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PREVIOUS YEAR PAPER · 2022

OLYMPIAD · STAGE I

NSEP

National Standard Examination in Physics

2022

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 2022, paper code 61.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

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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

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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

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Given in the question paper

Physical constants you may need….

Magnitude of charge on electron $e = 1.60 \times 10^{-19} C$	Avogadro's constant $A = 6.023 \times 10^{23}\ mol^{-1}$
Mass of electron $m_e = 9.10 \times 10^{-31}$ kg	Speed of light in free space $c = 3 \times 10^{8}$ m/s
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2 / Nm^2$
Acceleration due to gravity $g = 9.81\ ms^{-2}$	Permeability of free space $\mu_0 = 4\pi \times 10^{-7}\ H / m$
Universal gravitational constant $G = 6.67 \times 10^{-11}\ Nm^2 / Kg^2$	Planck's constant $h = 6.625 \times 10^{-34}$ Js
Universal gas constant R = 8.31 J / molK	Faraday constant = 96,500 C / mol
Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K	Rydberg constant $R = 1.097 \times 10^{7}\ m^{-1}$
Stefan's constant $\sigma = 5.67 \times 10^{-8}\ W / m^2 \times K^4$	Astronomical unit = 1.50×10^{11} m

PART A-1 · ONE CORRECT OPTION

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

1. A particle moves along a straight line. Its displacement S varies with time t according to the law $S^2 = at^2 + 2bt + c$ (a, b and c are constants). The acceleration of this particle varies as

(A) S^0 (B) S^{-1} (C) S^{-2} (D) S^{-3}

Solution · Q1 **Answer: (D)**

Differentiating the given relation:

$$2Sv = 2at + 2b$$

$$\Rightarrow Sv = at + b$$

Differentiating again, with f as the acceleration:

$$v^2 + Sf = a$$

$$f = \frac{a - v^2}{S}$$

$$\Rightarrow f = \frac{aS^2 - (at + b)^2}{S^3}$$

$$\Rightarrow f = \frac{ac - b^2}{S^3}$$

$$\therefore f \propto S^{-3}$$

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

2. A ball A (mass m_1) moving with velocity v experiences an elastic collision with another stationary ball B (mass m_2). Each ball flies apart symmetrically relative to the initial direction of motion of ball A, at an angle θ. Ratio of the masses of balls $\frac{m_1}{m_2}$ is

(A) $1 + 2\cos\theta$ (B) $2\cos 2\theta$ (C) $1 + 2\cos 2\theta$ (D) $1 + \cos 2\theta$

Solution · Q2 **Answer: (C)**

Let u and w be the final speeds of A and B. Perpendicular to the initial direction:

$$m_1 u \sin\theta = m_2 w \sin\theta$$

$$\Rightarrow m_1 u = m_2 w$$

Calling this common momentum p, along the initial direction:

$$m_1 v = 2p\cos\theta$$

By conservation of kinetic energy,

$$\frac{(2p\cos\theta)^2}{2m_1} = \frac{p^2}{2m_1} + \frac{p^2}{2m_2}$$

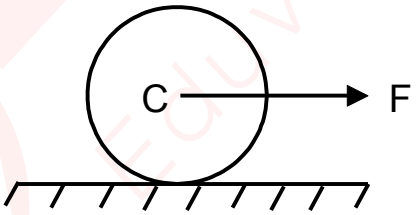
$$\Rightarrow 4\cos^2\theta = 1 + \frac{m_1}{m_2}$$

$$\Rightarrow \frac{m_1}{m_2} = 4\cos^2\theta - 1$$

$$\therefore \frac{m_1}{m_2} = 1 + 2\cos 2\theta$$

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

3. A solid cylinder of mass m is rolling without slipping on a rough horizontal surface, under the action of a horizontal force F such that the line of action of F passes through centre C of the cylinder. Choose the correct alternative.



(A) Acceleration of centre of cylinder is $\frac{F}{m}$

(B) Frictional force on cylinder acts forward

(C) Magnitude of friction force is $\frac{F}{3}$

(D) None of the above.

Solution · Q3 **Answer: (C)**

Let friction f act backward at the point of contact.

$$F - f = ma$$

Taking torques about C,

$$fR = I\alpha$$

$$\Rightarrow fR = \frac{1}{2}mR^2 \times \frac{a}{R}$$

$$\Rightarrow f = \frac{ma}{2}$$

$$\therefore a = \frac{2F}{3m}$$

$$\therefore f = \frac{F}{3}$$

Since f comes out positive, it does act backward.

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

4. A motor pump is used to deliver water at a certain rate r from a given pipe. To obtain thrice as much water from the same pipe in the same time, the power of the motor has to be increased to

(A) 3 times (B) 9 times (C) 27 times (D) 81 times

Solution · Q4 **Answer: (C)**

Volume of water delivered per second:

$$r = Av$$

The pipe is the same, so a rate 3r needs a speed 3v.

No lift or pipe friction is given, so only the kinetic energy of the water counts.

$$P = \frac{1}{2}(\rho Av)v^2$$

$$\Rightarrow P = \frac{1}{2}\rho Av^3$$

$$\Rightarrow P \propto v^3$$

$$\therefore \frac{P'}{P} = 3^3$$

$$\Rightarrow \frac{P'}{P} = 27$$

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

5. Two small solid balls of masses m and 8 m made up of same material are tied at the two ends of a thin weightless thread. They are dropped from a balloon in air. The tension T of thread during fall, after the motion of balls has reached steady state is

(A) 2 mg (B) 3.5 mg (C) 4.5 mg (D) zero

Solution · Q5 **Answer: (A)**

Same material, so the balls of mass m and 8m have radii r and 2r.

At the same terminal speed, Stokes drag is proportional to radius: let the drags be D and 2D (buoyancy neglected).

For both balls together:

$$D + 2D = 9mg$$

$$\Rightarrow D = 3mg$$

For the smaller ball:

$$mg + T = 3mg$$

$$\Rightarrow T = 2mg$$

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

6. Obtain the value of $\frac{e^2}{2\epsilon_0 hc}$

(A) 0.0073 (B) 0.0073 m (C) 0.073 s^{-1} (D) 0.0346 m^{-1}

Solution · Q6 **Answer: (A)**

The symbol ϵ_0 in the question stands for ε_0.

Both e^2/ε_0 and hc have units N m^2, so the expression is dimensionless.

$$\frac{e^2}{2\varepsilon_0 hc} = \frac{\left(1.60\times10^{-19}\right)^2}{2\times8.85\times10^{-12}\times6.625\times10^{-34}\times3\times10^{8}}$$

$$\Rightarrow \frac{e^2}{2\varepsilon_0 hc} = \frac{2.56\times10^{-38}}{3.52\times10^{-36}}$$

$$\Rightarrow \frac{e^2}{2\varepsilon_0 hc} \approx 7.3\times10^{-3}$$

That is, 0.0073.

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

7. A sound source of fix frequency is in unison with an open end organ pipe of length 30.0 cm and a close end organ pipe of length 23.0 cm (both of same diameter). Both pipes are sounding their first overtone. If velocity of sound is 340 ms^{-1}, frequency of sound source is nearly

(A) 1000 Hz (B) 1062 Hz (C) 1100 Hz (D) 1018 Hz

Solution · Q7 **Answer: (B)**

The diameters are equal, so each open end has the same end correction x. Lengths are in cm.

First overtone of the open pipe:

$$L_1 = 30.0 + 2x$$

$$f = \frac{v}{L_1}$$

First overtone of the closed pipe:

$$L_2 = 23.0 + x$$

$$f = \frac{3v}{4L_2}$$

In unison,

$$4(23.0 + x) = 3(30.0 + 2x)$$

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

$$\therefore L_1 = 32.0 \text{ cm}$$

$$\Rightarrow L_1 = 0.320 \text{ m}$$

$$f = \frac{340}{0.320}$$

$$\Rightarrow f = 1062.5 \text{ Hz}$$

$$\therefore f \approx 1062 \text{ Hz}$$

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

8. Solar constant for Earth is 2.0 cal per cm^2 per minute. [1cal = 4.2 J]. Angular diameter of the Sun (as seen from the Earth) is $\frac{1^\circ}{2}$ (= half a degree). Treating Sun as a black body, its surface temperature is estimated to be nearly

(A) 6000 K (B) 5800 K (C) 6200 K (D) 5500 K

Solution · Q8 **Answer: (A)**

In SI units,

$$S = \frac{2.0 \times 4.2}{10^{-4} \times 60}$$

$$\Rightarrow S = 1400 \text{ W m}^{-2}$$

Angular radius of the Sun:

$$\frac{R}{d} = \frac{\pi}{720}$$

$$\Rightarrow \frac{R}{d} = 4.36 \times 10^{-3}$$

Equating the power at the two spheres,

$$4\pi R^2 \sigma T^4 = 4\pi d^2 S$$

$$\Rightarrow T^4 = \frac{S}{\sigma}\left(\frac{d}{R}\right)^2$$

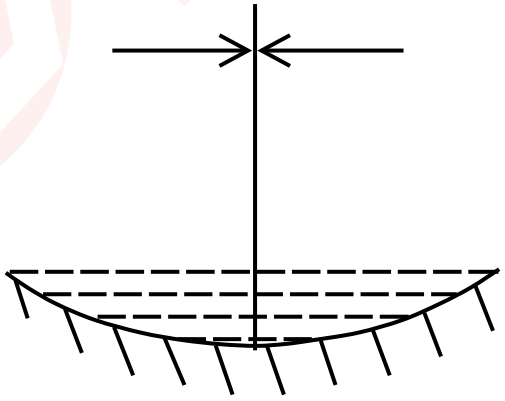
$$\Rightarrow T^4 = \frac{1400}{5.67 \times 10^{-8} \times \left(4.36 \times 10^{-3}\right)^2}$$

$$\Rightarrow T^4 \approx 1.30 \times 10^{15} \text{ K}^4$$

$$\therefore T \approx 6000 \text{ K}$$

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

9. A concave mirror when placed in air has a focal length f = 20 cm. The mirror is now placed horizontally and filled with a thin layer of water having refractive index $\frac{4}{3}$. The object is placed horizontally near the principal axis at a distance d from the mirror such that a real, inverted image is formed at the same plane as the object, as shown in the figure. What is the value of d ?



(A) 30 cm (B) 20 cm (C) 15 cm (D) 40 cm

Solution · Q9 **Answer: (A)**

In air,

$$R = 2f$$

$$\Rightarrow R = 40 \text{ cm}$$

For the inverted image to form in the object plane, the rays must retrace: in water they must meet the mirror normally, as if from its centre of curvature.

For a thin water layer and paraxial rays, the object appears from inside water to be at distance nd.

$$\therefore nd = R$$

$$\Rightarrow d = \frac{40 \times 3}{4}$$

$$\Rightarrow d = 30 \text{ cm}$$

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

10. When a sample of atoms is irradiated by neutrons, radioactive atoms are produced at a constant rate R, which decay with decay constant λ. The number of radioactive atoms accumulated after an irradiation time t is given by

(A) $N(t) = Rt\, e^{-\lambda t}$

(B) $N(t) = \frac{R}{\lambda} e^{-\lambda t}$

(C) $N(t) = \frac{R}{\lambda}\left(1 - e^{-\lambda t}\right)$

(D) $N(t) = Rt(1 - e^{-\lambda t})$

Solution · Q10 **Answer: (C)**

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

No active atoms are present at the start:

$$t = 0, N = 0$$

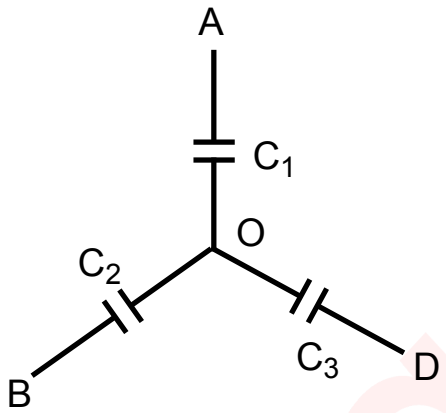
$$\int_0^N \frac{dN}{R - \lambda N} = \int_0^t dt$$

$$\Rightarrow -\frac{1}{\lambda} \ln \frac{R - \lambda N}{R} = t$$

$$\therefore N(t) = \frac{R}{\lambda}\left(1 - e^{-\lambda t}\right)$$

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

11. Three uncharged capacitors of capacitances $C_1 = 2\mu F$, $C_2 = 3\mu F$ and $C_3 = 5\mu F$ are connected as shown in figure to one another at O and to points A, B and D at potentials $V_A = 300$ V, $V_B = 200$ V and $V_D = 400$ V respectively the potential V_O at O is



(A) 300 V (B) 320 V (C) 240 V (D) 280 V

Solution · Q11 **Answer: (B)**

Junction O with its three plates is isolated and initially uncharged, so their net charge is zero.

$$C_1(V_O - V_A) + C_2(V_O - V_B) + C_3(V_O - V_D) = 0$$

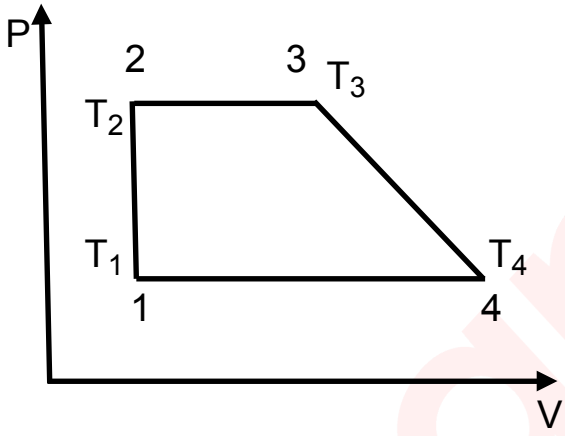
$$\Rightarrow V_O = \frac{C_1V_A + C_2V_B + C_3V_D}{C_1 + C_2 + C_3}$$

$$\Rightarrow V_O = \frac{600 + 600 + 2000}{10}$$

$$\Rightarrow V_O = 320 \text{ V}$$

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

12. A cyclic process 1–2–3–4–1 consisting of two isobars 2 – 3 and 4 – 1, an isochor 1 – 2 and a process 3 – 4 represented by straight line on a P – V diagram, as shown in figure, involves n moles of an ideal gas. The gas temperatures at states 1, 2, 3 & 4 are T_1, T_2, T_3 and T_4 respectively. Also points 3 and 4 lie on the same isotherm. The work done by gas during the cycle is



(A) $\frac{1}{2}nR(T_2-T_1)\left(\frac{T_2}{T_1}+\frac{T_3}{T_4}-2\right)$

(B) $\frac{1}{2}nR(T_3-T_2)\left(\frac{T_3}{T_2}+\frac{T_4}{T_1}-2\right)$

(C) $\frac{1}{2}nR(T_2-T_1)\left(\frac{T_3}{T_1}+\frac{T_3}{T_2}-2\right)$

(D) Zero

Solution · Q12 **Answer: (C)**

The work done is the area of the clockwise loop, a trapezium.

Let P_1 and P_2 be the lower and upper pressures, and V_0 the volume at states 1 and 2.

$$W=\frac{1}{2}(P_2-P_1)(V_3+V_4-2V_0)$$

From the gas equation for states 1 and 2,

$$(P_2-P_1)V_0=nR(T_2-T_1)$$

$$\Rightarrow W=\frac{1}{2}nR(T_2-T_1)\left(\frac{V_3}{V_0}+\frac{V_4}{V_0}-2\right)$$

On the two isobars,

$$\frac{V_3}{V_0}=\frac{T_3}{T_2}$$

$$\frac{V_4}{V_0}=\frac{T_4}{T_1}$$

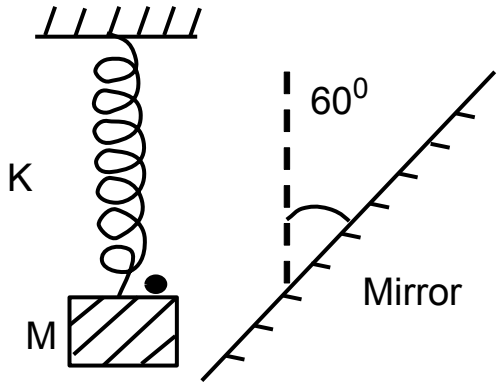
Points 3 and 4 lie on one isotherm:

$$T_4=T_3$$

$$\therefore W=\frac{1}{2}nR(T_2-T_1)\left(\frac{T_3}{T_2}+\frac{T_3}{T_1}-2\right)$$

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

13. An insect of negligible mass is sitting on a block of mass M, tied with a spring of force constant K. The block performs simple harmonic motion vertically with amplitude A in front of a mirror which is inclined at 60^0 with the vertical as shown. The maximum speed of insect relative to its image will be



(A) $2A\sqrt{\frac{K}{M}}$

(B) $A\sqrt{\frac{3K}{M}}$

(C) $A\sqrt{\frac{K}{M}}$

(D) zero

Solution · Q13 **Answer: (B)**

The insect moves with the block, so its velocity is vertical. Its maximum speed is

$$v = A\omega$$

$$\Rightarrow v = A\sqrt{\frac{K}{M}}$$

The mirror is at 60° to the vertical. For the image, the velocity component along the mirror is unchanged and the normal component is reversed.

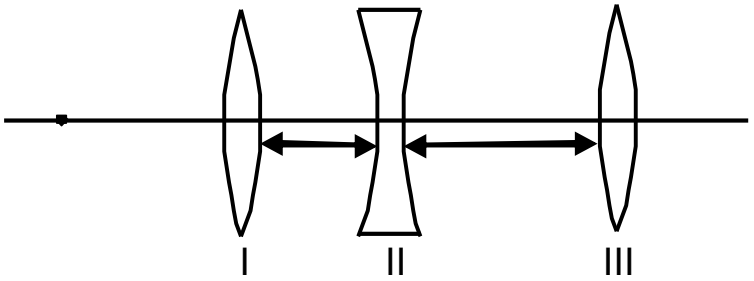
$$v_{rel} = 2v \sin 60°$$

$$\Rightarrow v_{rel} = \sqrt{3}\, v$$

$$\therefore v_{rel,\,max} = A\sqrt{\frac{3K}{M}}$$

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

14. A concave lens of focal length 10 cm is placed between two convex lenses of focal length 10 cm and 20 cm at a separation of 5 cm between the first and second lens and 10 cm between the second and third lens. An object is placed at 30 cm in front of the first convex lens. The final image is formed beyond the third lens at a distance v from it. Then



(A) v = 15 cm (B) v = ∞ (C) v = 45 cm (D) v = 20 cm

Solution · Q14 **Answer: (D)**

Apply the lens formula to each lens in turn.

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

For lens I:

$$\frac{1}{v_1} = \frac{1}{10} - \frac{1}{30}$$

$$\Rightarrow v_1 = 15 \text{ cm}$$

For lens II, the object is virtual:

$$u_2 = 15 - 5$$

$$\Rightarrow u_2 = +10 \text{ cm}$$

$$\frac{1}{v_2} = -\frac{1}{10} + \frac{1}{10}$$

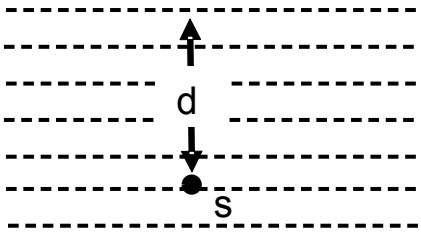
$$\Rightarrow \frac{1}{v_2} = 0$$

So the rays leave lens II parallel, and lens III brings them to its focus.

$$\therefore v = 20 \text{ cm}$$

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

15. A point source S of light is placed at a depth d below the surface of water in a large and deep lake. Fraction of light that escapes in space above directly from water (refractive index = μ) surface is given by



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

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

(C) $\frac{1}{2}\left\{1-\sqrt{1-\frac{1}{\mu^2}}\right\}$

(D) depends on d and increases with increasing d

Solution · Q15 **Answer: (C)**

At the critical angle,

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

$$\Rightarrow \cos\theta_c = \sqrt{1-\frac{1}{\mu^2}}$$

Only light inside a cone of half angle θ_c escapes (absorption and reflection losses neglected). Solid angle of this cone:

$$\Omega = 2\pi(1-\cos\theta_c)$$

Fraction escaping:

$$f = \frac{\Omega}{4\pi}$$

$$\Rightarrow f = \frac{1}{2}(1-\cos\theta_c)$$

$$\therefore f = \frac{1}{2}\left\{1-\sqrt{1-\frac{1}{\mu^2}}\right\}$$

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

16. A convex lens is held 45 cm above the bottom of an empty tank. The image of a point object at bottom of tank is formed 36 cm above the lens. Now a liquid is poured into the tank upto a height of 40 cm above the bottom. It is found that distance of image of same point object at the bottom of the tank is 60 cm above the lens. Refractive index of liquid is

(A) 1.33 (B) 1.37 (C) 1.40 (D) 1.60

Solution · Q16 **Answer: (D)**

For the empty tank:

$$\frac{1}{f} = \frac{1}{36} + \frac{1}{45}$$

$$\Rightarrow f = 20 \text{ cm}$$

With liquid, the lens is 5 cm above its surface. Distance of the apparent object from the lens:

$$x = 5 + \frac{40}{\mu}$$

For the new image,

$$\frac{1}{x} = \frac{1}{20} - \frac{1}{60}$$

$$\Rightarrow x = 30 \text{ cm}$$

$$\Rightarrow 5 + \frac{40}{\mu} = 30$$

$$\Rightarrow \mu = \frac{40}{25}$$

$$\therefore \mu = 1.60$$

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

17. A potential of 5 V is applied across the faces of a pure germanium plate of area 2×10^{-4} m^2 and of thickness 1.2×10^{-3} m. Concentration of carriers in germanium at room temperature is 1.6×10^{6} m^{-3}, Mobility of electrons and holes are 0.4 $m^2 V^{-1} s^{-1}$ and 0.2 $m^2 V^{-1} s^{-1}$ respectively. The current produced in germanium plate at room temperature, is

(A) 1.28×10^{-13} A (B) 1.28×10^{-9} A (C) 1.536×10^{-13} A (D) 6.4×10^{-10} A

Solution · Q17 **Answer: (A)**

In an intrinsic semiconductor, electrons and holes have equal concentration n.

$$\sigma = ne(\mu_e + \mu_h)$$

$$\Rightarrow \sigma = (1.6 \times 10^{6})(1.6 \times 10^{-19})(0.4 + 0.2)$$

$$\Rightarrow \sigma = 1.536 \times 10^{-13} \text{ S m}^{-1}$$

$$E = \frac{5}{1.2 \times 10^{-3}}$$

$$\Rightarrow E \approx 4.17 \times 10^{3} \text{ V m}^{-1}$$

$$J = \sigma E$$

$$\Rightarrow J = 6.4 \times 10^{-10} \text{ A m}^{-2}$$

$$I = JA$$

$$\Rightarrow I = (6.4 \times 10^{-10})(2 \times 10^{-4})$$

$$\therefore I = 1.28 \times 10^{-13} \text{ A}$$

The options use the printed carrier concentration; the actual value, about 2.4×10^{19} m^{-3}, is far larger.

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

18. Fission of one nucleus of ^{235}U releases 200 MeV energy in average. Minimum amount of ^{235}U required to run 1000 MW reactor per year of continuous operation (assuming 30% efficiency) is

(A) 1280 ton (B) 1.28 ton (C) 1.1 ton (D) 1.1×10^5 ton

Solution · Q18 **Answer: (B)**

Useful output in one year:

$$W = 10^9 \times 365 \times 24 \times 3600$$

$$\Rightarrow W \approx 3.15 \times 10^{16}\ J$$

Fission energy required:

$$E = \frac{3.15 \times 10^{16}}{0.30}$$

$$\Rightarrow E \approx 1.05 \times 10^{17}\ J$$

Energy released per fission:

$$E_1 = 200 \times 10^6 \times 1.6 \times 10^{-19}$$

$$\Rightarrow E_1 = 3.2 \times 10^{-11}\ J$$

Number of nuclei:

$$N = \frac{1.05 \times 10^{17}}{3.2 \times 10^{-11}}$$

$$\Rightarrow N \approx 3.28 \times 10^{27}$$

Mass of uranium:

$$m = \frac{3.28 \times 10^{27}}{6.023 \times 10^{23}} \times 0.235$$

$$\Rightarrow m \approx 1.28 \times 10^3\ kg$$

That is 1.28 ton, taking 1 ton as 1000 kg.

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

19. In a young's double slit experiment distance between slits is d = 1 mm, Wavelength of light used is 600 nm and distance of screen from the plane of slits is D = 1 m. The minimum distance between two points on the screen where intensity falls to 75 % of maximum intensity will be (Assume both sources of equal power).

(A) 0.1 mm (B) 0.2 mm (C) 0.45 mm (D) 0.9 mm

Solution · Q19 **Answer: (B)**

$$\beta = \frac{\lambda D}{d}$$

$$\Rightarrow \beta = \frac{600 \times 10^{-9} \times 1}{10^{-3}}\ m$$

$$\Rightarrow \beta = 0.6\ mm$$

$$I = I_{max} \cos^2 \frac{\varphi}{2}$$

For 75% of the maximum intensity,

$$\cos\frac{\varphi}{2} = \pm\frac{\sqrt{3}}{2}$$

$$\Rightarrow \phi = m \times 360° \pm 60°$$

Here m is any integer. A phase change of 360° spans one fringe width, so 60° spans a distance

$$x = \frac{60}{360} \times 0.6$$

$$\Rightarrow x = 0.1 \text{ mm}$$

The required points are at −0.1, +0.1, +0.5, +0.7 mm, ... from the central maximum.

Neighbouring gaps are alternately 0.2 mm and 0.4 mm, so the minimum distance is 0.2 mm.

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

20. A ball is projected from horizontal ground. It attains a maximum height H on its projectile path and there after strikes a stationary smooth vertical wall and falls on ground vertically below the point of maximum height. Assume the collision with wall to be perfectly elastic, the height of the point on the wall where the ball strikes is

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

(C) $\frac{H}{2}$ (D) $\frac{4H}{5}$

Solution · Q20 **Answer: (A)**

An elastic hit on the smooth wall only reverses the horizontal velocity; the vertical motion is unaffected.

Let T be the time of fall from the highest point.

$$H = \frac{1}{2}gT^2$$

The ball goes to the wall and back through equal horizontal distances at equal speeds. So it takes this time to reach the wall:

$$t_1 = \frac{T}{2}$$

Height of the point struck:

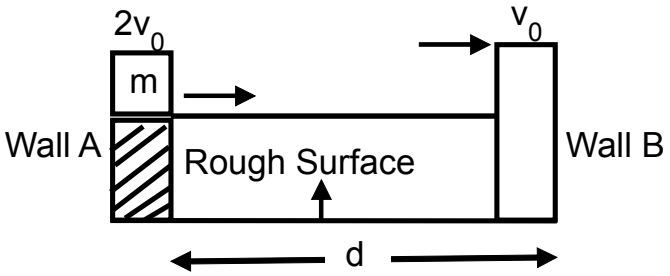
$$h = H - \frac{1}{2}g\left(\frac{T}{2}\right)^2$$

$$\Rightarrow h = H - \frac{H}{4}$$

$$\therefore h = \frac{3H}{4}$$

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

21. As shown in figure, a block of mass m is projected from wall A with velocity $2v_0$ on the rough surface with constant sliding friction to hit the wall B with velocity v_0. With what velocity same mass m should be projected to hit the wall B with same velocity v_0 if the surface is now moving upward with an acceleration of a = 4g ?



(A) $2\ v_0$ (B) $3\ v_0$ (C) $4\ v_0$ (D) $5\ v_0$

Solution · Q21 **Answer: (C)**

With the surface at rest, the retardation is μg.

$$v_0^2 = 4v_0^2 - 2\mu g d$$

$$\Rightarrow 2\mu g d = 3v_0^2$$

With the surface accelerating upward at 4g,

$$N = m(g + 4g)$$

$$\Rightarrow N = 5mg$$

So the retardation becomes 5μg.

$$v_0^2 = u^2 - 2(5\mu g)d$$

$$\Rightarrow v_0^2 = u^2 - 5(3v_0^2)$$

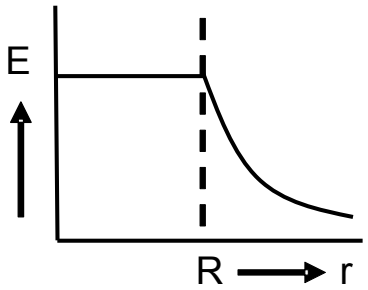
$$\Rightarrow u^2 = 16v_0^2$$

$$\therefore u = 4v_0$$

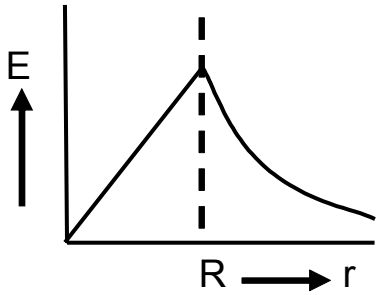
IAPT answer: (C) | **Zigyan answer:** (C)

22. A sphere of radius R, is charged with volume charge density ρ such that $\rho \propto r$ (r is distance from centre). Variation of electric field E with r (For all values of r : $r \le R$ and $r > R$) is best represented by

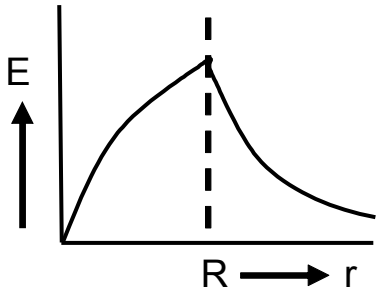
(A)



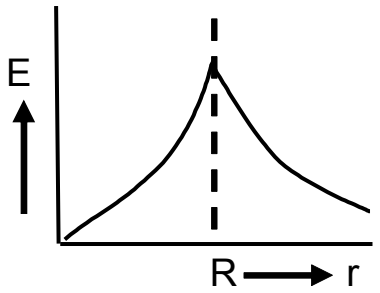
(B)



(C)



(D)



Solution · Q22 **Answer: (D)**

Take a positive constant k; the graphs show the magnitude of E.

$$\rho = kr$$

Charge within radius r, inside the sphere:

$$q = \int_0^r kx \times 4\pi x^2 dx$$

$$\Rightarrow q = \pi k r^4$$

By Gauss's law, inside the sphere:

$$E = \frac{\pi k r^4}{4\pi\varepsilon_0 r^2}$$

$$\Rightarrow E = \frac{kr^2}{4\varepsilon_0}$$

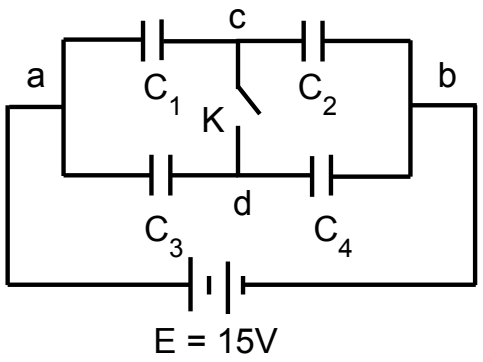
Outside the sphere:

$$E = \frac{kR^4}{4\varepsilon_0 r^2}$$

So E rises from zero along an upward-bending curve, is continuous at the surface and then falls as the inverse square of distance, as in graph (D).

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

23. A system of capacitors $C_1 = 4\ \mu F$, $C_2 = 1\ \mu F$, $C_3 = 2\ \mu F$ and $C_4 = 3\ \mu F$ connected across a battery of emf E = 15V is shown in figure. The charge that will flow, through the switch K, when it is closed, is



(A) 15 μ C c to d (B) 12 μ C c to d (C) 6 μ C d to c (D) 9 μ C d to c

Solution · Q23 **Answer: (A)**

From the battery symbol, a is the positive terminal.

$$V_a = 15\ V,\ V_b = 0$$

With K open, C_1 and C_2 are in series, of capacitance 0.8 μF.

$$q = 0.8 \times 15$$

$$\Rightarrow q = 12\ \mu C$$

Net charge on the plates at c:

$$Q_1 = -12 + 12$$

$$\Rightarrow Q_1 = 0$$

With K closed, the parallel pair C_1, C_3 is in series with the parallel pair C_2, C_4.

$$C_{ac} = 6\ \mu F,\ C_{cb} = 4\ \mu F$$

$$\Rightarrow V_{ac} = 6\ V,\ V_{cb} = 9\ V$$

Net charge on the plates at c now:

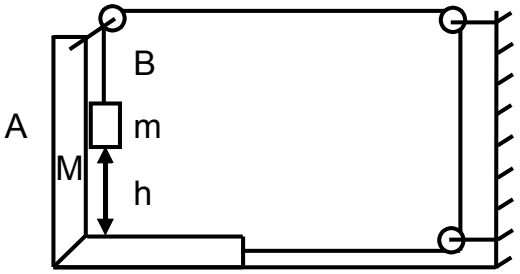
$$Q_2 = -4 \times 6 + 1 \times 9$$

$$\Rightarrow Q_2 = -15\ \mu C$$

Hence 15 μC flows through K from c to d.

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

24. A simplification of a kind of interlock is shown in figure. All surfaces are smooth and frictionless. The body m has a mass m = 1 kg and the block M = 15 kg. The time 'm' takes to reach the base if it is released at height h = 4 meter above the base of M, is [use g = 10 ms^{-2}]



(A) 1 s
(B) $\sqrt{3}$ s
(C) 2 s
(D) $2\sqrt{2}$ s

Solution · Q24 **Answer: (C)**

When M moves a distance x towards the wall, m drops by 2x. So if M has acceleration a, then m has acceleration a horizontally and 2a downward.

For m:

$$N = ma$$

$$mg - T = 2ma$$

For M:

$$2T - N = Ma$$

$$\Rightarrow 2mg - 4ma - ma = Ma$$

$$\Rightarrow a = \frac{2mg}{M + 5m}$$

$$\Rightarrow a = \frac{2 \times 1 \times 10}{15 + 5}$$

$$\Rightarrow a = 1 \text{ m s}^{-2}$$

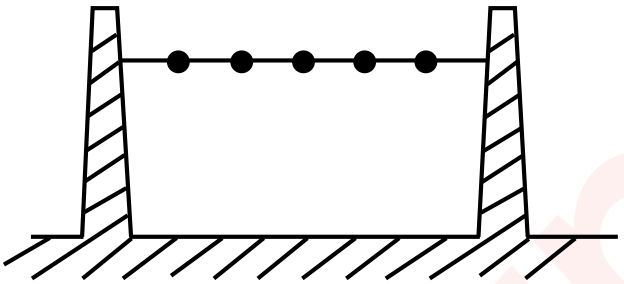
For the fall of m through 4 m,

$$4 = \frac{1}{2} \times 2 \times t^2$$

$$\therefore t = 2 \text{ s}$$

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

25. A number n of identical balls, each of mass m and radius r, are stringed like beads at random and at rest along a smooth, rigid horizontal rod of length L mounted between immovable supports; $\frac{r}{L}$ is small but not negligible. Collision between balls, or between balls and supports, are perfectly elastic. One of the balls is struck horizontally so as to acquire a speed v. Resulting outward force felt by supports, averaged over a long time, is



(A) $\frac{mv^2}{2(L-2nr)}$

(B) $\frac{mv^2}{(L-2nr)}$

(C) $\frac{2mv^2}{(L-2nr)}$

(D) $\frac{mv^2}{L}$

Solution · Q25 **Answer: (B)**

In an elastic head-on hit identical balls exchange velocities, so the speed v passes from ball to ball.

It travels only the free length of the rod. Time between two hits on a support:

$$T = \frac{2(L-2nr)}{v}$$

Impulse on the support per hit:

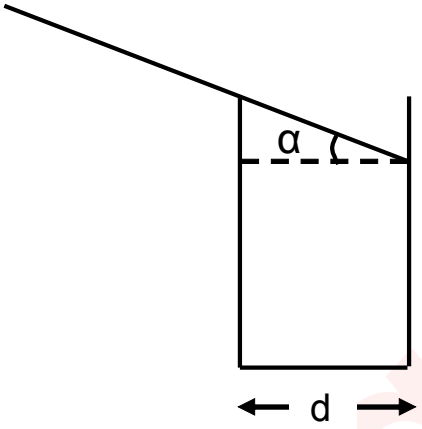
$$J = 2mv$$

$$F = \frac{J}{T}$$

$$\therefore F = \frac{mv^2}{L-2nr}$$

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

26. A cylindrical tumbler of diameter d has smooth sides and smooth edge. A thin rod of length L is balanced on the edge of the tumbler as shown in figure. The angle α that the rod makes with horizontal for this trick to work is



(A) $\sin^{-1}\left(\frac{d}{L}\right)^{1/2}$

(B) $\cos^{-1}\left(\frac{2d}{L}\right)^{1/3}$

(C) $\cos^{-1}\left(\frac{d}{L}\right)^{1/3}$

(D) $\sin^{-1}\left(\frac{2d}{L}\right)^{1/3}$

Solution · Q26 **Answer: (B)**

The rim force N is normal to the rod; the wall force at the lower end is horizontal.

Vertically,

$$N\cos\alpha = W$$

Taking moments about the lower end,

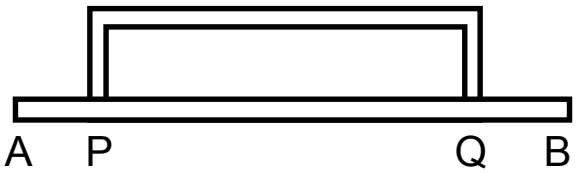
$$N\frac{d}{\cos\alpha} = W\frac{L\cos\alpha}{2}$$

$$\Rightarrow \cos^3\alpha = \frac{2d}{L}$$

$$\therefore \alpha = \cos^{-1}\left(\frac{2d}{L}\right)^{1/3}$$

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

27. End A of a uniform thin rod of length 2L is in boiling water (100^0C) and end B is in melting ice (0^0C). P and Q are two points at distance $\frac{L}{2}$ from A and B respectively. A similar bent rod of length $\frac{3L}{2}$ of same material and equal cross section is joined to rod AB between points P and Q as shown in figure. Then



(A) Temperature at P will increase and that at Q will decrease

(B) Rate of flow of heat will increase by 25%

(C) Rate of flow of heat will decrease by 20%

(D) Rate of heat flow will increase by 37.5%

Solution · Q27 **Answer: (B)**

Take the resistance of a length L as R. Resistances of the parts, with the bent rod marked b:

$$R_{AP} = R_{QB} = \frac{R}{2}$$

$$R_{PQ} = R$$

$$R_b = \frac{3R}{2}$$

Initially,

$$H = \frac{100}{2R}$$

$$\Rightarrow H = \frac{50}{R}$$

After joining, the resistance between P and Q is

$$R_p = \frac{R \times \frac{3R}{2}}{R + \frac{3R}{2}}$$

$$\Rightarrow R_p = \frac{3R}{5}$$

$$R_{net} = \frac{R}{2} + \frac{3R}{5} + \frac{R}{2}$$

$$\Rightarrow R_{net} = \frac{8R}{5}$$

$$H' = \frac{100}{\frac{8R}{5}}$$

$$\Rightarrow H' = \frac{62.5}{R}$$

So the rate of heat flow increases by 25%.

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

28. Two stars of masses M and m (M = 2 m) separated by a distance d = 3 astronomical unit, revolve in circular orbit about their centre of mass with a period of 2 years. If M_s is mass of Sun then

(A) $m = 2.25\ M_s$ (B) $m = 1.25\ M_s$ (C) $m = 2.50\ M_s$ (D) $m = 4.50\ M_s$

Solution · Q28 **Answer: (A)**

M is twice m, so the lighter star moves in a circle of radius 2 AU.

$$r_m = \frac{2d}{3}$$

For the lighter star,

$$\frac{G(2m)m}{d^2} = m\omega^2\frac{2d}{3}$$

$$\Rightarrow \omega^2 = \frac{3Gm}{d^3}$$

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

Comparing with the Earth–Sun system (time in years, distance in AU),

$$T^2 = \frac{d^3 M_s}{M+m}$$

$$\Rightarrow 4 = \frac{27M_s}{M+m}$$

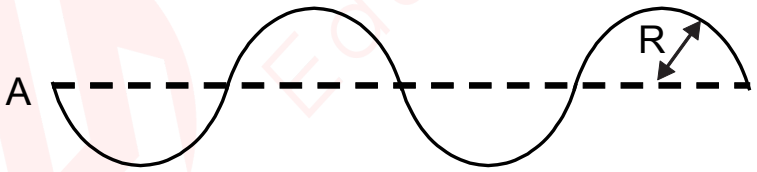
$$\Rightarrow M + m = 6.75\ M_s$$

$$\Rightarrow 3m = 6.75\ M_s$$

$$\therefore m = 2.25\ M_s$$

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

29. A thin uniform rod of mass M is bent in to four adjacent semicircles of radius of curvature R lying in same plane. Moment of inertia of the bent rod about an axis through one end A and perpendicular to plane of the rod is



(A) $\frac{17}{2}MR^2$ (B) $44\ MR^2$

(C) $22\ M\ R^2$ (D) $\frac{43}{2}MR^2$

Solution · Q29 **Answer: (C)**

Each semicircle has a quarter of the mass. Distances of their centres from A:

$$D = R, 3R, 5R, 7R$$

For a point on one arc,

$$s^2 = (D + R\cos\theta)^2 + R^2\sin^2\theta$$

$$\Rightarrow s^2 = D^2 + R^2 + 2DR\cos\theta$$

The mean of $\cos\theta$ over an arc is zero. So for one arc,

$$I_k = \frac{M}{4}\left(D_k^2 + R^2\right)$$

Adding the four arcs,

$$I = \frac{M}{4}\left(84R^2 + 4R^2\right)$$

$$\therefore I = 22MR^2$$

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

30. Three point charges +q, −2q and +q are placed on x – axis at x = −d, x = 0 and x = +d respectively. The value of electric field at a point P on x axis at x = r (r >> d) is given by $E = \frac{1}{4\pi\varepsilon_0}\frac{aQ}{r^n}$ (Here $Q = 2qd^2$) Then

(A) a = 3, n = 3
(B) a = 6 , n = 4
(C) a = 3, n = 4
(D) $a = \frac{3}{2}$, n = 4

Solution · Q30 **Answer: (C)**

At point P,

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r+d)^2} + \frac{1}{(r-d)^2} - \frac{2}{r^2}\right]$$

As r is much larger than d,

$$\frac{1}{(r \pm d)^2} \approx \frac{1}{r^2}\left(1 \mp \frac{2d}{r} + \frac{3d^2}{r^2}\right)$$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{6qd^2}{r^4}$$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{3Q}{r^4}$$

$$\therefore a = 3, n = 4$$

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

31. The frequency of the transverse oscillations of a proton (mass M) trapped in a cylindrical relativistic electron beam of circular cross section of radius R and current I is given by [assume that speed v of relativistic electrons ≈ c (the speed of light in vacuum) and ignore magnetic effect]

(A) $\frac{1}{2\pi R}\sqrt{\frac{eI}{2\pi\varepsilon_0 Mc}}$
(B) $\frac{1}{2\pi R}\sqrt{\frac{2\pi\varepsilon_0 I}{Mc}}$
(C) $\frac{1}{R}\sqrt{\frac{2\pi\varepsilon_0 Mc}{eI}}$
(D) $\frac{1}{2\pi\varepsilon_0}\sqrt{\frac{2\pi\varepsilon_0 Mc}{eI}}$

Solution · Q31 **Answer: (A)**

Magnitude of the beam's charge density:

$$\rho = \frac{I}{\pi R^2 c}$$

By Gauss's law, at a distance x from the axis,

$$E(2\pi x\ell) = \frac{\rho\pi x^2\ell}{\varepsilon_0}$$

$$\Rightarrow E = \frac{Ix}{2\pi\varepsilon_0 cR^2}$$

The force on the proton is towards the axis (magnetic effect ignored).

$$F = -\frac{eI}{2\pi\varepsilon_0 cR^2}x$$

This is simple harmonic, with force constant k.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

$$\therefore f = \frac{1}{2\pi R}\sqrt{\frac{eI}{2\pi\varepsilon_0 Mc}}$$

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

32. Current I flows through a long thin walled metallic cylinder of radius R with a thin longitudinal slit of width ξ (ξ << R) running parallel to the axis of the cylinder. The magnetic induction **B** produced at any point on the axis of the cylinder is approximately

(A) **B** = zero

(B) $B = \frac{\mu_0 I}{2\pi R^2}$

(C) $B = \frac{\mu_0 I\xi}{4\pi^2 R^2}$

(D) $B = \frac{\mu_0 I\xi}{2\pi R^2}$

Solution · Q32 **Answer: (C)**

The slit tube equals a complete tube plus a strip over the slit, carrying an equal current per unit width in the opposite direction.

The complete tube gives no field inside. As the slit is very narrow, the strip acts as a straight wire with current

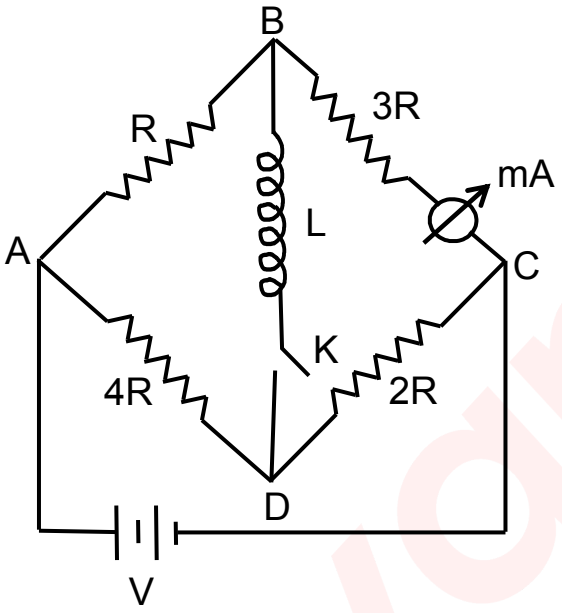
$$i = \frac{I\xi}{2\pi R}$$

$$B = \frac{\mu_0 i}{2\pi R}$$

$$\therefore B = \frac{\mu_0 I\xi}{4\pi^2 R^2}$$

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

33. The reading of the ammeter, used in the electrical network shown below, is 20 mA, a long time after the key K is closed



The reading of the same ammeter, immediately after the key was closed was

(A) zero (B) 16 mA (C) 25 mA (D) 32 mA

Solution · Q33 **Answer: (C)**

Long after closing, L acts as a wire.

$$R_{eq} = (R \parallel 4R) + (3R \parallel 2R)$$

$$\Rightarrow R_{eq} = \frac{4R}{5} + \frac{6R}{5}$$

$$\Rightarrow R_{eq} = 2R$$

The ammeter carries two fifths of the battery current.

$$\frac{2}{5} \times \frac{V}{2R} = 20 \text{ mA}$$

$$\Rightarrow \frac{V}{R} = 100 \text{ mA}$$

Just after closing, L carries no current. Resistance of branch ABC:

$$R + 3R = 4R$$

Reading at that instant:

$$I = \frac{V}{4R}$$

$$\therefore I = 25 \text{ mA}$$

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

34. At the Earth's surface, a projectile is launched straight up at a speed of 10.0 km/s. Height to which it will rise is [g at surface of Earth = 9.8 ms^{-2} and radius of earth R = 6400 km]

(A) 1.63 x 10^3 km (B) 1.56 x 10^4 km (C) 2.52 x 10^4 km (D) 5.1 x 10^3 km

Solution · Q34 **Answer: (C)**

By conservation of energy (air resistance and the Earth's rotation ignored),

$$\frac{1}{2}mv^2 - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

$$GM = gR^2$$

$$\Rightarrow h = \frac{Rv^2}{2gR - v^2}$$

In SI units,

$$2gR = 2 \times 9.8 \times 6.4 \times 10^6$$

$$\Rightarrow 2gR = 1.2544 \times 10^8$$

$$v^2 = 1.000 \times 10^8$$

$$h = 6400 \times \frac{1.000 \times 10^8}{2.544 \times 10^7} \text{ km}$$

$$\therefore h \approx 2.52 \times 10^4 \text{ km}$$

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

35. A small sphere of mass 2.00 g is released from rest in a large cylindrical vessel filled with oil. The resistive force due to viscosity of oil acting on sphere is proportional to its velocity. Sphere approaches a terminal speed of 5.00 cm/s. The time it takes the sphere to reach 90.0% of its terminal speed is approximately.

(A) 3.22 ms (B) 5.10 ms (C) 10.2 ms (D) 11.7 ms

Solution · Q35 **Answer: (D)**

Neglecting buoyancy,

$$m\frac{dv}{dt} = mg - kv$$

$$\Rightarrow v = v_t(1 - e^{-t/\tau})$$

$$\tau = \frac{m}{k}$$

$$\Rightarrow \tau = \frac{v_t}{g}$$

For 90.0% of the terminal speed,

$$e^{-t/\tau} = 0.100$$

$$\Rightarrow t = \tau \ln 10$$

$$\Rightarrow t = 2.303\tau$$

$$\tau = \frac{0.0500}{9.8} \text{ s}$$

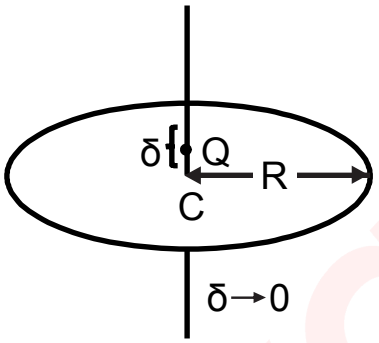
$$\Rightarrow \tau \approx 5.10 \text{ ms}$$

$$\therefore t = 2.303 \times 5.10 \text{ ms}$$

$$\Rightarrow t \approx 11.7 \text{ ms}$$

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

36. A static point charge Q is located just above the centre C ($\delta \to 0$) of a horizontal circle of radius R on its geometric axis, as shown in figure. The magnitude of electric flux through this circle is



(A) Zero

(B) $\frac{Q}{4\varepsilon_0}$

(C) $\frac{Q}{2\varepsilon_0}$

(D) $\frac{Q}{\varepsilon_0}$

Solution · Q36 **Answer: (C)**

Solid angle of the disc at the charge:

$$\Omega = 2\pi\left(1 - \frac{\delta}{\sqrt{R^2 + \delta^2}}\right)$$

$$\varphi = \frac{Q}{\varepsilon_0} \times \frac{\Omega}{4\pi}$$

$$\Rightarrow \varphi = \frac{Q}{2\varepsilon_0}\left(1 - \frac{\delta}{\sqrt{R^2 + \delta^2}}\right)$$

In the limit of very small δ,

$$\therefore \varphi = \frac{Q}{2\varepsilon_0}$$

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

37. Three small identical neutral metal balls are at the vertices of an equilateral triangle. The balls are in turn touched to an isolated large charged conducting sphere whose centre is on a line perpendicular to the plane of triangle and passing through its centre. As a result the first and second balls have acquired charges q_1 and q_2 respectively. The charge acquired by the third ball is

[Assume that charge and potential of large spherical conductor change insignificantly in charging of the balls and that charges on balls are spherically symmetric]

(A) $\frac{q_1^2}{q_2}$ (B) $\frac{q_2^2}{q_1}$

(C) $2q_2 - q_1$ (D) $q_3 = q_2 = q_1$

Solution · Q37 **Answer: (B)**

Each ball, of radius r much smaller than the triangle side a, is joined to the sphere while at its vertex and reaches its fixed potential V.

The sphere's own potential U is the same at all three vertices.

$$D = V - U$$

For the first ball,

$$\frac{kq_1}{r} = D$$

For the second ball,

$$\frac{kq_2}{r} = D - \frac{kq_1}{a}$$

$$\Rightarrow q_2 = q_1\left(1 - \frac{r}{a}\right)$$

For the third ball,

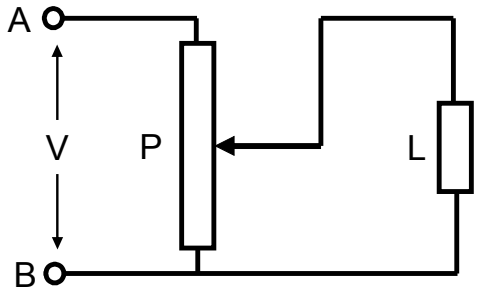
$$\frac{kq_3}{r} = D - \frac{kq_1}{a} - \frac{kq_2}{a}$$

$$\Rightarrow q_3 = q_2\left(1 - \frac{r}{a}\right)$$

$$\therefore q_3 = \frac{q_2^2}{q_1}$$

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

38. Voltage across the load L is controlled by using circuit as shown in figure. P is a potentiometer. Resistance R_L of the load and R_P of the potentiometer are equal to R. Load L is connected to the middle of potentiometer. Input voltage V is constant. If now R_L is doubled, the voltage across load will change by a factor



(A) $\frac{5}{4}$ (B) $\frac{7}{5}$

(C) $\frac{8}{9}$ (D) $\frac{10}{9}$

Solution · Q38 **Answer: (D)**

Only the lower half of the potentiometer is in parallel with the load.

$$R_1 = \frac{(0.5R)R}{0.5R + R}$$

$$\Rightarrow R_1 = \frac{R}{3}$$

By the voltage divider rule,

$$V_1 = V\frac{\frac{R}{3}}{\frac{R}{2} + \frac{R}{3}}$$

$$\Rightarrow V_1 = \frac{2V}{5}$$

With the load resistance doubled,

$$R_2 = \frac{(0.5R)(2R)}{0.5R + 2R}$$

$$\Rightarrow R_2 = \frac{2R}{5}$$

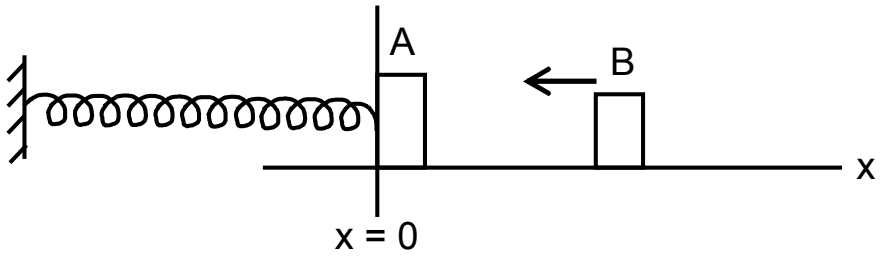
$$V_2 = V\frac{\frac{2R}{5}}{\frac{R}{2} + \frac{2R}{5}}$$

$$\Rightarrow V_2 = \frac{4V}{9}$$

$$\therefore \frac{V_2}{V_1} = \frac{10}{9}$$

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

39. A small block A of mass 2 kg is attached to a spring of force constant 1200 Nm^{-1}, and rests on a smooth horizontal surface at x = 0 as shown in figure. A second block B of mass 1kg slides along the surface towards A at 6 ms^{-1} and sticks to it. Assuming that the collision occurs at t = 0, position x (in meter) of block A as a function of time t is expressed as



(A) $x = 0.173 \cos 20\, t$

(B) $x = 0.1 \cos 40\, \pi\, t$

(C) $x = -0.173 \sin \frac{\pi}{10} t$

(D) $x = -0.1 \sin 20\, t$

Solution · Q39 **Answer: (D)**

Momentum is conserved in the sticking collision (rightward positive).

$$(1)(-6) = 3v$$

$$\Rightarrow v = -2 \text{ m s}^{-1}$$

For the combined mass of 3 kg,

$$\omega = \sqrt{\frac{k}{m}}$$

$$\Rightarrow \omega = \sqrt{\frac{1200}{3}}$$

$$\Rightarrow \omega = 20 \text{ rad s}^{-1}$$

This velocity is at the mean position, so it is the maximum speed.

$$A = \frac{2}{20}$$

$$\Rightarrow A = 0.1 \text{ m}$$

The motion starts from the mean position towards negative x.

$$\therefore x = -0.1 \sin 20t$$

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

40. Two plane glass testing slides each of surface area A are stuck with each other by a small water drop squeezed between them as an extremely thin film of thickness d. If the surface tension of water be T and the angle of contact be zero, then the force required to pull apart the two glass plates will be

(A) $\frac{8TA}{d}$

(B) $\frac{4TA}{d}$

(C) $\frac{2TA}{d}$

(D) $\frac{TA}{d}$

Solution · Q40 **Answer: (C)**

With zero angle of contact, the edge of the film is concave and semicircular in section; its other curvature is negligible.

$$r = 0.5d$$

Pressure difference across this cylindrical surface:

$$P_0 - P = \frac{T}{0.5d}$$

$$\Rightarrow P_0 - P = \frac{2T}{d}$$

Force needed to pull the plates apart:

$$F = (P_0 - P)A$$

$$\therefore F = \frac{2TA}{d}$$

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

41. The rate of flow of a certain liquid of viscocity η through a horizontal capillary of length l and radius r is Q when the pressure head at the inlet is just twice the atmospheric pressure. The rate of flow of the same liquid through another capillary of length 2l and radius 2r when the inlet pressure head is 4 times the atmospheric pressure will be (The outlet being open to atmosphere in each case)

(A) 24 Q (B) 16 Q (C) 8 Q (D) 4Q

Solution · Q41 **Answer: (A)**

By Poiseuille's law,

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

The outlet is at atmospheric pressure each time.

$$\Delta P_1 = 2P_0 - P_0$$

$$\Rightarrow \Delta P_1 = P_0$$

$$\Delta P_2 = 4P_0 - P_0$$

$$\Rightarrow \Delta P_2 = 3P_0$$

$$\frac{Q'}{Q} = 3 \times 2^4 \times \frac{1}{2}$$

$$\therefore Q' = 24Q$$

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

42. A uniform rod of the material of Young's modulus Y is pushed over a smooth horizontal surface by a constant horizontal force F. The area of cross - section of the rod is A. The compressional strain in the rod is

(A) $\frac{F}{AY}$ (B) $\frac{F}{2AY}$

(C) $\frac{3F}{2AY}$ (D) $\frac{2F}{AY}$

Solution · Q42 **Answer: (B)**

For a rod of mass m and length L, the acceleration is

$$a = \frac{F}{m}$$

At distance x from the free end, the compressive force is

$$N = \frac{mx}{L} \times \frac{F}{m}$$

$$\Rightarrow N = \frac{Fx}{L}$$

Local strain:

$$\varepsilon = \frac{N}{AY}$$

$$\Rightarrow \varepsilon = \frac{Fx}{AYL}$$

$$\Delta L = \int_0^L \frac{Fx}{AYL} dx$$

$$\Rightarrow \Delta L = \frac{FL}{2AY}$$

$$\therefore \frac{\Delta L}{L} = \frac{F}{2AY}$$

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

43. A total charge Q is uniformly distributed over a non – conducting ring of radius r. There is a time varying magnetic field perpendicular to its plane and changing at the uniform rate of $\frac{dB}{dt}$. The magnitude of induced tangential electric field E on ring is

(A) $r\frac{dB}{dt}$ (B) $r^2\frac{dB}{dt}$

(C) $\frac{1}{2}r\frac{dB}{dt}$ (D) $\frac{1}{2}r^2\frac{dB}{dt}$

Solution · Q43 **Answer: (C)**

Taking B uniform over the ring, the induced field is tangential and equal at all its points.

By Faraday's law,

$$E(2\pi r) = \pi r^2 \frac{dB}{dt}$$

$$\therefore E = \frac{1}{2}r\frac{dB}{dt}$$

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

44. DC *emf* of 15 V is applied to a circuit containing 5 H inductance and 10 Ω resistance in series at t = 0. The ratio of the currents in the circuit at t = 0.5 sec and at t = 1.0 sec is

(A) $\frac{e^2}{e^2-1}$ (B) $\frac{\sqrt{e}}{\sqrt{e}-1}$

(C) $\frac{e}{e+1}$ (D) $\frac{1}{e}$

Solution · Q44 **Answer: (C)**

Current growth in an LR circuit, with E as the emf:

$$i = \frac{E}{R}\left(1 - e^{-t/\tau}\right)$$

$$\tau = \frac{L}{R}$$

$$\Rightarrow \tau = 0.5 \text{ s}$$

So the two instants are one and two time constants.

$$\frac{i_1}{i_2} = \frac{1 - \frac{1}{e}}{1 - \frac{1}{e^2}}$$

$$\Rightarrow \frac{i_1}{i_2} = \frac{1}{1 + \frac{1}{e}}$$

$$\therefore \frac{i_1}{i_2} = \frac{e}{e + 1}$$

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

45. An insulating rod of length ℓ carries a charge q distributed uniformly all over its length. The rod is pivoted at its midpoint and is rotated at a frequency f (in Hz) about an axis perpendicular to the rod passing through the point at the pivot. The magnetic moment of the system is

(A) $\frac{1}{12}\pi q f \ell^2$ (B) $\frac{1}{6}\pi q f \ell^2$

(C) $\frac{1}{3}\pi q f \ell^2$ (D) $\pi\, q\, f\, \ell^2$

Solution · Q45 **Answer: (A)**

Take an element dx of the rod at distance x from the pivot. It is equivalent to a current loop of this current and area:

$$dI = \frac{qf}{\ell} dx$$

$$A = \pi x^2$$

Its magnetic moment:

$$d\mu = A\, dI$$

$$\Rightarrow \mu = \frac{\pi q f}{\ell} \int_{-\ell/2}^{\ell/2} x^2 dx$$

$$\Rightarrow \mu = \frac{\pi q f}{\ell} \times \frac{\ell^3}{12}$$

$$\therefore \mu = \frac{1}{12}\pi q f \ell^2$$

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

46. A circular loop of radius r is placed inside another circular loop of radius R (R >> r). The loops are coplanar and concentric. The mutual inductance (M) of the system is proportional to

(A) $\frac{r}{R}$ (B) $\frac{r^2}{R}$

(C) $\frac{R^2}{r}$ (D) $\frac{r^2}{R^2}$

Solution · Q46 **Answer: (B)**

Pass a current I through the large loop. Field at its centre:

$$B = \frac{\mu_0 I}{2R}$$

As r is much smaller than R, this field is uniform over the small loop.

$$\Phi = \frac{\mu_0 I \pi r^2}{2R}$$

$$M = \frac{\Phi}{I}$$

$$\Rightarrow M = \frac{\mu_0 \pi r^2}{2R}$$

$$\therefore M \propto \frac{r^2}{R}$$

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

47. The amplitude of the electric and magnetic fields associated with a beam of light of intensity 477.9 W/m^2 are, respectively,

(A) 6×10^2 V / m and 2×10^{-6} T
(B) 3×10^2 V / m and 1×10^{-6} T
(C) 12×10^2 V / m and 4×10^{-6} T
(D) 9×10^2 V / m and 3×10^{-6} T

Solution · Q47 **Answer: (A)**

$$I = \frac{1}{2}\varepsilon_0 c E_0^2$$

$$\Rightarrow E_0 = \sqrt{\frac{2I}{\varepsilon_0 c}}$$

$$\Rightarrow E_0 = \sqrt{\frac{2 \times 477.9}{2.655 \times 10^{-3}}}$$

$$\Rightarrow E_0 = 600 \text{ V m}^{-1}$$

$$B_0 = \frac{E_0}{c}$$

$$\Rightarrow B_0 = \frac{600}{3 \times 10^8}$$

$$\therefore B_0 = 2 \times 10^{-6} \text{ T}$$

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

48. Given that the critical angle of incidence for total internal reflection within a transparent material when placed in air is 45°. The Brewster's angle of incidence for light propagating from air to the transparent material will be

(A) 54.74°
(B) 35.26°
(C) 25.26°
(D) 44.74°

Solution · Q48 **Answer: (A)**

At the critical angle,

$$n = \frac{1}{\sin 45^\circ}$$

$$\Rightarrow n = \sqrt{2}$$

By Brewster's law, going from air into the material,

$$\tan \theta_B = n$$

$$\Rightarrow \tan\theta_B = \sqrt{2}$$

$$\therefore \theta_B \approx 54.74^\circ$$

IAPT 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. A hydrogen atom is in ground state (n = 1). The magnetic field produced by revolving electron, at centre of atom is B_0. Atom is excited to state n = 4. According to Bohr model, the correct alternative(s) is/are

(A) Magnetic field at centre of atom for (n = 4) becomes $B_4 = \frac{B_0}{64}$

(B) Energy absorbed by atom in going from (n = 1) to (n = 4) is 12.75 eV

(C) Change in magnitude of angular momentum of electron is $\frac{3h}{2\pi}$

(D) Assume that this excited atom (n = 4) is at rest and it makes transition to ground state (n = 1) in a single quantum jump of an electron, (Take mass of atom $M_H = 1.67 \times 10^{-27}$ Kg) the recoil speed of atom will be nearly v = 4.1 ms^{-1}.

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

(A) Current of the orbiting electron, and its field at the centre:

$$i = \frac{ev_n}{2\pi r_n}$$

$$B = \frac{\mu_0 i}{2r_n}$$

$$v_n \propto n^{-1},\ r_n \propto n^2$$

$$\Rightarrow B \propto n^{-5}$$

$$\Rightarrow B_4 = \frac{B_0}{1024}$$

So (A) is false.

(B)

$$\Delta E = 13.6 - 0.85$$

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

So (B) is true.

(C) By Bohr's condition,

$$\Delta L = \frac{3h}{2\pi}$$

So (C) is true.

(D) The atom recoils with the photon's momentum.

$$M_H v = \frac{\Delta E}{c}$$

$$\Rightarrow v = \frac{6.80 \times 10^{-27}}{1.67 \times 10^{-27}}$$

$$\Rightarrow v \approx 4.1 \text{ m s}^{-1}$$

So (D) is true.

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

50. In an experimental set up to study the photoelectric effect a point source of light of power 3.2 mW is used. The source emits mono energetic photons of energy 5 eV and is located at a distance d = 0.8 m from centre of a stationary metallic sphere of work function W = 3.0 eV. The radius of the sphere is R = 8 mm. Assume that the sphere is isolated and photo electrons are instantly swept away after emission. Also assume that the efficiency of photoelectric emission is one for every 10^6 photons. In the present set up

(A) The de Broglie wave length of fastest moving photoelectron is nearly 8.7 A^0

(B) It is observed that after some time emission of photoelectrons from the surface of metal sphere is stopped, the charge on sphere just when the electron emission stops is $64\pi\epsilon_0 \times 10^{-3}$C

(C) Time after which photo electric emission stops is nearly 111 s

(D) The light source emits 4×10^{15} photons per sec

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

(D) Photons emitted per second:

$$N = \frac{3.2 \times 10^{-3}}{5 \times 1.6 \times 10^{-19}}$$

$$\Rightarrow N = 4 \times 10^{15}\ s^{-1}$$

So (D) is true.

(A)

$$K_{max} = 5 - 3$$

$$\Rightarrow K_{max} = 2\ eV$$

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$$\Rightarrow \lambda \approx 8.7 \times 10^{-10}\ m$$

So (A) is true.

(B) Emission stops when the sphere's potential equals the stopping potential.

$$\frac{Q}{4\pi\varepsilon_0 R} = 2\ V$$

$$\Rightarrow Q = 4\pi\varepsilon_0 \times (8 \times 10^{-3}) \times 2$$

$$\Rightarrow Q = 64\pi\varepsilon_0 \times 10^{-3}\ C$$

So (B) is true.

(C) Fraction of the light falling on the sphere:

$$\frac{\pi R^2}{4\pi d^2} = 2.5 \times 10^{-5}$$

So 1.0×10^{11} photons strike it per second, releasing 1.0×10^5 electrons per second.

$$t = \frac{Q/e}{1.0 \times 10^5}$$

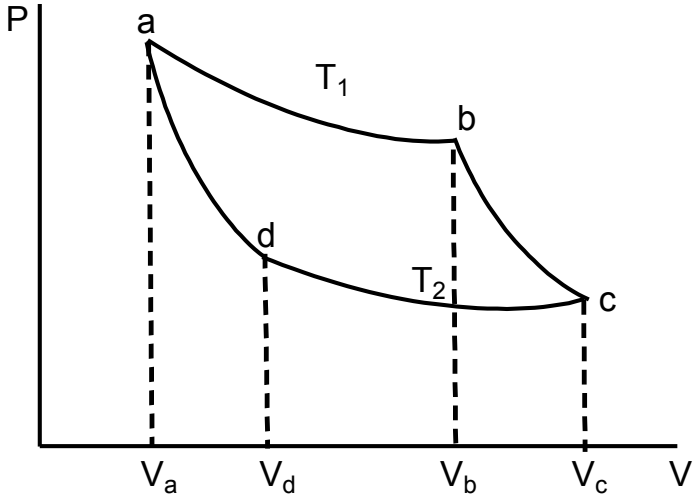
$$\Rightarrow t = \frac{1.11 \times 10^7}{1.0 \times 10^5}$$

$$\Rightarrow t \approx 111\ s$$

So (C) is true.

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

51. Two identical Carnot (cycles) engines operate between maximum and minimum temperatures T_1 and T_2 and volume limits , V_a, V_b, V_c & V_d as shown in figure. Given that $\frac{V_c}{V_a} = e^3$ and $\frac{T_1}{T_2} = e$ (e is the base of natural logarithm). Engine 1 operates on mono atomic gas while the engine 2 on diatomic gas. Choose correct alternatives



(A) Ratio of volumes $\frac{V_{b,1}}{V_{b,2}} = e$

(B) Ratio of work done per cycle for the two is $\frac{W_1}{W_2} = 3$

(C) Ratio of work per cycle for the two is $\frac{W_1}{W_2} = 1$

(D) Ratio of efficiencies (η) of two engines $\frac{\eta_1}{\eta_2} = 1$

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

The sketch is only schematic. Identical engines are taken to use equal moles. On the adiabat bc:

$$T_1 V_b^{\gamma-1} = T_2 V_c^{\gamma-1}$$

$$\Rightarrow \frac{V_c}{V_b} = e^{1/(\gamma-1)}$$

$$V_c = e^{3/2} V_{b,1}$$

$$V_c = e^{5/2} V_{b,2}$$

$$\Rightarrow \frac{V_{b,1}}{V_{b,2}} = e$$

So (A) is true.

The two isothermal volume ratios are equal; call each r.

$$r = \frac{V_b}{V_a}$$

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

$$\ln r = 3 - \frac{1}{\gamma - 1}$$

$$\ln r_1 = 1.5, \ln r_2 = 0.5$$

$$\Rightarrow \frac{W_1}{W_2} = 3$$

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

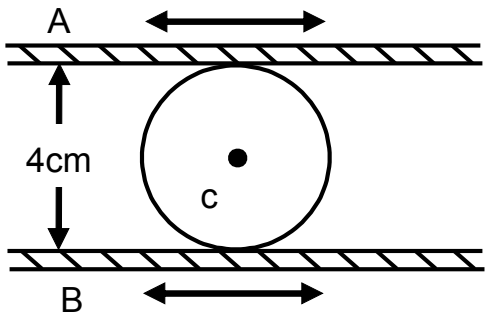
$$\eta = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \frac{\eta_1}{\eta_2} = 1$$

So (D) is true.

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

52. In a certain machine two steel plates are separated by a hardened steel cylindrical roller (see fig). In operation, the plates move back and forth horizontally, perpendicular to the axis of roller, and the roller rolls freely between plates without slipping on either one. At a particular instant plate A is moving with a speed of 18 cm sec^{-1} to the right and an acceleration of 30 cm sec^{-2} to the left, and the plate B is moving with a speed of 6 cm sec^{-1} to the right and an acceleration of 8 cm sec^{-2} to the left. At that instant, for the roller



(A) Its angular speed is 3 rad sec^{-1} clockwise

(B) Its angular acceleration is 6 rad sec^{-2} clockwise

(C) The liner speed of its axis is 12 cm sec^{-1} towards right

(D) The linear acceleration of its axis is 20 cm sec^{-2} towards left

Solution · Q52 **Answer: (A), (C)**

Radius of the roller (rightward and clockwise positive):

$$r = 2 \text{ cm}$$

The rim points in contact move with the plates.

$$v + \omega r = 18$$

$$v - \omega r = 6$$

$$\Rightarrow v = 12 \text{ cm s}^{-1}$$

$$\Rightarrow \omega = 3 \text{ rad s}^{-1}$$

So (A) and (C) are true.

Horizontally, the centripetal terms play no part.

$$a + \alpha r = -30$$

$$a - \alpha r = -8$$

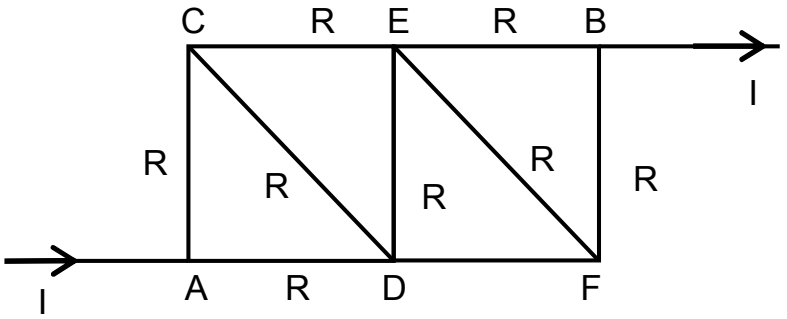
$$\Rightarrow a = -19 \text{ cm s}^{-2}$$

$$\Rightarrow \alpha = -5.5 \text{ rad s}^{-2}$$

The signs show a leftward a and an anticlockwise α. So (B) and (D) are false.

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

53. Each of 9 sides of frame A C D E F B has resistance R (Nine in all) A current I enters at A and leaves at B. Choose the correct alternatives.



(A) Currents in branches CD and EF are zero.

(B) Currents in branches CE and DF are each equal to $\frac{4}{11}I$

(C) Effective resistance between A and B is $\frac{15}{11}R$

(D) Effective resistance between A and B is $\frac{3}{4}R$

Solution · Q53 **Answer: (B), (C)**

By the half-turn symmetry of the frame:

$$V_A = V, V_B = 0$$

$$V_F = V - V_C, V_E = V - V_D$$

Take the potentials of C and D as x and y. At junction C,

$$(x - V) + (x - V + y) + (x - y) = 0$$

$$\Rightarrow 3x = 2V$$

At junction D,

$$(y - V) + (y - x) + (2y - V) + (y - V + x) = 0$$

$$\Rightarrow 5y = 3V$$

In units of V/15, the potentials of C, D, E, F are 10, 9, 6, 5.

$$I = \frac{5V}{15R} + \frac{6V}{15R}$$

$$\Rightarrow I = \frac{11V}{15R}$$

$$\Rightarrow R_{eq} = \frac{15}{11}R$$

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

A drop of one unit therefore carries one eleventh of I.

$$I_{CD} = I_{EF} = \frac{I}{11}$$

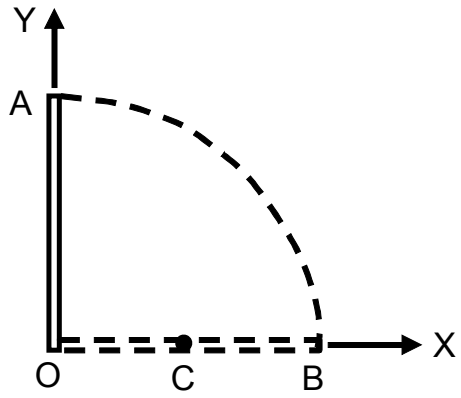
So (A) is false.

$$I_{CE} = I_{DF} = \frac{4I}{11}$$

So (B) is true.

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

54. A long uniform rod of length L and mass M is pivoted vertically on a horizontal, friction less pivot at its lower end. The rod is released from rest in its vertical position OA (see figure). It falls off without slipping at O. At the instant the rod is horizontal,



(A) Its angular speed is $\sqrt{\frac{3g}{L}}$

(B) Magnitude of its angular acceleration is $\frac{3g}{2L}$

(C) Acceleration of its centre of mass $\vec{a}_{CM} = -\frac{3g}{4}\hat{j}$ ($\hat{j}$ unit vector in Y direction)

(D) Reaction force at pivot $= \frac{Mg}{4}\hat{j}$ (Take X, Y axis as shown)

Solution · Q54 **Answer: (A), (B)**

By conservation of energy,

$$Mg\frac{L}{2} = \frac{1}{2}\frac{ML^2}{3}\omega^2$$

$$\Rightarrow \omega = \sqrt{\frac{3g}{L}}$$

So (A) is true. Taking torques about O,

$$Mg\frac{L}{2} = \frac{ML^2}{3}\alpha$$

$$\Rightarrow \alpha = \frac{3g}{2L}$$

So (B) is true.

For the centre of mass, the tangential and centripetal parts are

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

$$\Rightarrow a_t = \frac{3g}{4}$$

$$a_c = \omega^2\frac{L}{2}$$

$$\Rightarrow a_c = \frac{3g}{2}$$

$$\vec{a}_{CM} = -\frac{3g}{2}\hat{i} - \frac{3g}{4}\hat{j}$$

So (C) is false.

$$\vec{N} = M\vec{a}_{CM} + Mg\hat{j}$$

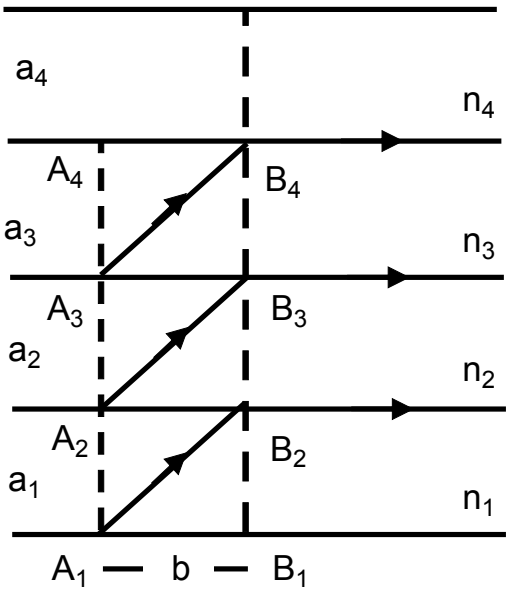
$$\Rightarrow \vec{N} = -\frac{3Mg}{2}\hat{i} + \frac{Mg}{4}\hat{j}$$

So (D) is false.

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

55. There are four layers of glass plates, placed on top of each other such that bottom one has thickness a_1 and refractive index $n_1 = 2.7$. Next one has thickness a_2 and refractive index $n_2 = 2.43$. The third one and the top one have thickness a_3 and a_4 and refractive indices n_3 and n_4 respectively. Three rays starting at the same moment from A_1, A_2 and A_3 reach points B_2, B_3, B_4 at the same time, with their angles of incidence being critical angle. You are given $A_1B_1 = A_2B_2 = A_3B_3 = A_4B_4 = b = 10$ mm. Choose correct statement (s).

[In four significant figures]



(A) $n_3 = 1.968$ (B) $n_4 = 1.291$ (C) $a_2 = 7.243$ mm (D) $a_3 = 11.51$mm

Solution · Q55 **As per Zigyan: (A), (B), (C), (D)**

At the critical angle,

$$\sin\theta_k = \frac{n_{k+1}}{n_k}$$

$$t_k = \frac{b / \sin\theta_k}{c / n_k}$$

$$\Rightarrow t_k = \frac{bn_k^2}{cn_{k+1}}$$

Equal times make this ratio the same for the three layers. For the bottom layer,

$$\frac{n_1^2}{n_2} = \frac{7.29}{2.43}$$

$$\Rightarrow \frac{n_1^2}{n_2} = 3$$

$$n_3 = \frac{2.43^2}{3}$$

$$\Rightarrow n_3 = 1.9683$$

$$\Rightarrow n_3 \approx 1.968$$

$$n_4 = \frac{1.9683^2}{3}$$

$$\Rightarrow n_4 = 1.2914$$

$$\Rightarrow n_4 \approx 1.291$$

So (A) and (B) are true.

Carry the four-figure indices forward, writing s for the sine in a layer.

$$a_k = b \cot \theta_k$$

$$\Rightarrow a_k = \frac{b\sqrt{1 - s_k^2}}{s_k}$$

$$s_2 = \frac{1.968}{2.43}$$

$$\Rightarrow s_2 \approx 0.80988$$

$$\Rightarrow a_2 = 7.243 \text{ mm}$$

$$s_3 = \frac{1.291}{1.968}$$

$$\Rightarrow s_3 \approx 0.65600$$

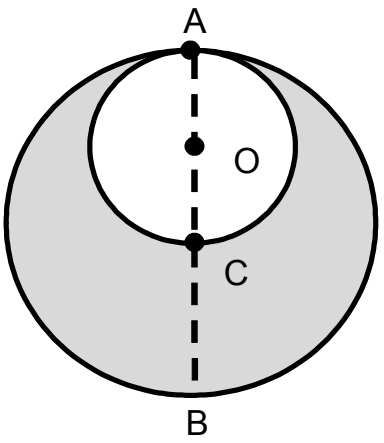
$$\Rightarrow a_3 = 11.51 \text{ mm}$$

So (C) and (D) are true.

Check: Equal times make each sine equal to its layer's index divided by 3, namely 0.9, 0.81 and 0.6561.

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

56. In an isolated asteroid of radius R and uniform density ρ, a spherical cavity of diameter AC = R is excavated, where C is centre of asteroid. Choose correct alternative (s)



(A) A ball just dropped from A will strike C with speed $v = 2R\sqrt{\frac{\pi\rho G}{3}}$

(B) A ball dropped from A will reach C after time $t = \sqrt{\frac{3}{\pi\rho G}}$

(C) Acceleration of ball dropped from A varies as its distance from O (centre of cavity)

(D) Weight of a body placed at B (diametrically opposite to A) on surface of asteroid decreases by a factor $\frac{7}{8}$ due to excavation of cavity.

Solution · Q56 **Answer: (A), (B)**

Take a full sphere of density ρ plus a sphere of density −ρ filling the cavity. For a cavity point at position r from C, with O at d:

$$\vec{g} = -\frac{4\pi G\rho}{3}\vec{r} + \frac{4\pi G\rho}{3}\left(\vec{r} - \vec{d}\right)$$

$$\Rightarrow \vec{g} = -\frac{4\pi G\rho}{3}\vec{d}$$

$$\Rightarrow g = \frac{2\pi G\rho R}{3}$$

The field is uniform, so (C) is false.

$$v^2 = 2gR$$

$$\Rightarrow v = 2R\sqrt{\frac{\pi\rho G}{3}}$$

So (A) is true.

$$R = \frac{1}{2}gt^2$$

$$\Rightarrow t = \sqrt{\frac{3}{\pi\rho G}}$$

So (B) is true.

At B, subtract the pull of the removed sphere: mass one eighth of M, centre 1.5R away.

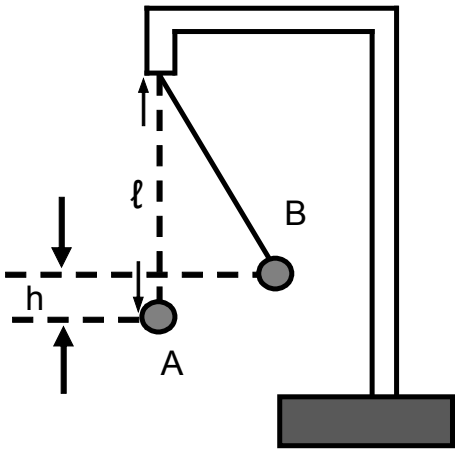
$$g_B = \frac{GM}{R^2}\left(1 - \frac{1}{18}\right)$$

$$\Rightarrow g_B = \frac{17}{18}\frac{GM}{R^2}$$

So (D) is false.

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

57. A small positively charged ball of mass m is suspended by a long insulating thread of negligible mass. Other positively charged small ball is moved very slowly from a large distance (along horizontal direction) until it is at original position A of first ball. As a result the first ball rises by h to position B such that h << ℓ. Choose the correct statement (s)



(A) Electrostatic energy of system of charges is 2 mgh.

(B) Total work done on system to bring two balls in their final position is mgh.

(C) Total work done on the system to bring two balls in their final position is 3 mgh.

(D) Work done on system to bring two balls in their final position does not depend on the magnitude of charges explicitly.

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

At B, the forces mg, F, T form a triangle similar to SAB, where S is the support, SB is ℓ and AB is s.

$$\frac{F}{s} = \frac{mg}{\ell}$$

$$T = mg$$

$$s = 2\ell\sin\frac{\theta}{2}$$

$$h = \ell(1 - \cos\theta)$$

$$\Rightarrow s^2 = 2\ell h$$

Interaction energy of the two charges:

$$U = Fs$$

$$\Rightarrow U = \frac{mgs^2}{\ell}$$

$$\Rightarrow U = 2mgh$$

So (A) is true.

The ball is moved very slowly, so the work done equals the gain in potential energy.

$$W = mgh + 2mgh$$

$$\Rightarrow W = 3mgh$$

So (C) is true and (B) is false. No charge appears in this result, so (D) is true.

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

58. A rope of mass m and length L is suspended vertically. A mas M is suspended from bottom of the rope. A transverse wave is produced on the rope, which travels the length of rope in time t choose the correct statement (s)

(A) $t = 2\sqrt{\frac{L}{mg}}\left(\sqrt{M+m} - \sqrt{M}\right)$

(B) For m << M The time $t = \sqrt{\frac{mL}{Mg}}$

(C) For M = 0 (i.e. no mass hanging) the time $t = \sqrt{\frac{L}{g}}$

(D) Time to travel the lower half of the rope by the wave is less than that to travel the upper half.

Solution · Q58 **Answer: (A), (B)**

At height x above the lower end,

$$T = Mg + \frac{mgx}{L}$$

$$v^2 = \frac{T}{m/L}$$

$$\Rightarrow v^2 = g\left(x + \frac{ML}{m}\right)$$

$$t = \int_0^L \frac{dx}{v}$$

$$\Rightarrow t = 2\sqrt{\frac{L}{mg}}\left(\sqrt{M+m} - \sqrt{M}\right)$$

So (A) is true. When m is much smaller than M,

$$\sqrt{M+m} - \sqrt{M} \approx \frac{m}{2\sqrt{M}}$$

$$\Rightarrow t \approx \sqrt{\frac{mL}{Mg}}$$

So (B) is true. With no hanging mass,

$$t = 2\sqrt{\frac{L}{g}}$$

So (C) is false.

Wave speed increases upward, so the lower half takes longer: (D) is false.

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

59. A long solenoid having 1000 turns per meter carries a current of 1A. It has a soft iron core of $\mu_r = 1000$. The core is heated beyond the Curie temperature (T_C). Then

(A) The H field in the solenoid is nearly unchanged but the B field decreases drastically.

(B) The H and B fields in the solenoid are nearly unchanged.

(C) The magnetization in the core reverses direction.

(D) The magnetization in the core diminishes by a factor of about 10^8

Solution · Q59 **As per Zigyan: (A), (D)**

Taking a long solenoid,

$$H = nI$$

$$\Rightarrow H = 1000 \text{ A m}^{-1}$$

$$B = \mu_0\mu_r H$$

Before and after heating, B is about 1.26 T and 1.26×10^{-3} T, while H is unchanged. So (A) is true and (B) is false.

Hot iron is paramagnetic, with a small positive susceptibility, so magnetisation does not reverse: (C) is false.

Before heating,

$$M = (\mu_r - 1)H$$

$$\Rightarrow M = 999 \times 1000$$

$$\Rightarrow M \approx 10^6 \text{ A m}^{-1}$$

After heating, take the textbook value

$$\chi \approx 10^{-5}$$

$$M = \chi H$$

$$\Rightarrow M \approx 10^{-2} \text{ A m}^{-1}$$

With this value the factor is 10^8, so (D) is true.

Reference: NCERT Physics Class XII (Part I), Chapter 5 'Magnetism and Matter', section 5.5.3: a hot enough ferromagnet becomes a paramagnet.

Reference: Points to Ponder 4 of that chapter takes paramagnetic susceptibility as $+10^{-5}$.

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

60. A thin and infinitely long metal sheet of appreciable finite width b carrying current I (distributed uniformly through out of its cross section) parallel to its length is placed in an external magnetic field B_e parallel to its plane and perpendicular to the direction of current

(A) The thin metal sheet experiences a mechanical pressure $P = \frac{IB_e}{b}$ perpendicular to its face.

(B) The direction of the pressure does not change if the direction of current is reversed.

(C) In case the external magnetic field B_e is switched off, a magnetic field $B = \frac{\mu_0 I}{2b}$ is observed parallel to the plane of the sheet but perpendicular to the direction current.

(D) The magnetic field produced in part (c) is $B = \frac{2\mu_0 I}{b}$

Solution · Q60 **Answer: (A), (C)**

On a length ℓ, the force normal to the sheet is

$$F = I\ell B_e$$

$$P = \frac{F}{b\ell}$$

$$\Rightarrow P = \frac{IB_e}{b}$$

So (A) is true.

$$\vec{F} = I\vec{\ell} \times \vec{B}_e$$

Reversing only the current reverses this force, so (B) is false.

Close to the sheet and away from its edges, by Ampere's law for a rectangle of width w,

$$2Bw = \mu_0 \frac{I}{b} w$$

$$\Rightarrow B = \frac{\mu_0 I}{2b}$$

It is parallel to the sheet and normal to the current: (C) is true. (D) is four times this value, so it is false.

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

ANSWER KEY

NSEP 2022 · PAPER CODE 61

60
QUESTIONS · 216 MARKS

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

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

★ Answers as per Zigyan

- **Q55** — As per Zigyan: (A), (B), (C), (D); IAPT key (A), (B), (C), (D).
- **Q59** — As per Zigyan: (A), (D); IAPT key (A), (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.

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

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RESULTS · 2021 – 2026

Our toppers, year by year

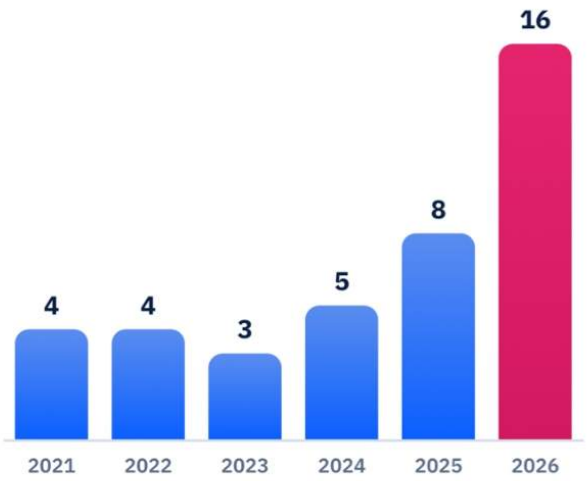
40
JEE Advanced selections in 6 years

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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0129-4048800 · +91 92115 38800 · info@zigyan.com