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PREVIOUS YEAR PAPER · 2021-22

OLYMPIAD · STAGE I

IOQP

Indian Olympiad Qualifier in Physics (Part I)

2021-22

Question paper, answer key and Zigyan solutions

32	120	75 min	61
Questions	Maximum marks	Time	Paper code

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), IOQP 2021-22, 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

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AIR 1,315	AIR 1,095
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- 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....

Mass of electron $m_e = 9.10\times10^{-31} kg$	Magnitude of charge on electron $e = 1.60\times10^{-19} C$
Mass of proton $m_p = 1.67\times10^{-27} kg$	Permittivity of free space $\varepsilon_0 = 8.85\times10^{-12} C^2 N^{-1} m^{-2}$
Acceleration due to gravity g = 9.81 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 $R = 8.31\ Jmol^{-1} K^{-1}$	Faraday constant $= 96,500\ Cmol^{-1}$
Boltzmann constant $k = 1.38\times10^{-23} J\,K^{-1}$	Rydberg constant $R = 1.097\times10^7 m^{-1}$
Stefan's constant $\sigma = 5.67\times10^{-8} Wm^{-2} K^{-4}$	Density of water at $4^\circ C$, $\rho = 1.0\times10^3\ kg\,m^{-3}$
Avogadro's constant $A = 6.023\times10^{23}\ mol^{-1}$	Density of mercury $\rho = 13.6\times10^3\ kg\,m^{-3}$
Speed of light in free space $c = 3.0\times10^8\ ms^{-1}$	Speed of sound in air = 330 ms^{-1}

PART A-1 · ONE CORRECT OPTION

Q. 1 – 24 · +3 for a correct answer, –1 for a wrong one

1. Consider the process of the melting of a spherical ball of ice originally at 0°C. Assuming that the heat is being absorbed uniformly through the surface and the rate of absorption is proportional to the instantaneous surface area. Which of the following is true for the radius (r) of the ice ball at any instant of time? Assume that the initial radius of the ice ball at t = 0 is r = R_0 and that the shape of the ball always remains spherical during melting. Also assume that L and ρ are respectively the latent heat and density of ice at 0°C

(A) radius decreases exponentially with time as r = $R_0\, e^{-kt/\rho L}$. Here k is constant

(B) radius decreases exponentially with time as r = $R_0\, e^{-k\rho t/2L}$

(C) radius of the ice ball decreases with time linearly with a slope $-\frac{k}{\rho L}$

(D) radius of the ice ball decreases with time linearly with a slope $-\frac{k\rho}{2L}$

Solution · Q1 **Answer: (C)**

Let k be the heat absorbed per second per unit area.

$$\frac{dQ}{dt} = k\left(4\pi r^2\right)$$

Also, in terms of latent heat,

$$\frac{dQ}{dt} = -L\frac{dm}{dt}$$

$$m = \frac{4}{3}\pi r^3 \rho$$

$$\Rightarrow \frac{dm}{dt} = 4\pi r^2 \rho \frac{dr}{dt}$$

$$\Rightarrow \frac{dr}{dt} = -\frac{k}{\rho L}$$

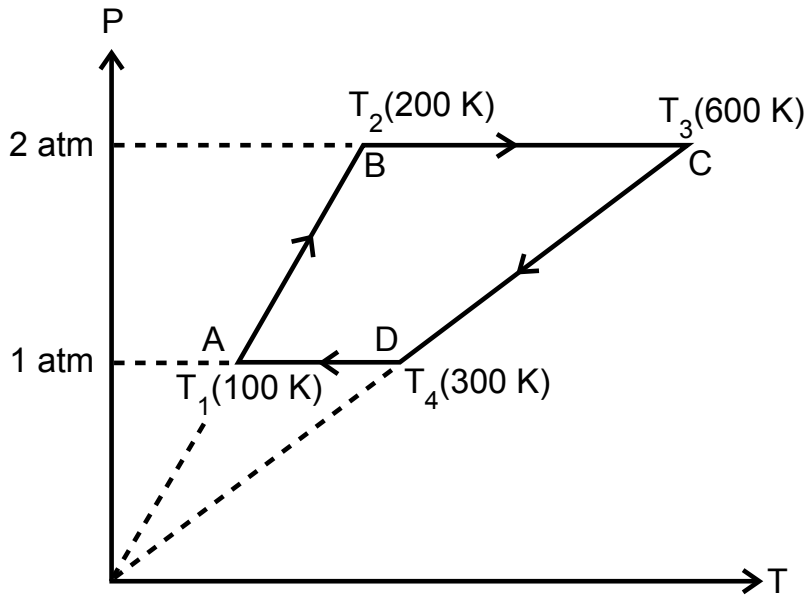
This is a constant, so the radius decreases linearly with time.

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

2. The work done by the three moles of an ideal gas in the cyclic process ABCD shown in the diagram is approximately. Given that

$T_1 = 100$ K, $T_2 = 200$ K and

$T_3 = 600$K, $T_4 = 300$ K



(A) 7.5 kJ (B) 5.0 kJ (C) 2.5 kJ (D) Zero

Solution · Q2 **Answer: (B)**

Along AB and CD the lines pass through the origin, so the volume is constant and no work is done.

Along BC,

$$W_{BC} = 3R\,(600 - 200)$$

$$\Rightarrow W_{BC} = 1200R$$

Along DA,

$$W_{DA} = 3R\,(100 - 300)$$

$$\Rightarrow W_{DA} = -600R$$

$$W = W_{BC} + W_{DA}$$

$$\Rightarrow W = 600R$$

$$\Rightarrow W = 600 \times 8.31 \text{ J}$$

$$\therefore W \approx 5.0 \text{ kJ}$$

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

3. The molar specific heat capacity of a certain gas is expressed as $C = C_V + \alpha\frac{P}{T}$.

The equation of state for the process can be written as (α & A are constant)

(A) $PV = RT$ (B) $V = \alpha T^2$ (C) $V^2 = \alpha \ln T$ (D) $T = Ae^{V/\alpha}$

Solution · Q3 **Answer: (D)**

For one mole, by the first law,

$$C\,dT = C_V dT + P\,dV$$

$$\Rightarrow C = C_V + P\frac{dV}{dT}$$

Comparing with the given relation,

$$dV = \alpha\frac{dT}{T}$$

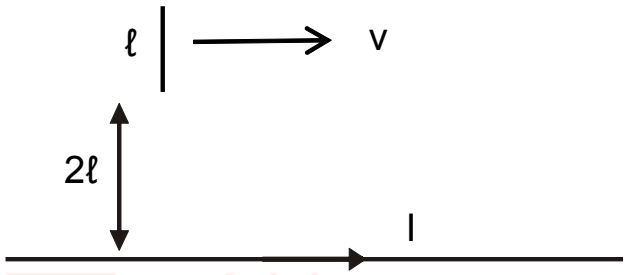
With a constant of integration c,

$$V = \alpha \ln T + c$$

$$\therefore T = Ae^{V/\alpha}$$

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

4. A metal bar of length ℓ moves with a velocity v parallel to an infinitely long straight wire carrying a current I as shown in the figure. If the nearest end of the perpendicular bar always remains at a distance 2ℓ from the current carrying wire, the potential difference (in volt) between two ends of the moving bar is



(A) $\frac{\mu_0 Iv}{2\pi}$ (B) $\frac{\mu_0 Iv}{6\pi}$

(C) $\frac{\mu_0 Iv}{2\pi}\ln 2$ (D) $\frac{\mu_0 Iv}{2\pi}\ln 1.5$

Solution · Q4 **Answer: (D)**

The printed page hides the endings of (C) and (D); in the paper's own file they read ln 2 and ln 1.5.

The bar extends from 2ℓ to 3ℓ from the wire.

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

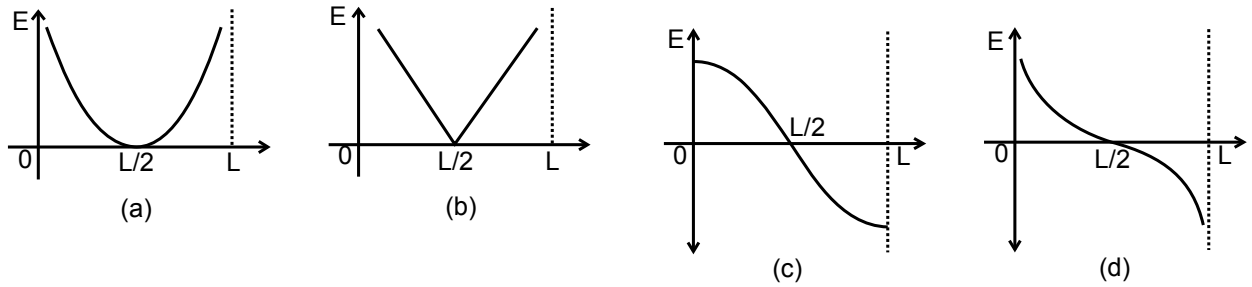
$$d\varepsilon = Bv\,dr$$

$$\varepsilon = \frac{\mu_0 Iv}{2\pi}\int_{2\ell}^{3\ell}\frac{dr}{r}$$

$$\therefore \varepsilon = \frac{\mu_0 Iv}{2\pi}\ln 1.5$$

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

5. Two point charges +Q each are located at (0, 0) and (L, 0) at a distance L apart on the X - axis. The electric field (E) in the region 0 < x < L is best represented by



(A) Fig. a (B) Fig. b (C) Fig. c (D) Fig. d

Solution · Q5 **Answer: (D)**

Taking the field towards increasing x as positive,

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

$$E = kQ\left[\frac{1}{x^2} - \frac{1}{(L-x)^2}\right]$$

E is large and positive near the origin, zero at the mid-point, and large and negative near the other charge.

$$\frac{dE}{dx} = -2kQ\left[\frac{1}{x^3} + \frac{1}{(L-x)^3}\right]$$

The slope is always negative, which matches graph (d).

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

6. A long straight wire AB of length L (L >> a, L >> b) and resistance R is connected to a time varying source of emf V(t). The variation of applied emf V(t) with time is shown in Fig. B. A circular metallic loop of radius r = b is placed coplanar with the current carrying wire with its centre at a distance 'a' from the axis of the wire as shown. The induced current in the loop is

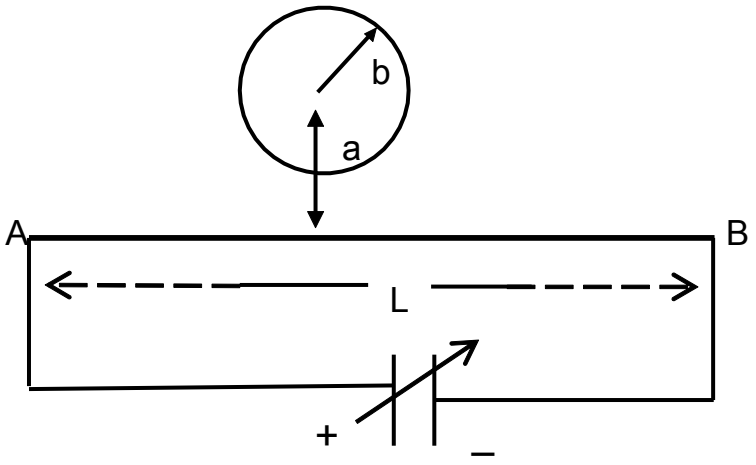


Fig. A

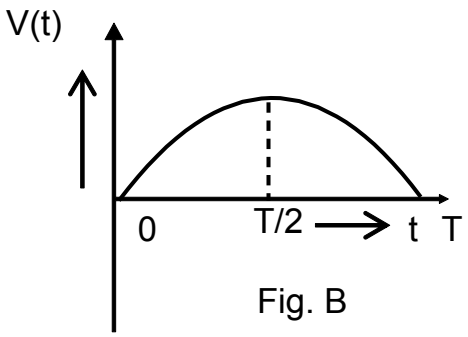


Fig. B

(A) clockwise from 0 to T/2 and anticlockwise from T/2 to T

(B) anticlockwise from 0 to T/2 and clockwise from T/2 to T

(C) clock wise from 0 to T

(D) anticlockwise from 0 to T

Solution · Q6 **Answer: (A)**

In wire AB, the current flows from A to B. So its field through the loop, which lies above the wire, is out of the page.

Neglecting self-inductance,

$$I = \frac{V(t)}{R}$$

In the first half the outward flux increases, so by Lenz's law the induced current is clockwise.

In the second half the flux decreases, so the induced current is anticlockwise.

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

7. A simple circuit consists of a known resistance R_A = 2 MΩ and an unknown resistance R_B both in series with a battery of 9 volt and negligible internal resistance. When the voltmeter is connected across the resistance R_A, it measures 3 volt but when the same voltmeter is connected across R_B it reads 4.5 volt. The voltmeter measures 9 V across the battery. Considering that the voltmeter has a finite resistance r, the correct option is

(A) R_B = 3MΩ and r = 6.0 MΩ
(B) R_B = 2.5MΩ and r = 6.0 MΩ
(C) R_B = 4MΩ and r = 12 MΩ
(D) R_B = 4.5MΩ and r = 6.0 MΩ

Solution · Q7 **Answer: (A)**

Working in MΩ, with the voltmeter across R_A,

$$R_B = \frac{4r}{2+r}$$

With it across R_B, that pair and R_A share 9 V equally, so their resistances are equal.

$$\frac{R_B r}{R_B + r} = 2$$

$$\Rightarrow R_B = \frac{2r}{r-2}$$

Equating the two values,

$$2(r-2) = 2 + r$$

$$\Rightarrow r = 6\ \text{MΩ}$$

$$\Rightarrow R_B = 3\ \text{MΩ}$$

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

8. The optical powers of the objective and the eyepiece of a compound microscope are 100 D and 20 D respectively. The microscope magnification being equal to 50 when the final image is formed at d = 25 cm i.e., the least distance of distinct vision. If the separation between the objective and the eyepiece is increased by 2 cm, the magnification of the microscope will be

(A) 62 (B) 50 (C) 38 (D) 25

Solution · Q8 **Answer: (A)**

$$f_o = 1\ \text{cm and } f_e = 5\ \text{cm}$$

$$m_e = 1 + \frac{D}{f_e}$$

$$\Rightarrow m_e = 6$$

$$m_o = \frac{50}{6}$$

$$\Rightarrow m_o = \frac{25}{3}$$

$$v_o = f_o(1 + m_o)$$

$$\Rightarrow v_o = \frac{28}{3}\ \text{cm}$$

The eyepiece works as before, so the whole increase adds to this image distance.

$$v_o' = \frac{28}{3} + 2$$

$$\Rightarrow v_o' = \frac{34}{3}\ \text{cm}$$

$$M = \left(\frac{34}{3} - 1\right) \times 6$$

$$\therefore M = 62$$

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

9. A hollow non-conducting cone of base radius R = 50 cm and semi vertical angle of 15^0 has been uniformly charged on its curved surface up to three-fourth of its slant length from base with a surface charge density $\sigma = 2.5\ \mu C/m^2$. The electric field produced at the location of the vertex of the cone is

(A) $\frac{\sigma \ln 2}{2\varepsilon_0}$ (B) $\frac{\sigma \ln 2}{4\varepsilon_0}$

(C) $\frac{\sigma \ln 2}{8\varepsilon_0}$ (D) $\frac{\sigma \ln 2}{16\varepsilon_0}$

Solution · Q9 **Answer: (B)**

Let s be the slant distance from the vertex and l the slant length. The charge extends from one quarter of l to l.

For a ring of width ds, with α the semi-vertical angle,

$$dq = \sigma (2\pi s \sin\alpha)\, ds$$

$$dE = \frac{dq\cos\alpha}{4\pi\varepsilon_0 s^2}$$

$$E = \frac{\sigma \sin\alpha\cos\alpha}{2\varepsilon_0} \ln 4$$

$$\sin 15^\circ \cos 15^\circ = \frac{1}{4}$$

$$\therefore E = \frac{\sigma \ln 2}{4\varepsilon_0}$$

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

10. A freely falling spherical rain drop gathers moisture (maintaining its spherical shape all the way) from the atmosphere at a rate $\frac{dm}{dt} = kt^2$ where t is the time and m is the instantaneous mass of the drop, the constant $k = 12\ gm/s^3$. If the drop, of initial mass $m_0 = 2gm$, starts falling from rest, the instantaneous velocity of the drop exactly after 5 second shall be (ignore air friction and air buoyancy)

(A) $12.4\ ms^{-1}$ (B) $49.0\ ms^{-1}$

(C) $122.5\ ms^{-1}$ (D) data insufficient

Solution · Q10 **Answer: (A)**

Taking the collected moisture to be initially at rest,

$$\frac{d(mv)}{dt} = mg$$

With m in grams,

$$m = 2 + 4t^3$$

$$\Rightarrow mv = g(2t + t^4)$$

At 5 s,

$$v = 9.81 \times \frac{635}{502}$$

$$\therefore v \approx 12.4 \text{ m s}^{-1}$$

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

11. Two planets, each of mass M and radius R are positioned (at rest) in space, with their centres a distance 4R apart. You wish to fire a projectile from the surface of one planet to the other. The minimum initial speed for which this may be possible is

(A) $\sqrt{\frac{2GM}{5R}}$ (B) $\sqrt{\frac{2GM}{3R}}$

(C) $\sqrt{\frac{4GM}{3R}}$ (D) $\sqrt{\frac{3GM}{2R}}$

Solution · Q11 **Answer: (B)**

The projectile only has to reach the mid-point, where the net field is zero. It is fired from the point facing the other planet.

Potential at the launch point:

$$V_1 = -\frac{GM}{R} - \frac{GM}{3R}$$

$$\Rightarrow V_1 = -\frac{4GM}{3R}$$

Potential at the mid-point:

$$V_2 = -\frac{GM}{2R} - \frac{GM}{2R}$$

$$\Rightarrow V_2 = -\frac{GM}{R}$$

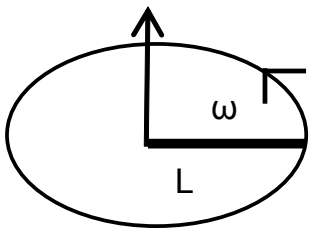
By energy conservation,

$$\frac{v^2}{2} + V_1 = V_2$$

$$\therefore v = \sqrt{\frac{2GM}{3R}}$$

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

12. A thin uniform metallic rod of length L and radius R rotates with an angular velocity ω in a horizontal plane about a vertical axis passing through one of its ends. The density and the Young's modulus of the material of the rod are ρ and Y respectively.
The elongation in its length is



(A) $\frac{\rho\omega^2 L^3}{6Y}$
(B) $\frac{\rho\omega^2 L^3}{3Y}$
(C) $\frac{\rho\omega^2 RL^2}{2Y}$
(D) $\frac{\rho\omega^2 L^3}{2Y}$

Solution · Q12 **Answer: (B)**

Let A be the area of cross-section. The tension at distance x from the axis is

$$T(x) = \int_x^L \rho A\omega^2 r\, dr$$

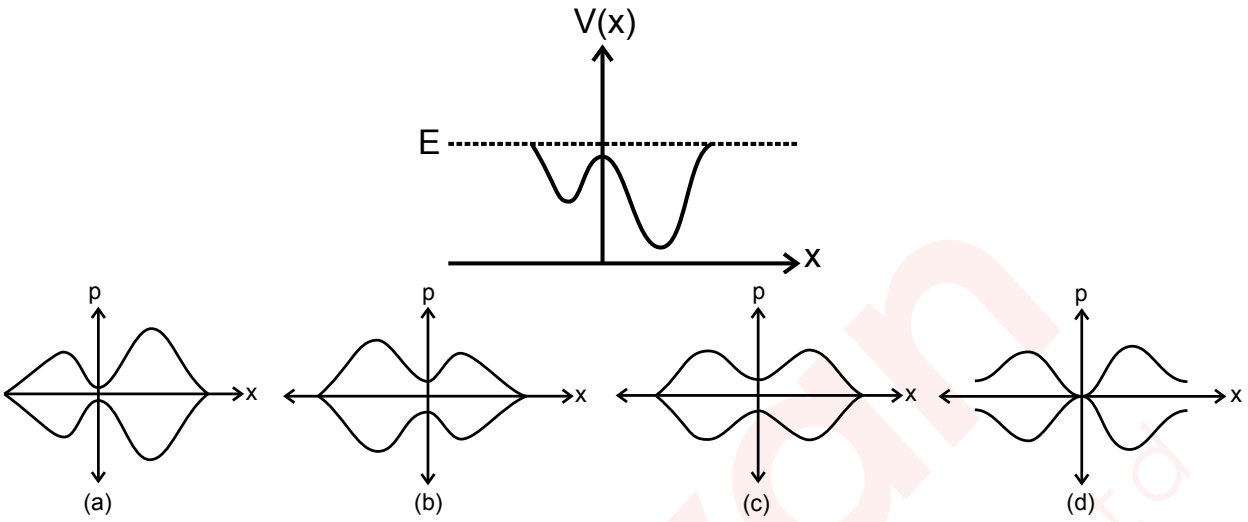
$$\Rightarrow T(x) = \frac{1}{2}\rho A\omega^2\left(L^2 - x^2\right)$$

$$\Delta L = \int_0^L \frac{T(x)\,dx}{AY}$$

$$\therefore \Delta L = \frac{\rho\omega^2 L^3}{3Y}$$

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

13. Consider a particle of mass m with a total energy E moving in a one dimensional potential field. The potential V(x) is plotted against x in the figure beside.
The plot of momentum – position graph of this particle is qualitatively best represented by



All plots are symmetrical about x - axis

(A) Fig. a (B) Fig. b (C) Fig. c (D) Fig. d

Solution · Q13 **Answer: (A)**

By energy conservation,

$$p = \pm\sqrt{2m[E - V(x)]}$$

At the two turning points p is zero, so the graph is a closed loop.

At the origin V is slightly below E, so the momentum is small but not zero.

The well on the right is deeper, so the right bulge is taller. Only figure (a) shows all these features.

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

14. Knowing that the parallel currents attract, the inward pressure on the curved surface of a thin walled, long hollow metallic cylinder of radius R = 50 cm carrying a current of i = 2 amp parallel to its axis distributed uniformly over the entire circumference, is

(A) $2.05 \times 10^{-1}\ Nm^{-2}$ (B) $2.55 \times 10^{-3}\ Nm^{-2}$

(C) $2.05 \times 10^{-5}\ Nm^{-2}$ (D) $2.55 \times 10^{-7}\ Nm^{-2}$

Solution · Q14 **Answer: (D)**

Current per unit width of the wall:

$$k = \frac{i}{2\pi R}$$

At a small patch, the field due to the rest of the cylinder is the mean of the fields inside and outside.

$$B' = \frac{\mu_0 k}{2}$$

$$P = kB'$$

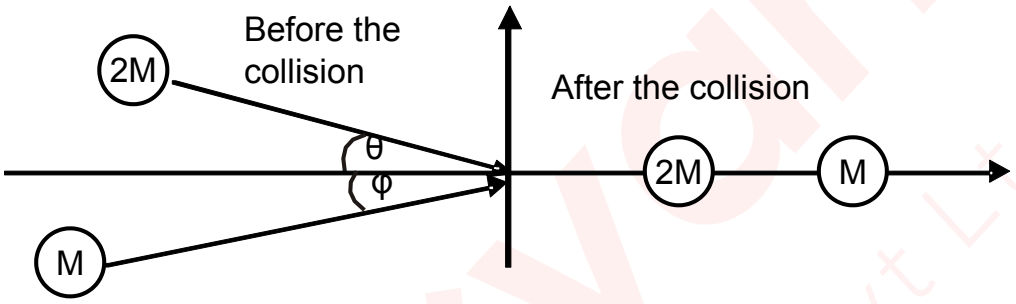
$$\Rightarrow P = \frac{\mu_0 i^2}{8\pi^2 R^2}$$

$$\Rightarrow P = \frac{4\pi \times 10^{-7} \times 4}{8\pi^2 \times 0.25}$$

$$\therefore P \approx 2.55 \times 10^{-7}\ \text{N m}^{-2}$$

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

15. Two masses move on a collision path as shown. Before the collision the object with mass 2M moves with a speed v making an angle $\theta = \sin^{-1}\frac{3}{5}$ to the x-axis while the object with mass M moves with a speed $\frac{3}{2}$v making an angle $\varphi = \sin^{-1}\frac{4}{5}$ with the x-axis. After the collision the object of mass 2M is observed to be moving to the right along the x-axis with a speed of $\frac{4}{5}$v. There are no external forces acting during the collision. The correct option is



(A) The velocity of mass M, after the collision, is zero.

(B) The centre of mass is moving along x-axis before the collision.

(C) The velocity of centre of mass after the collision is $\frac{5}{2}$v

(D) The total linear momentum of the system before the collision along x - axis is $\frac{5}{6}$Mv

Solution · Q15 **Answer: (B)**

$$\sin\theta = 0.6 \text{ and } \sin\phi = 0.8$$

Before the collision,

$$p_y = -2Mv\,(0.6) + M\,(1.5v)\,(0.8)$$

$$\Rightarrow p_y = 0$$

$$p_x = 2Mv\,(0.8) + M\,(1.5v)\,(0.6)$$

$$\Rightarrow p_x = 2.5Mv$$

(A) For mass M after the collision,

$$2.5Mv - 1.6Mv = 0.9Mv$$

It moves with speed 0.9v, so (A) is false.

(B) The vertical momentum is zero. Also, at a time τ before they meet at the origin, the heights give

$$2M\,(0.6v\tau) - M\,(1.2v\tau) = 0$$

So the centre of mass moves along the x axis and (B) is true.

$$v_{cm} = \frac{2.5Mv}{3M}$$

$$\Rightarrow v_{cm} = \frac{5}{6}v$$

So (C) and (D) are false.

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

16. A large hemispherical water tank of radius R is filled with water initially upto a height $h = \frac{R}{2}$. The water starts dripping out through a small orifice of cross section area 'a' at its spherical bottom. The time taken to get the tank completely empty (neglect viscosity) is

(A) $t = \frac{19\pi R^2}{60a}\sqrt{\frac{R}{g}}$ (B) $t = \frac{3\pi R^2}{10a}\sqrt{\frac{R}{g}}$

(C) $t = \frac{17\pi R^2}{60a}\sqrt{\frac{R}{g}}$ (D) $t = \frac{\pi R^2}{4a}\sqrt{\frac{R}{g}}$

Solution · Q16 **Answer: (C)**

At water depth y, with surface radius s,

$$s^2 = 2Ry - y^2$$

By continuity and Torricelli's law,

$$-\pi\left(2Ry - y^2\right)dy = a\sqrt{2gy}\ dt$$

$$t = \frac{\pi}{a\sqrt{2g}}\int_0^{R/2}\left(2Ry^{1/2} - y^{3/2}\right)dy$$

$$\therefore t = \frac{17\pi R^2}{60a}\sqrt{\frac{R}{g}}$$

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

17. If Pascal (Pa), the unit of pressure volt (V), the unit of potential and meter (L), the unit of length are taken as fundamental units, the dimensional formula for the permittivity ε_0 of free space is expressed as

(A) $Pa^{-1}V^2L^{-2}$ (B) $Pa^1V^{-2}L^2$ (C) $Pa^1V^2L^{-2}$ (D) $Pa^{-1}V^{-2}L^2$

Solution · Q17 **Answer: (B)**

Energy density of an electric field:

$$u = \frac{1}{2}\varepsilon_0 E^2$$

The unit of u is Pa, and that of E is volt per unit length.

$$[\varepsilon_0] = Pa\ V^{-2}\ L^2$$

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

18. A cycle wheel of mass M and radius R fitted with a siren at a point on its circumference, is mounted with its plane vertical on a horizontal axle at about 3 feet above the ground. An observer stands in the vertical plane of the wheel at 100 m away from the axle of the wheel on a horizontal platform. The siren emits a sound of frequency 1000 Hz and the wheel rotates clockwise with a uniform angular speed ω = π rad / sec. Initially at t = 0 sec the siren is nearest to the observer and moves downwards. The observer records the highest pitch of sound for the first time after (speed of sound in air is 330 ms^{-1})

(A) 0.30 s (B) 1.8 s (C) 2.3 s (D) 9.8 s

Solution · Q18 **Answer: (B)**

The observer is far from the wheel, so the highest pitch is emitted when the siren moves straight towards him. For clockwise rotation with the observer on the right, this happens at the top.

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

$$\Rightarrow T = 2 \text{ s}$$

The siren reaches the top after three quarters of a turn.

$$t_1 = 1.5 \text{ s}$$

Time taken by the sound:

$$t_2 = \frac{100}{330}$$

$$\Rightarrow t_2 \approx 0.30 \text{ s}$$

$$t = 1.5 + 0.30$$

$$\therefore t = 1.8 \text{ s}$$

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

19. On a right angled transparent triangular prism ABC, when a ray of light is incident on face AB, parallel to the hypotenuse B**C**, it emerges out of the prism grazing along the surface AC. If instead the ray is made incident on face AC, parallel to the hypotenuse CB it gets totally reflected on face AB. The refractive index μ of the material of the prism is

(A) $\mu > \sqrt{2}$

(B) $\sqrt{2} > \mu > \sqrt{\frac{3}{2}}$

(C) $\sqrt{3} > \mu > \sqrt{2}$

(D) $\mu < \sqrt{\frac{3}{2}}$

Solution · Q19 **Answer: (B)**

Faces AB and AC are perpendicular. Let β be the angle at B and c the critical angle. For the first ray,

$$\cos\beta = \mu \sin r$$

It grazes along AC.

$$r = 90° - c$$

$$\Rightarrow \sin r = \sqrt{1 - \frac{1}{\mu^2}}$$

$$\Rightarrow \cos^2\beta = \mu^2 - 1$$

Since this is less than 1,

$$\mu^2 < 2$$

For the second ray, with angle of refraction e,

$$\sin\beta = \mu \sin e$$

Total reflection at AB needs

$$\mu \cos e > 1$$

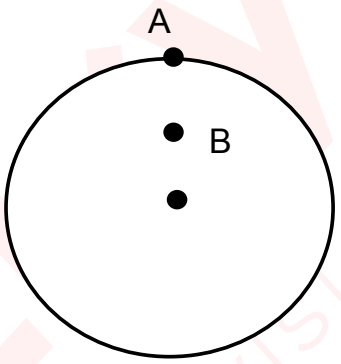
$$\Rightarrow \mu^2 - \sin^2\beta > 1$$

$$\Rightarrow 2\mu^2 > 3$$

$$\therefore \sqrt{2} > \mu > \sqrt{\frac{3}{2}}$$

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

20. A circular disc of radius R = 10 cm is uniformly rolling on a horizontal surface with a velocity v = 4 ms^{-1} of centre of mass without slipping, the time taken by the disc to have the speed of point A (which lies on the circumference) equal to the present speed of point B (point B lies midway between centre and the point A) is



(A) t = 0.025 s (B) t = 0.036 s (C) t = 0.046 s (D) t = 0.064 s

Solution · Q20 **Answer: (B)**

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

$$\Rightarrow \omega = \frac{4}{0.10}$$

$$\Rightarrow \omega = 40 \text{ rad/s}$$

Present speed of B:

$$v_B = 4 + 2$$

$$\Rightarrow v_B = 6 \text{ m } s^{-1}$$

After the disc turns through θ, the speed of A is

$$v_A = 2v\cos\frac{\theta}{2}$$

$$\Rightarrow \cos\frac{\theta}{2} = 0.75$$

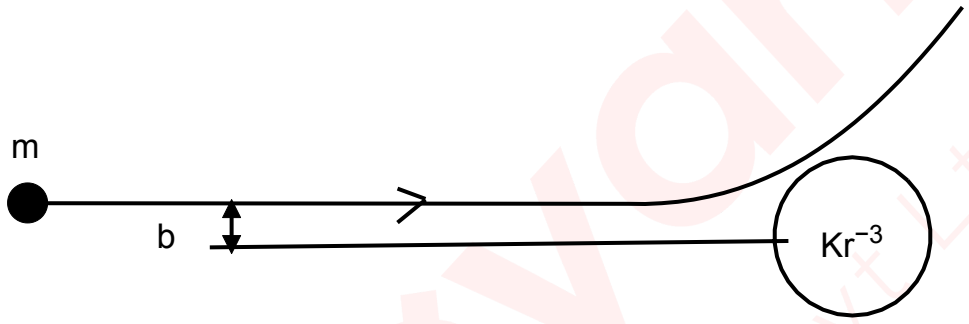
$$\Rightarrow \theta = 82.82°$$

$$\Rightarrow \theta = 1.445 \text{ rad}$$

$$t = \frac{\theta}{\omega}$$
$$\Rightarrow t = \frac{1.445}{40}$$
$$\therefore t \approx 0.036 \text{ s}$$

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

21. As shown in the figure, a particle of mass m = 10^{-10} kg, moving with velocity $v_0 = 10^5$ m/s approaches a stationary fixed target with impact parameter b from a large distance. If the fixed rigid target has a core with repulsive central force $F(r) = \frac{K}{r^3}$ where constant K > 0 and the particle scatters elastically. The closest distance of approach (if numerically K = b^2) is



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

Solution · Q21 **Answer: (B)**

Potential energy of the repulsive force:

$$U = \int_r^\infty \frac{K}{r^3} dr$$
$$\Rightarrow U = \frac{K}{2r^2}$$

Let v be the speed at the closest distance d. By conservation of angular momentum,

$$mv_0 b = mvd$$

By energy conservation,

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + \frac{K}{2d^2}$$
$$\Rightarrow d^2 = b^2 + \frac{K}{mv_0^2}$$

$mv_0^2 = 1$ J and $K = b^2$

$$\therefore d = b\sqrt{2}$$

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

22. If the specific activity of C^{14} nuclide in a certain ancient wooden toy is known to be $\frac{3}{5}$ of that in a recently fallen tree of the same class, the age of the ancient wooden toy is
(The half life of C^{14} is 5570 years)

(A) 5570 years (B) 4105 years (C) 3342 years (D) 2785 years

Solution · Q22 **Answer: (B)**

Taking the carbon-14 level in the air as unchanged,

$$S = S_0 e^{-\lambda t}$$

$$\Rightarrow e^{-\lambda t} = 0.60$$

$$\Rightarrow \lambda t = 0.5108$$

$$t = \frac{0.5108}{0.6931} \times 5570$$

$\therefore t \approx 4105$ years

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

23. Statement I: Work done in bringing a charge q from infinity to the center of a uniformly charged non – conducting solid sphere of radius R (with a total charge Q) is zero.

Statement II: The potential difference between the Centre and the surface of the uniformly charged non – conducting solid sphere of radius R (with a total charge Q) is $\frac{1}{4\pi\varepsilon_0} \times \frac{Q}{2R}$.

(A) If statement I is true and statement II is true and also if the statement II is a correct explanation of statement I

(B) If statement I is true and statement II is true but the statement II is a not a correct explanation of statement I

(C) If statement I is true but the statement II is false

(D) If statement I is false but statement II is true

Solution · Q23 **Answer: (D)**

Take the potential at infinity as zero. At the surface,

$$V_s = \frac{Q}{4\pi\varepsilon_0 R}$$

Inside the sphere,

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

$$V_c - V_s = \int_0^R E\, dr$$

$$\Rightarrow V_c - V_s = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{2R}$$

So statement II is true.

$$V_c = \frac{3Q}{8\pi\varepsilon_0 R}$$

This is not zero, so the work done is not zero and statement I is false.

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

24. Statement I: The current flowing through a p-n junction is more in forward bias than that in the reverse bias.

Statement II: The diffusion current, dominant in forward bias, is more than the drift current, dominant in the reverse bias.

(A) If statement I is true and statement II is true and also if the statement II is a correct explanation of statement I

(B) If statement I is true and statement II is true but the statement II is a not a correct explanation of statement I

(C) If statement I is true but the statement II is false

(D) If statement I is false but statement II is true

Solution · Q24 **Answer: (A)**

Forward bias lowers the barrier, so a large diffusion current of majority carriers flows.

Reverse bias raises the barrier, leaving only a very small drift current of minority carriers.

So both statements are true, and II correctly explains I.

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

Q. 25 – 32 · 6 marks only if all correct options are marked · no negative marking

25. A simple pendulum consisting of a small bob of mass m attached to a massless inextensible string of length ℓ = 2m, hanging vertically from the ceiling, is oscillating in a vertical plane with an angular amplitude θ_m such that the maximum tension in its string is three times the minimum tension in the string i.e., $T_{max} = 3T_{min}$. The correct option(s) is/are

(A) The maximum tension in the string is $T_{max} = mg\,(3 - 2\cos\theta_m)$

(B) The maximum tension in the string is $T_{max} = \frac{9}{5}mg$

(C) The maximum velocity of the bob on its way is $v_{max} = 3.96\ ms^{-1}$

(D) The angular amplitude θ_m lies in the range $\frac{\pi}{4} < \theta_m < \frac{\pi}{3}$

Solution · Q25 **Answer: (A), (B), (C), (D)**

At angle θ, from energy conservation and the radial equation,

$$T = mg\,(3\cos\theta - 2\cos\theta_m)$$

At the lowest point,

$$T_{max} = mg\,(3 - 2\cos\theta_m)$$

So (A) is true. At the extreme position,

$$T_{min} = mg\cos\theta_m$$

Using the given condition,

$$T_{max} = 3T_{min}$$

$$\Rightarrow \cos\theta_m = 0.6$$

$$\Rightarrow T_{max} = \frac{9}{5}mg$$

So (B) is true.

$$v_{max} = \sqrt{2 \times 9.8 \times 2 \times 0.4}$$

$$\Rightarrow v_{max} = 3.96 \text{ m/s}$$

So (C) is true. Also,

$$\cos 60° < 0.6 < \cos 45°$$

So (D) is true.

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

26. Two small masses m and M lie on a large horizontal frictionless circular track of radius R. The two masses are free to slide on the track but constrained to move along a circle. Initially the two masses are tied by a thread with a compressed spring between them (spring of negligible length being attached with none of the two masses). The compressed spring stores a potential energy U_0. At a certain time t = 0 the thread is burnt and the two masses are released to run opposite to each other leaving the spring behind. The total mechanical energy remaining conserved. On the circular track the two masses make a head on perfectly elastic collision. Take M = 2m for all calculations. Which of the following option(s) is / are correct?

(A) The angle turned by mass m before the collision is $\theta = 4\frac{\pi}{3}$

(B) The velocity of mass m on the track is $u = \sqrt{\frac{4U_0}{3m}}$

(C) The time taken to collide for the first time is $t_1 = 2\pi R\sqrt{\frac{m}{3U_0}}$

(D) The time taken for the second collision is $t_2 = 2\pi R\sqrt{\frac{2m}{3U_0}}$

Solution · Q26 **Answer: (A), (B), (C)**

The total angular momentum about the centre stays zero, so the heavier mass has half the speed u of the lighter one. If m turns through θ before meeting,

$$\theta + \frac{\theta}{2} = 2\pi$$

$$\Rightarrow \theta = \frac{4\pi}{3}$$

So (A) is true.

$$\frac{1}{2}mu^2 + \frac{1}{2}(2m)\left(\frac{u}{2}\right)^2 = U_0$$

$$\Rightarrow u = \sqrt{\frac{4U_0}{3m}}$$

So (B) is true.

$$t_1 = \frac{2\pi R}{u + \frac{u}{2}}$$

$$\Rightarrow t_1 = 2\pi R\sqrt{\frac{m}{3U_0}}$$

So (C) is true.

In the elastic collision both velocities reverse. The second collision therefore occurs at

$$t = 2t_1$$

The printed time is neither this total nor the interval, so (D) is false.

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

27. The electric field component of an electromagnetic wave is expressed as $E = (3j + bk) \times 10^{-3} \sin[10^7(x + 2y + 3z - \beta t)]$ in SI units. Taking $c = 3 \times 10^8$ ms^{-1} as the speed of electromagnetic wave in vacuum, choose the correct option(s)

(A) The value of constant beta is $\beta = 3 \times 10^8 \times \sqrt{14}$

(B) The value of constant b is b = 2.

(C) The average energy density of the em wave is $U = 6.5 \times 10^{-6}\ \varepsilon_0$ in SI units.

(D) The amplitude of magnetic field is $B = 1.20 \times 10^{-11}$ Tesla

Solution · Q27 **Answer: (A), (C), (D)**

Magnitude of the wave vector:

$$k = 10^7\sqrt{14}\ \ m^{-1}$$

$$\omega = ck$$

$$\Rightarrow \beta = 3 \times 10^8 \times \sqrt{14}$$

So (A) is true.

The electric field is perpendicular to the wave vector.

$$6 + 3b = 0$$

$$\Rightarrow b = -2$$

So (B) is false.

$$U = \frac{1}{2}\varepsilon_0 E_0^2$$

$$\Rightarrow U = 6.5 \times 10^{-6}\varepsilon_0$$

So (C) is true.

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

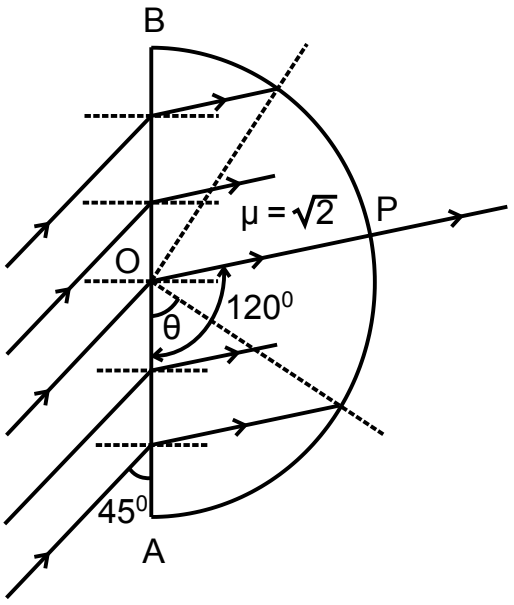
$$\Rightarrow B_0 = \frac{\sqrt{13} \times 10^{-3}}{3 \times 10^8}$$

$$\Rightarrow B_0 = 1.20 \times 10^{-11}\ T$$

So (D) is true.

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

28. A parallel beam of light is made incident (as shown) on the flat diametric plane of a transparent semi-circular thin sheet of thickness t (t << R) of refractive index $\mu = \sqrt{2}$ at an angle of 45^0. As a result of refraction, the light enters the semi-circular sheet and comes out at its curved surface.



Here θ is the angle between the vertical diameter AB and the concerned radius of the semicircular sheet of radius R.

(A) Light rays come out at the curved surface for values of θ in the range $75^0 \le \theta \le 165^0$.

(B) The range of angle θ is independent of the angle of incidence.

(C) The range of angle θ depends on the refractive index of the material

(D) All the emergent rays of light shall cross the line OP which is a refracted ray at $\theta = 120^0$

Solution · Q28 **As per Zigyan: (A), (C), (D)**

For the critical angle C and refraction angle r,

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

$$\sin 45° = \sqrt{2} \sin r$$

$$\Rightarrow C = 45°$$

$$\Rightarrow r = 30°$$

The drawing is not to scale; the marked angle puts the refracted rays along

$$\theta = 120°$$

They emerge if

$$|\theta - 120°| \le 45°$$

$$\Rightarrow 75° \le \theta \le 165°$$

So (A) is true.

The range of θ means the whole interval between its two limits.

The limits are

$$\theta = 90° + r \mp C$$

They depend on incidence and on μ, so (B) is false and (C) is true.

With incidence i and emergence e on the arc, a ray bends towards OP and meets it at X.

$$OX = \frac{R\sin e}{\sin(e - i)}$$

This exceeds R, so (D) is true.

Check: At normal incidence the limits are 45° and 135°, and at 45° incidence they are 75° and 165°.

So the interval moves with the angle of incidence.

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

29. A certain rod of uniform area of cross section A (A = 1.0 cm^2) with its length = 2 m is thermally insulated on its lateral surface. The thermal conductivity (K) of the material of the rod varies with temperature T as $K = \frac{\alpha}{T}$ where α is a constant. The two ends of the rod are maintained at temperature of T_1 = 90°C and T_2 = 10°C. The correct option(s) is /are

(A) The temperature at 50 cm from the colder end is 17.32°C

(B) The temperature at 50 cm from the hotter end is 51.96°C

(C) The rate of heat flow per unit area of cross section of the rod is 1.1α in SI units.

(D) The temperature gradient is numerically higher near the hot end compare to that near the cold end.

Solution · Q29 **As per Zigyan: (A), (B), (C), (D)**

In steady state the heat flux J is constant. With x from the hot end, and with T in this law taken in °C,

$$J = -\frac{\alpha}{T}\frac{dT}{dx}$$

$$\Rightarrow Jx = \alpha \ln\frac{90}{T}$$

Using the cold end,

$$T = 90 \times 9^{-x/2}$$

At 50 cm from the colder end,

$$T = 90 \times 3^{-3/2}$$

$$\Rightarrow T = 17.32\ °C$$

At 50 cm from the hotter end,

$$T = 90 \times 3^{-1/2}$$

$$\Rightarrow T = 51.96\ °C$$

$$J = \frac{\alpha}{2}\ln 9$$

$$\Rightarrow J = \alpha \ln 3$$

$$\Rightarrow J \approx 1.1\alpha$$

The size of the gradient is

$$\left|\frac{dT}{dx}\right| = \frac{JT}{\alpha}$$

It is larger near the hot end. So all four are true.

Check: Equal lengths divide T by equal factors, here √3 for each 50 cm.

From the hot end this gives 90 °C, 51.96 °C, 30 °C, 17.32 °C and 10 °C.

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

30. Positronium is a short-lived ($\approx 10^{-9}$s) bound state of an electron and a positron (a positively charged particle with mass and charge equal (in magnitude) to an electron) revolving round their common centre of mass. If E_0, v_0 and a_0 are respectively the ground state energy, the orbital speed of electron in first orbit and the radius of the first (n = 1) Bohr orbit for Hydrogen atom, the corresponding quantities E, v and a for the positronium are

(A) $E = \frac{E_0}{2}$

(B) $a = a_0$

(C) $a = 2a_0$

(D) $E = E_0$, $v = v_0$, $a = a_0$

Solution · Q30 **As per Zigyan: (A), (C)**

The reduced mass of positronium is

$$\mu = \frac{m}{2}$$

Energy is proportional to the reduced mass, and the separation is inversely proportional to it.

The Bohr radius a of positronium is the electron–positron separation.

$$E = \frac{E_0}{2}$$

$$a = 2a_0$$

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

(D) is false, as E is halved and the electron's speed is also half of the hydrogen value.

Check: Take two circles of radius r about the centre of mass, Coulomb pull across 2r and total angular momentum ħ.

Then r is a_0 and each speed is half of v_0, so the separation is $2a_0$.

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

31. A thin double convex lens of radii of curvature R_1 = 20 cm and R_2 = 60 cm is made-up of a transparent material of refractive index μ = 1.5. Choose the correct option(s)

(A) The focal length of the lens is f = 30 cm when in air.

(B) The lens behaves as a concave mirror of focal length f_M = 10 cm when silvered on the surface of radius R_2 = 60 cm

(C) The lens behave as a concave lens (diverging lens) if the image space beyond R_2 = 60 cm radius surface is filled with a transparent liquid of refractive index $\mu = \frac{5}{3}$. The object space prior to the surface of radius R_1 = 20 cm is air.

(D) A beam of rays incident parallel to principal axis focuses at 48 cm behind the lens if water $\left(\mu = \frac{4}{3}\right)$ fills the entire space behind the surface of radius R_2 = 60 cm. The object space prior to the surface of radius R_1 = 20 cm is air.

Solution · Q31 **Answer: (A), (B), (D)**

$$R_1 = +20 \text{ cm}, R_2 = -60 \text{ cm}$$

(A) In air,

$$\frac{1}{f} = 0.5\left(\frac{1}{20} + \frac{1}{60}\right)$$
$$\Rightarrow \frac{1}{f} = \frac{1}{30}$$

So f is 30 cm; true.

(B) With the second surface silvered,

$$\frac{1}{F} = \frac{2}{30} + \frac{1}{30}$$
$$\Rightarrow \frac{1}{F} = \frac{1}{10}$$

It is a concave mirror, so (B) is true.

(C) With the liquid behind,

$$P = \frac{1}{40} - \frac{1}{360}$$
$$\Rightarrow P = \frac{1}{45}$$

The power is positive, so (C) is false.

(D) With water behind,

$$P = \frac{1}{40} + \frac{1}{360}$$
$$\Rightarrow P = \frac{1}{36}$$

Distance of the focus:

$$\frac{4}{3} \times 36 = 48 \text{ cm}$$

So (D) is true.

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

32. A thick hollow cylinder of height h and inner and outer radii a and b (b > a) made up of a poorly conducting material of resistivity ρ lies coaxially inside a long solenoid at its middle. The radius of the solenoid is larger than b. Throughout the interior of the solenoid, a uniform time varying magnetic field B = βt is produced parallel to solenoid axis. Here β is a constant. In this time varying magnetic field

(A) the emf induced at a certain radius r (a < r < b) in the hollow cylinder is $\pi r^2\beta$

(B) the induced current circulating in the thick hollow cylinder between radii a and b is $i = \frac{\beta h}{4\rho}\left(b^2 - a^2\right)$

(C) the resistance offered to the circulation of current by the thick hollow cylinder is $R = \frac{2\pi\rho}{h \times \ln\frac{b}{a}}$

(D) no electric field is detectable outside the solenoid.

Solution · Q32 **Answer: (A), (B), (C)**

The field of the induced current is neglected.

(A) For a circle of radius r,

$$\text{emf} = \pi r^2\beta$$

So (A) is true.

(B) For a thin ring of width dr,

$$di = \frac{\beta h}{2\rho} r dr$$

$$\Rightarrow i = \frac{\beta h}{4\rho}\left(b^2 - a^2\right)$$

So (B) is true.

(C) The rings are in parallel.

$$\frac{1}{R} = \int_a^b \frac{h dr}{2\pi\rho r}$$

$$\Rightarrow \frac{1}{R} = \frac{h}{2\pi\rho} \ln\frac{b}{a}$$

So (C) is true.

(D) Outside a solenoid of radius s,

$$E = \frac{\beta s^2}{2r}$$

This is not zero, so (D) is false.

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

ANSWER KEY

IOQP 2021-22 · PAPER CODE 61

32
QUESTIONS · 120 MARKS

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

1	(C)	2	(B)	3	(D)	4	(D)	5	(D)
6	(A)	7	(A)	8	(A)	9	(B)	10	(A)
11	(B)	12	(B)	13	(A)	14	(D)	15	(B)
16	(C)	17	(B)	18	(B)	19	(B)	20	(B)
21	(B)	22	(B)	23	(D)	24	(A)	25	(A), (B), (C), (D)
26	(A), (B), (C)	27	(A), (C), (D)	28	(A), (C), (D)★	29	(A), (B), (C), (D)★	30	(A), (C)★
31	(A), (B), (D)	32	(A), (B), (C)						

★ Answers as per Zigyan

- **Q28** — As per Zigyan: (A), (C), (D); IAPT key (A), (C), (D).
- **Q29** — As per Zigyan: (A), (B), (C), (D); IAPT key (A), (B), (C), (D).
- **Q30** — As per Zigyan: (A), (C); IAPT key (A), (C).

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Olympiad results



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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

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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

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PHYSICS



Sulokya Bibhuty
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Above MAS

PHYSICS



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RESULTS · 2021 – 2026

Our toppers, year by year

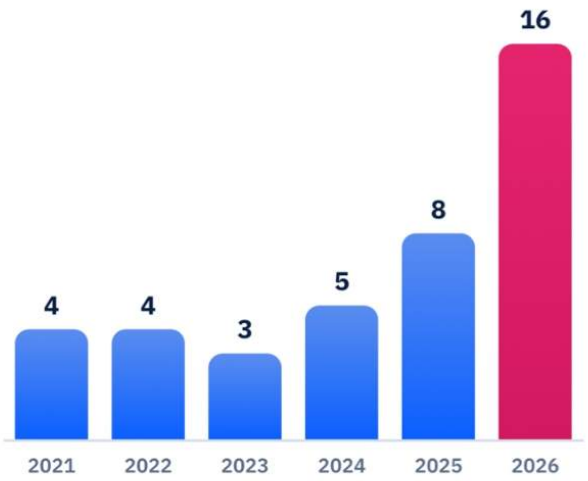
40
JEE Advanced selections in 6 years

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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