis, is supporting a weight after passing over a pulley fixed on a vertical pole (see figure). At the other end, a simple harmonic oscillator (a clamped iron rod along the axis of a solenoid fed with AC voltage and oscillating between north and south poles) at x = 0, generates a transverse wave of frequency 100 Hz and an amplitude of 2 cm, in the rope. The wave propagates along the rope. The mass per unit length of the rope is 20 g/m. Ignoring the effect of gravity (on the rope), the correct option(s) is /are



(A) Wavelength of the transverse wave is 20 cm.

(B) Maximum magnitude of transverse acceleration of any point on the rope is nearly 800 ms^{-2}

(C) If the oscillator produces maximum negative displacement at x = 0 at time t = 0, the equation of the wave can be expressed as $y(x, t) = -0.02 \sin[10\pi x - 100\pi t]$ in SI units.

(D) Tension in the given rope remaining unchanged, if a harmonic oscillator of frequency 200 Hz is used (instead of earlier frequency 100 Hz), the wavelength will be 10 cm.

Solution · Q50 **Answer: (A), (D)**

Wave speed:

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8}{0.020}} = 20 \text{ m/s}$$

$$\text{(A) } \lambda = \frac{v}{f} = \frac{20}{100} = 0.20 \text{ m}$$

$\therefore$ (A) is true.

$$\text{(B) } a_{max} = \omega^2 y_0 = (200\pi)^2 \times 0.020$$

$$\Rightarrow a_{max} = 800\pi^2 \text{ m s}^{-2}$$

$\therefore$ (B) is false.

(C) The correct wave equation is

$$y = -0.02 \cos(10\pi x - 200\pi t)$$

$\therefore$ (C) is false.

$$\text{(D) } \lambda = \frac{20}{200} = 0.10 \text{ m}$$

$\therefore$ (D) is true.

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

51. Nuclei of a radioactive element A are being produced at a constant rate α. The element A has a decay constant λ. If there are N_0 nuclei at t = 0, then

(A) number of nuclei N(t), at time t, is $N(t) = \frac{1}{\lambda}\left[(\alpha - \lambda N_0)e^{-\lambda t}\right]$

(B) if $\alpha = \lambda N_0$, the number of nuclei N(t) at any time t will remain constant

(C) if $\alpha = 2\lambda N_0$ then $N(t) = 2N_0$ as $t \to \infty$

(D) if $\alpha = 2\lambda N_0$, the number of nuclei N(t) after one half-life of A is $N\left(\frac{T}{2}\right) = \frac{3}{2}N_0$

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

$$\frac{dN}{dt} = \alpha - \lambda N$$

$$\Rightarrow N(t) = \frac{1}{\lambda}\left[\alpha - (\alpha - \lambda N_0)e^{-\lambda t}\right]$$

(A) The printed expression does not match this, so (A) is false.

(B) If production balances decay,

$$\alpha = \lambda N_0$$

$$\Rightarrow N = N_0$$

∴ (B) is true.

(C) For the other case,

$$\alpha = 2\lambda N_0$$

$$\Rightarrow N(t) = 2N_0 - N_0 e^{-\lambda t}$$

For very large t,

$N \to 2N_0$

∴ (C) is true.

(D) The time here is read as one half-life.

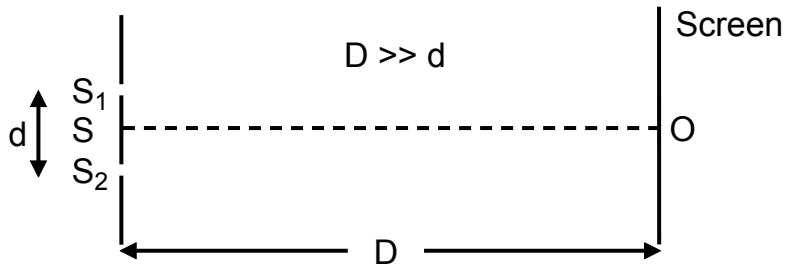
$$N = 2N_0 - \frac{N_0}{2} = \frac{3}{2}N_0$$

∴ (D) is true.

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

52. In Young's double slit experiment, a fine beam of coherent monochromatic light of wavelength λ = 600 nm is incident on identical slits S_1 and S_2 at separation d. The intensity at the central maximum formed at O is I_{max} and the angular fringe width is β = 0.1°. When a thin transparent film is placed in front of the slit S_2, the intensity at O changes. It is found that the smallest thickness of the film, for which the intensity at O becomes half the maximum intensity $\left(\text{i.e. } \frac{I_{max}}{2}\right)$, is 250 nm. Neglecting the absorption of light by the film, the zero order fringe earlier at O now forms at O′ where OO′ = 0.5 mm.

Choose correct option(s)



(A) The refractive index of the film is 1.6

(B) The fringe width near O is 2 mm

(C) On the screen, O′ is above O

(D) The distance D of the screen from the double slit is nearly 1.15 m

Solution · Q52 **Answer: (A), (B), (D)**

(A) For half the maximum intensity at O, the least path difference is a quarter wavelength.

$$(\mu - 1) \times 250 = \frac{600}{4}$$

$$\Rightarrow \mu = 1.6$$

∴ (A) is true.

(B) A quarter-wavelength path shifts the pattern by a quarter of the fringe width w.

$$w = 4 \times 0.5 \text{ mm} = 2 \text{ mm}$$

∴ (B) is true.

(C) The pattern shifts towards the covered lower slit, so O′ lies below O. Hence (C) is false.

(D) Using the angular width in radians,

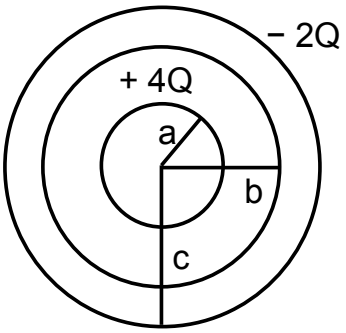
$$\beta = 0.1° = 1.745 \times 10^{-3} \text{ rad}$$

$$\Rightarrow D = \frac{w}{\beta} = \frac{2.0 \times 10^{-3}}{1.745 \times 10^{-3}} \approx 1.15 \text{ m}$$

∴ (D) is true.

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

53. An insulated non-conducting solid sphere of radius 'a', carrying a positive charge +4Q uniformly distributed throughout its volume, is surrounded by a concentric thick conducting spherical shell of inner radius b and outer radius c. This thick shell carries a negative charge – 2Q (see figure). The correct option(s) is/are



(A) Electric field strength at distance r (r < a) from the center is $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{4Q}{a^3}\vec{r}$

(B) Charge on the inner surface of the conducting spherical shell is + 2Q

(C) Charge on the outer surface of the conducting spherical shell is + 2Q

(D) Electrical energy stored in region 0 < r < a [i.e. in the inner sphere] is $\frac{2Q^2}{5\pi\epsilon_0 a}$

Solution · Q53 — **As per Zigyan: (A), (C), (D)**

(A) By Gauss's law, for a point inside the sphere,

$$E = \frac{4Qr}{4\pi\varepsilon_0 a^3}$$

This field is radially outward, and the printed permittivity symbol means ε_0. So (A) is true.

(B) The field inside the metal is zero, so the inner surface carries −4Q. Hence (B) is false.

(C) Charge on the outer surface:

$$-2Q - (-4Q) = +2Q$$

∴ (C) is true.

(D) Energy stored inside the sphere:

$$U = \int_0^a \frac{1}{2}\varepsilon_0 E^2 4\pi r^2 dr$$

$$\Rightarrow U = \frac{2Q^2}{5\pi\varepsilon_0 a}$$

∴ (D) is true.

Reference: NCERT Physics Class XII (Part I), Chapter 1 'Electric Charges and Fields', section 1.13: the electric flux through a closed surface equals the charge inside it divided by ε_0. This is the law that settles (A).

Check: for (D), the whole self-energy of the charged sphere by itself, $3(4Q)^2$ divided by $20\pi\varepsilon_0 a$, less the field energy outside it, $(4Q)^2$ divided by $8\pi\varepsilon_0 a$, leaves the value in (D).

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

54. A single electron orbits around a stationary nucleus of charge +Ze in a hydrogen-like atom, where Z is the atomic number and e is the magnitude of the charge on an electron. It requires 47.25 eV to excite the electron from second Bohr orbit to the third Bohr orbit. Ionization energy of hydrogen atom is 13.6 eV. Then

(A) the value of Z is 5

(B) the energy required to excite the electron from the 3rd orbit to the 4th orbit is 16.53 eV (nearly)

(C) the wavelength of electromagnetic radiation required to liberate the electron completely when in the first Bohr orbit is 36.56 Å

(D) the angular momentum of an electron in the second Bohr orbit is 1.056×10^{-33} Js

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

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

$$\text{(A)}\ 13.6Z^2\left(\frac{1}{4}-\frac{1}{9}\right) = 47.25$$

$$\Rightarrow Z = 5$$

$\therefore$ (A) is true.

$$\text{(B)}\ 13.6 \times 25\left(\frac{1}{9}-\frac{1}{16}\right) = 16.53\ \text{eV}$$

$\therefore$ (B) is true.

(C) Ionisation energy from the first orbit:

$$13.6 \times 25\ \text{eV} = 340\ \text{eV}$$

With rounded constants,

$$\lambda = \frac{hc}{E} = \frac{12431}{340} = 36.56\ \text{Å}$$

So (C) is accepted as true; more precise constants give about 36.5 Å.

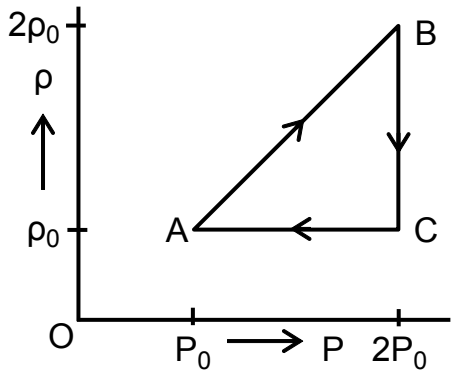
$$\text{(D)}\ L = \frac{2h}{2\pi} = \frac{h}{\pi}$$

$$\Rightarrow L \approx 2.11 \times 10^{-34}\ \text{J s}$$

$\therefore$ (D) is false.

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

55. One mole of an ideal monoatomic gas of molecular mass M undergoes a cyclic process (ABCA) shown in the figure as a density (ρ) versus pressure (P) curve. The correct option(s) is/are



(A) Work done on the gas in going from A to B is $W_{AB} = \frac{MP_0}{\rho_0}\ell n\, 2$

(B) Work done by the gas in the process BC is $W_{BC} = \frac{MP_0}{2\rho_0}$

(C) Efficiency (η) of the complete cycle ABCA is $\eta = \frac{2}{5}(1 - \ell n\, 2)$

(D) Heat rejected by the gas in the complete cycle ABCA is $Q_{ABCA} = \frac{MP_0}{\rho_0}(1 - \ell n\, 2)$

Solution · Q55 **Answer: (A), (C)**

From the graph, AB is isothermal, BC is isobaric and CA is isochoric. For temperature T_0 at A,

$$RT_0 = \frac{MP_0}{\rho_0}$$

(A) Work done on the gas along AB:

$$W_{AB} = RT_0 \ln 2$$

∴ (A) is true.

$$\text{(B) } W_{BC} = 2P_0\left(\frac{M}{\rho_0} - \frac{M}{2\rho_0}\right) = \frac{MP_0}{\rho_0}$$

∴ (B) is false.

(C) Heat is absorbed only along BC.

$$Q_{BC} = 2.5RT_0$$

$$\Rightarrow \eta = \frac{RT_0(1 - \ln 2)}{2.5RT_0} = \frac{2}{5}(1 - \ln 2)$$

∴ (C) is true.

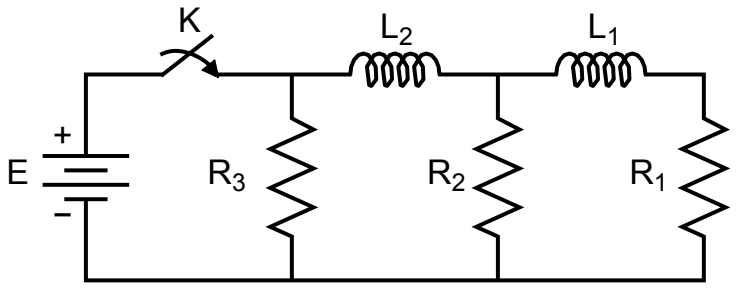
(D) Heat rejected along AB and CA:

$$Q_{out} = RT_0(1.5 + \ln 2)$$

The printed expression is only the net heat, so (D) is false.

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

56. Two ideal inductors $L_1 = L_2 = L$ and three identical resistors $R_1 = R_2 = R_3 = R$ have been connected to a DC source of emf E as shown in the circuit. When the key K is kept pressed (closed) for a long time, the current through the resistance R_1 on the extreme right is measured to be I. Immediately after releasing (switching off) the key, the current through the resistors is



(A) I downwards in R_1

(B) I downwards in R_2

(C) 2I upwards in R_3

(D) zero in each R_1, R_2 and R_3

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

In the steady state each inductor acts as a wire, and each resistor carries current I downwards. The inductor currents are then

$$I_{L_1} = I$$

$$I_{L_2} = 2I$$

Just after release these currents cannot change.

(A) R_1 still carries I downwards, so (A) is true.

(B) By the junction rule, R_2 carries this current downwards:

$$2I - I = I$$

$\therefore$ (B) is true.

(C) R_3 must now supply the whole current of L_2, which is 2I upwards. So (C) is true.

(D) The currents do not vanish at once, so (D) is false.

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

57. A particle of mass m moves along x axis with its potential energy as $U(x) = \frac{\alpha}{x^2} - \frac{\beta}{x}$ where α and β are positive constants. The particle is released from rest at $x_0 = \frac{\alpha}{\beta}$. Then

(A) U(x) can be expressed as $U(x) = \frac{\alpha}{x_0^2}\left[\left(\frac{x_0}{x}\right)^2 - \frac{x_0}{x}\right]$

(B) velocity of the particle v(x) as a function of x can be expressed as $v(x) = \left[\frac{2\alpha}{mx_0^2}\left\{\frac{x_0}{x} - \left(\frac{x_0}{x}\right)^2\right\}\right]^{1/2}$

(C) the maximum speed of the particle is $v_{max} = \sqrt{\frac{\alpha}{2mx_0^2}}$

(D) the total energy of the particle KE(x) + U(x) is zero

Solution · Q57 **Answer: (A), (B), (C), (D)**

$$x_0 = \frac{\alpha}{\beta}$$

$$\text{(A) } U = \frac{\alpha}{x^2} - \frac{\alpha}{x_0 x} = \frac{\alpha}{x_0^2}\left[\left(\frac{x_0}{x}\right)^2 - \frac{x_0}{x}\right]$$

$\therefore$ (A) is true.

(D) At the release point,

$$U = 0 \text{ and } K = 0$$

So the total energy is always zero; (D) is true.

$$\text{(B) } \frac{1}{2}mv^2 = -U$$

$$\Rightarrow v^2 = \frac{2\alpha}{mx_0^2}\left[\frac{x_0}{x} - \left(\frac{x_0}{x}\right)^2\right]$$

$\therefore$ (B) is true.

(C) The bracket is maximum when

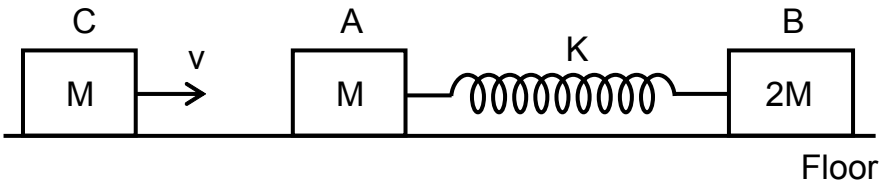
$$\frac{x_0}{x} = \frac{1}{2}$$

$$\Rightarrow v_{max}^2 = \frac{2\alpha}{mx_0^2} \times \frac{1}{4} = \frac{\alpha}{2mx_0^2}$$

$\therefore$ (C) is true.

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

58. Two blocks A and B, of masses M and 2M, respectively, are connected by a massless spring of natural length L_0 and spring constant K. The blocks are initially at rest on a smooth horizontal floor with spring at its natural length L_0. A third block C of mass M, identical to that of block A, moves on the floor with speed v along the line joining A and B and collides with A elastically. In the subsequent motion



(A) the spring will be compressed to a maximum when at a length of $v\sqrt{\frac{M}{3K}}$

(B) the kinetic energy of A and B together, when the spring is compressed to the maximum, is $\frac{Mv^2}{6}$

(C) the blocks A and B stop for a moment when the spring is at the maximum compression

(D) the time required to reach the maximum compression from the normal length is $\frac{\pi}{2}\sqrt{\frac{2M}{3K}}$

Solution · Q58 **Answer: (B), (D)**

In the elastic collision C stops and A moves with speed v. At maximum compression x, both A and B have velocity u.

$$Mv = 3Mu$$

$$\Rightarrow u = \frac{v}{3}$$

$$\text{(A) } \frac{1}{2}Mv^2 = \frac{1}{2}(3M)u^2 + \frac{1}{2}Kx^2$$

$$\Rightarrow x = v\sqrt{\frac{2M}{3K}}$$

This does not match (A), so (A) is false.

$$\text{(B)}\ \frac{1}{2}(3M)\left(\frac{v}{3}\right)^2 = \frac{Mv^2}{6}$$

∴ (B) is true.

(C) Both blocks are still moving, so (C) is false.

(D) Reduced mass:

$$\mu = \frac{2M}{3}$$

The time taken is a quarter period.

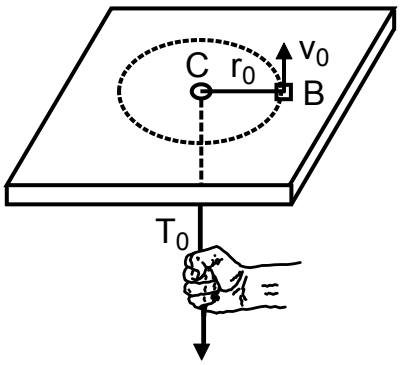
$$t = \frac{\pi}{2}\sqrt{\frac{\mu}{K}} = \frac{\pi}{2}\sqrt{\frac{2M}{3K}}$$

∴ (D) is true.

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

59. A small block B of mass m = 0.25 kg, lying on a frictionless horizontal table, is attached to a massless cord (breaking strength 40 N) passing through a narrow hole C at the center of the table. Initially when the block is revolving in a circle of radius r_0 = 0.80 m about a vertical axis through the hole, with a tangential speed of v_0 = 4.00 m/s; the tension in the string is T_0 and the kinetic energy of the block is K_0. The string is then pulled down slowly from below, decreasing the radius of circular path from r_0 to r so that the kinetic energy of the block is now K and the tension in the string is T.

As a result



(A) the tension $T = T_0\frac{r_0^4}{r^4}$

(B) the kinetic energy $K = K_0\frac{r_0^2}{r^2}$

(C) the radius r of the circular path just when the string breaks is 0.40 m

(D) the work done by the tension in the string in reducing the radius of circle from r_0 to $\frac{r_0}{2}$ is 4 K_0

Solution · Q59 **Answer: (B), (C)**

$$T_0 = \frac{mv_0^2}{r_0} = 5.0\ \text{N}$$

$$K_0 = \frac{1}{2}mv_0^2 = 2.0\ \text{J}$$

By conservation of angular momentum,

$$v = \frac{v_0 r_0}{r}$$

$$\text{(A) } T = T_0\left(\frac{r_0}{r}\right)^3$$

$\therefore$ (A) is false.

$$\text{(B) } K = K_0\left(\frac{r_0}{r}\right)^2$$

$\therefore$ (B) is true.

(C) At breaking,

$$5.0\left(\frac{0.80}{r}\right)^3 = 40$$

$$\Rightarrow r = 0.40 \text{ m}$$

$\therefore$ (C) is true.

(D) By the work-energy theorem,

$$W = 4K_0 - K_0 = 3K_0$$

$\therefore$ (D) is false.

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

60. A circular coil of thin insulated copper wire (N = 2000 turns), wrapped around an iron cylinder of cross-section area $\Delta S = 0.001\ m^2$, is connected to a suspended type moving coil ballistic galvanometer. The suspended rectangular coil of the galvanometer is of mass m = 80 g, length ℓ = 5 cm, breadth b = 3 cm and has n = 100 turns of fine copper wire wound on a non-metallic frame of ivory. This rectangular coil of the galvanometer is free to execute torsional oscillations in a radial magnetic field B = 0.1 tesla. The galvanometer is being used to measure the charge by employing the formula $q = \frac{T}{2\pi}\frac{c}{nAB}\theta$. [Given that the moment of inertia of the oscillating coil about the vertical axis is $I = 2.7 \times 10^{-6}$ kg m^2 and the torsional constant (torsional rigidity) of the suspension fiber is $c = 3.0 \times 10^{-3}$ Nm/radian : $A = \ell \times b$ is the area of the coil]

When the magnetic induction of 1.0 weber per $meter^2$, perpendicular to the plane of the circular coil, is reversed (in opposite direction), a deflection of 40 mm is observed on a scale placed 1.0 meter away in front of the reflecting mirror attached with the suspension fiber of the rectangular coil. The correct statement(s) is/are

(A) the time period of the oscillating rectangular coil is T = 0.19 s

(B) the net change in flux through the circular coil wrapped on the iron cylinder is 4.0 weber

(C) the induced charge in the circular coil wrapped on the iron cylinder is q_{ind} = 240 μC

(D) total resistance of the circuit containing the circular coil is R = 33.3 kΩ

Solution · Q60 — **As per Zigyan: (A), (B), (D)**

The field is taken to reverse quickly, and damping is neglected.

$$\text{(A) } T = 2\pi\sqrt{\frac{I}{c}} \approx 0.19 \text{ s}$$

$\therefore$ (A) is true.

(B) Read as the change in flux linkage,

$$2000 \times 2 \times (1.0 \times 0.001) \text{ Wb} = 4.0 \text{ Wb}$$

$\therefore$ (B) is true.

(C) The reflected ray turns through twice the coil angle.

$$2\theta = 0.040 \text{ rad}$$

$$\Rightarrow \theta = 0.020 \text{ rad}$$

For the galvanometer coil,

$$nAB = 100 \times 1.5 \times 10^{-3} \times 0.1 = 0.015$$

$$\Rightarrow q = 0.030 \times \frac{3.0 \times 10^{-3}}{0.015} \times 0.020 \text{ C} = 120 \ \mu\text{C}$$

$\therefore$ (C) is false.

$$\text{(D) } R = \frac{4.0}{1.2 \times 10^{-4}} \Omega \approx 33.3 \text{ k}\Omega$$

$\therefore$ (D) is true.

Check: the charge gives the coil a starting angular speed of nABq divided by I. Equating its kinetic energy to the twist energy ½cθ^2, with θ of 0.020 rad, again gives q as 120 μC.

IAPT answer: question dropped by IAPT | **Zigyan answer:** (A), (B), (D)

ANSWER KEY

NSEP 2025 · PAPER CODE 61

60
QUESTIONS · 216 MARKS

IAPT final answer key for paper code 61. ★ marks an answer given as per Zigyan.

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

★ Answers as per Zigyan

- **Q10** — As per Zigyan: (A); IAPT key (A).
- **Q53** — As per Zigyan: (A), (C), (D); IAPT key (A), (C), (D) or (C), (D).
- **Q60** — As per Zigyan: (A), (B), (D); dropped by IAPT.

zigyan

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.

Zigyan Eduvision Pvt. Ltd. · SCO No. 107, Sector 16, Faridabad 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com

zigyan

RESULTS · 2021 – 2026

Our toppers, year by year

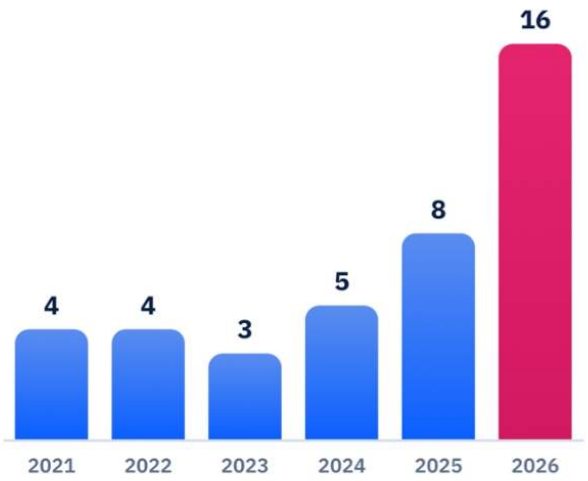
40
JEE Advanced selections in 6 years

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.

Zigyan Eduvision Pvt. Ltd. · SCO No. 107, Sector 16, Faridabad 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com