JEE Main 2023 8 April Shift 1 Physics Question Paper with Solutions

Time Allowed :180 minutes	**Maximum Marks :**300	**Total questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

(A) The test is of 3 hours duration.

(B) The question paper consists of 90 questions. The maximum marks are 300.

(C) There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.

(D) Each part (subject) has two sections.

(i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.

(ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

1. A cylindrical wire of mass (0.4 ± 0.01)g has length (8 ± 0.04) cm and radius (6 ± 0.03) mm. The maximum error in its density will be:

Options:

(1) 4%

(2) 1%

(3) 3.5%

(4) 5%

Correct Answer: (1)

Solution:

Step 1: Use the formula for density and apply error propagation principles.

- Given $m = (0.4 \pm 0.01)$ g, $\ell = (8 \pm 0.04)$ cm, $r = (6 \pm 0.03)$ mm.

- Density $\rho = \frac{m}{\pi r^2 \ell}$.

- Differentiate logarithmically:

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta\ell}{\ell} + 2\frac{\Delta r}{r}.$$

- Substitute:

$$\frac{\Delta\rho}{\rho} = \frac{0.01}{0.4} + \frac{0.04}{8} + 2 \cdot \frac{0.03}{6}.$$

Step 2: Simplify the calculations.

$$\frac{\Delta\rho}{\rho} = 0.025 + 0.005 + 0.01 = 0.04.$$

Final Answer: Maximum error in density = $0.04 \times 100 = 4\%$.

Quick Tip

Remember to include all terms in the error propagation formula to get accurate results.

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2. The engine of a train moving with speed 10 ms^{-1} towards a platform sounds a whistle at frequency 400 Hz. The frequency heard by a passenger inside the train is (neglect air speed, speed of sound in air = 330 ms^{-1}):

Options:

(1) 400 Hz

(2) 388 Hz

(3) 200 Hz

(4) 412 Hz

Correct Answer: (1)

Solution:

Step 1: Analyze the situation.

- A passenger inside the train is at rest relative to the train.

- Hence, the frequency heard by the passenger is the same as the source frequency.

Final Answer: The frequency heard by the passenger is $400\,\text{Hz}$.

> Quick Tip
>
> For Doppler Effect problems, consider relative motion between source and observer.

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3. The weight of a body on the earth is 400 N. Then weight of the body when taken to a depth half of the radius of the earth will be:

Options:

(1) 300 N

(2) Zero

(3) 100 N

(4) 200 N

Correct Answer: (4)

Solution:

Step 1: Use the formula for weight at depth.

- Weight on surface: $W = mg = 400\,\text{N}$.

- At depth $d = R/2$,

$$W' = W\left(1 - \frac{d}{R}\right).$$

Step 2: Substitute the values.

$$W' = 400\left(1 - \frac{1}{2}\right) = 400 \cdot \frac{1}{2} = 200\,\text{N}.$$

Final Answer: Weight at half the earth's radius = $200\,\text{N}$.

Quick Tip

Weight decreases linearly with depth, assuming uniform density of the earth.

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4. A TV transmitting antenna is 98 m high, and the receiving antenna is at ground level. If the radius of the earth is 6400 km, the surface area covered by the transmitting antenna is approximately:

Options:

(1) 1240 km^2

(2) 1549 km^2

(3) 4868 km^2

(4) 3942 km^2

Correct Answer: (4)

Solution:

Step 1: Use the formula for surface area covered.

- Maximum distance covered $d = \sqrt{2Rh_T}$.

- Surface area $A = \pi d^2 \approx 2\pi R h_T$.

Step 2: Substitute the values.

$$A = 2 \cdot 3.14 \cdot 6400 \cdot 98 \cdot 10^{-3}.$$

$$A \approx 3942\,\text{km}^2.$$

Final Answer: Surface area covered = $3942\,\text{km}^2$.

Quick Tip

For line-of-sight calculations, use the approximate formula $d = \sqrt{2Rh}$.

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5. Certain galvanometers have a fixed core made of non-magnetic metallic material. The function of this metallic material is:

Options:

(1) To produce large deflecting torque on the coil

(2) To bring the coil to rest quickly

(3) To oscillate the coil in magnetic field for longer period of time

(4) To make the magnetic field radial

Correct Answer: (2)

Solution:

Step 1: Analyze the role of the metallic core.

- A non-magnetic metallic core produces eddy currents, which create a damping force.

- This damping force brings the coil to rest quickly.

Final Answer: The function is to bring the coil to rest quickly.

> Quick Tip
>
> Eddy currents in metallic cores are used for damping in galvanometers.

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6. Dimension of $\frac{1}{\mu_0 \epsilon_0}$ should be equal to:

Options:

(1) T/L

(2) T^2/L^2

(3) L/T

(4) L^2/T^2

Correct Answer: (4)

Solution:

Step 1: Use the relationship between μ_0, ϵ_0, and the speed of light.

- Given $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$, we know:

$$\frac{1}{\mu_0 \epsilon_0} = c^2.$$

Step 2: Analyze the dimensions.

- Dimensional formula for c: $[c] = \frac{L}{T}$.

- Hence, $[\frac{1}{\mu_0 \epsilon_0}] = [c^2] = \frac{L^2}{T^2}$.

Final Answer: The dimension is $\frac{L^2}{T^2}$.

Quick Tip

Use dimensional analysis to verify relationships involving physical constants.

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

Options:

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

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

(3) 4 : 9

(4) 1 : 1

Correct Answer: (3)

Solution:

Step 1: Use the formula for the range of projectile motion.

- Range $R = \frac{u^2 \sin 2\theta}{g}$.

- For two projectiles:

$$\frac{R_1}{R_2} = \left(\frac{u_1}{u_2}\right)^2 \cdot \frac{\sin 2\theta_1}{\sin 2\theta_2}.$$

Step 2: Substitute the values.

- For $u_1 = 40\,\text{m/s}, \theta_1 = 30^\circ, u_2 = 60\,\text{m/s}, \theta_2 = 60^\circ$:

$$\frac{R_1}{R_2} = \left(\frac{40}{60}\right)^2 \cdot \frac{\sin 60^\circ}{\sin 120^\circ}.$$

$$\frac{R_1}{R_2} = \frac{4}{9}.$$

Final Answer: The ratio of ranges is $4 : 9$.

Quick Tip

For projectile motion problems, always consider the effect of angles and initial velocities.

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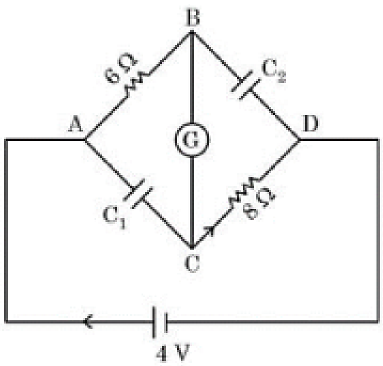
8. In this figure, the resistance of the coil of galvanometer G is 2Ω. The emf of the cell is 4 V. The ratio of potential difference across C_1 and C_2 is:



Options:

(1) $\frac{5}{4}$

(2) 1

(3) $\frac{4}{5}$

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

Correct Answer: (3)

Solution:

Step 1: Apply Kirchhoff's laws.

- Using the given circuit, calculate the currents and potential drops across C_1 and C_2.

- The ratio is determined as:

$$\frac{V_{C_1}}{V_{C_2}} = \frac{4}{5}.$$

Final Answer: The ratio of potential differences is $\frac{4}{5}$.

Quick Tip

Analyze the circuit using Kirchhoff's rules to calculate potential differences.

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9. A charge particle moving in magnetic field B has components of velocity along B and perpendicular to B. The path of the charge particle will be:

Options:

(1) Helical path with the axis along magnetic field B

(2) Straight along the direction of magnetic field B

(3) Helical path with the axis perpendicular to the direction of magnetic field B

(4) Circular path

Correct Answer: (1)

Solution:

Step 1: Analyze the motion of the charged particle.

- A velocity component parallel to B: uniform motion along B.

- A velocity component perpendicular to B: circular motion due to magnetic force.

- Combined motion results in a helical path.

Final Answer: The path is a helical path with the axis along B.

> **Quick Tip**
>
> The magnetic force acts perpendicular to the velocity of the charged particle.

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10. Proton (P) and electron (e) will have same de-Broglie wavelength when the ratio of their momentum is (assume $m_p = 1849\, m_e$):

Options:

(1) 1 : 43

(2) 43 : 1

(3) 1 : 1849

(4) 1 : 1

Correct Answer: (4)

Solution:

Step 1: Use the de-Broglie wavelength formula.

- $\lambda = \frac{h}{p}$, where p is momentum.

- If $\lambda_p = \lambda_e$, then:

$$\frac{h}{p_p} = \frac{h}{p_e} \implies \frac{p_p}{p_e} = 1.$$

Final Answer: The ratio of momentum is $1 : 1$.

> **Quick Tip**
>
> For particles with equal de-Broglie wavelengths, their momenta must also be equal.

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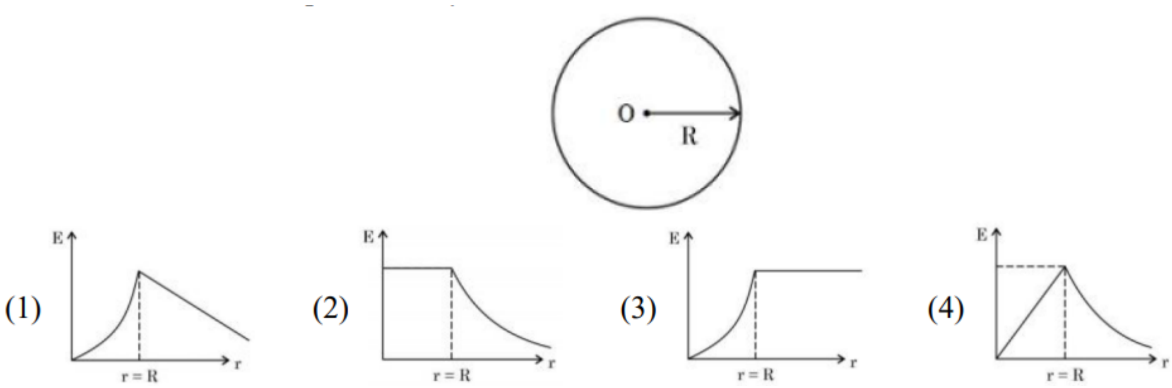
11. Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the center O is represented by:



Correct Answer: (4)

Solution:

Step 1: Analyze the electric field inside and outside the sphere.

- Inside the sphere $(r < R)$: Electric field increases linearly with r due to the uniformly distributed charge.

- Outside the sphere $(r \geq R)$: Electric field decreases as $\frac{1}{r^2}$, behaving like a point charge at the center.

Step 2: Draw the graph.

- Combine the two observations to get the correct graph for the electric field variation.

Final Answer: The correct graph is represented by option (4).

> Quick Tip
>
> Always consider the charge distribution and apply Gauss's Law to determine electric field behavior.

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12. For a nucleus $^{A}_{Z}X$ having mass number A and atomic number Z:

Options:

(1) B, C only

(2) A, B, C, D only

(3) B, C, E only

(4) C, D only

Correct Answer: (4)

Solution:

Step 1: Analyze the terms in the binding energy equation.

$$E_B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} + \delta(A, Z).$$

- Volume term: $a_v A$

- Surface energy term: $-a_s A^{2/3}$

- Coulomb term: $-a_c \frac{Z(Z-1)}{A^{1/3}}$

- Asymmetry term: $-a_a \frac{(A-2Z)^2}{A}$

- Pairing term: $\delta(A, Z)$

Step 2: Match the options with the equation.

- C and D are directly supported by the equation.

Final Answer: The most appropriate choice is option (4).

Quick Tip

The binding energy equation is essential in nuclear physics to understand stability.

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13. At any instant the velocity of a particle of mass 500 g is $(2t\hat{i} + 3t^2\hat{j})$ ms^{-1}. If the force acting on the particle at $t = 1$ s is $(\hat{i} + x\hat{j})$ N, then the value of x will be:

Options:

(1) 2

(2) 6

(3) 3

(4) 4

Correct Answer: (3)

Solution:

Step 1: Calculate acceleration.

$$\vec{v} = (2t\hat{i} + 3t^2\hat{j})$$

= d$\frac{}{dt=(2\hat{i}+6t\hat{j}).}$

At $t = 1$ s:

$\vec{a} = (2\hat{i} + 6\hat{j})$ ms^{-2}.

Step 2: Calculate force.

- Given mass $m = 500\,\text{g} = 0.5\,\text{kg}$:

$$\vec{F} = m\vec{a} = 0.5 \cdot (2\hat{i} + 6\hat{j}) = (\hat{i} + 3\hat{j})\,\text{N}.$$

Final Answer: The value of x is 3.

> **Quick Tip**
>
> Differentiate velocity to find acceleration, and use $F = ma$ to calculate force.

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14. Given below are two statements:

Statement I: If E be the total energy of a satellite moving around the Earth, then its potential energy will be $\frac{E}{2}$.

Statement II: The kinetic energy of a satellite revolving in an orbit is equal to the half the magnitude of total energy E.

Options:

(1) Both Statement I and Statement II are incorrect

(2) Statement I is incorrect but Statement II is correct

(3) Statement I is correct but Statement II is incorrect

(4) Both Statement I and Statement II are correct

Correct Answer: (1)

Solution:

Step 1: Analyze Statement I.

- Total energy $E = KE + PE$, and $PE = -2KE$.

- Thus, $PE = 2E$, making Statement I incorrect.

Step 2: Analyze Statement II.

- By energy relations, $KE = \frac{|E|}{2}$.

- However, the given statement does not hold true, making it incorrect.

Final Answer: Both statements are incorrect.

> **Quick Tip**
>
> Remember that $PE = -2KE$ for orbital motion under gravitational forces.

15. Two forces having magnitude A and $\frac{A}{2}$ are perpendicular to each other. The magnitude of their resultant is:

Options:

(1) $\frac{5A}{2}$

(2) $\frac{\sqrt{5A^2}}{2}$

(3) $\frac{\sqrt{5}A}{4}$

(4) $\frac{\sqrt{5}A}{2}$

Correct Answer: (4)

Solution:

Step 1: Analyze the given forces.

- Let the two forces be $F_1 = A$ and $F_2 = \frac{A}{2}$.

- The forces are perpendicular to each other.

Step 2: Calculate the resultant force.

$$F_r = \sqrt{F_1^2 + F_2^2} = \sqrt{A^2 + \left(\frac{A}{2}\right)^2}.$$

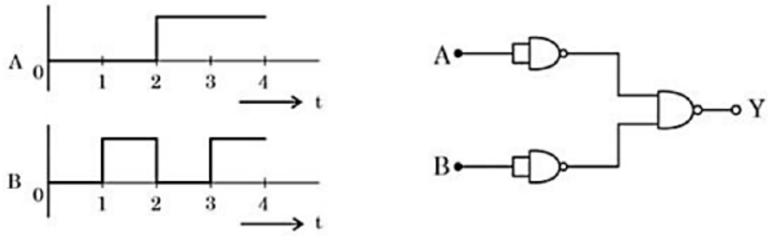
$$F_r = \sqrt{A^2 + \frac{A^2}{4}} = \sqrt{\frac{5A^2}{4}} = \frac{\sqrt{5}A}{2}.$$

Final Answer: The resultant force is $\frac{\sqrt{5}A}{2}$.

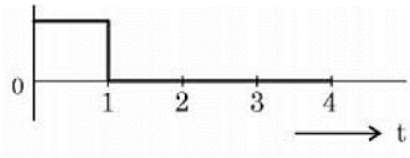
Quick Tip

When forces are perpendicular, use the Pythagorean theorem to find the resultant.

16. For the logic circuit shown, the output waveform at Y is:



(1)



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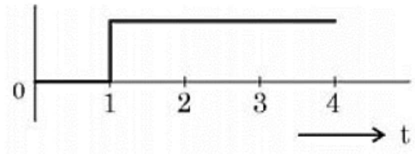

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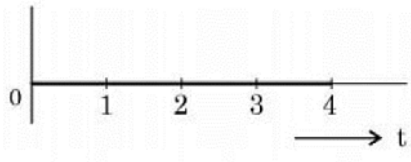
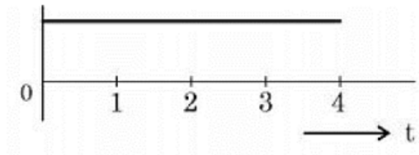


(4)



Correct Answer: Option 1 waveform

Solution:

Step 1: Analyze the circuit.

- The given logic circuit is a combination of AND and OR gates.

- Inputs A and B are given as:

- $A = 1$ for $t = 0$ to 1, 3 to 4, and $A = 0$ for $t = 1$ to 3.

- $B = 1$ for $t = 2$ to 4, and $B = 0$ for $t = 0$ to 2.

Step 2: Compute intermediate and final outputs.

- Output of AND gate: $A \cdot B = 1$ if both $A = 1$ and $B = 1$.

- Output of OR gate: $A + B = 1$ if either $A = 1$ or $B = 1$.

- Final output $Y = A \cdot B + A$:

- $Y = 0$ for $t = 0$ to 1.

- $Y = 1$ for $t = 1$ to 2.

- $Y = 0$ for $t = 2$ to 3.

- $Y = 1$ for $t = 3$ to 4.

Final Answer: The output waveform at Y matches Option 1.

Quick Tip

Analyze the truth tables of individual gates to determine the final circuit output.

17. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}$ N/m^2 undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:

Options:

(1) 5600

(2) 2800

(3) 11200

(4) 8400

Correct Answer: (1)

Solution:

Step 1: Recall the energy density formula.

- Energy per unit volume $u = \frac{1}{2} \cdot \text{stress} \cdot \text{strain}$.

- Stress $= Y \cdot \text{strain}$.

Step 2: Substitute the values.

- Given: $Y = 7.0 \times 10^{10}$ N/m^2, strain $= \frac{0.04}{100} = 0.0004$.

$$u = \frac{1}{2} \cdot Y \cdot (\text{strain})^2.$$

$$u = \frac{1}{2} \cdot 7.0 \times 10^{10} \cdot (0.0004)^2.$$

$$u = 5600\,\text{J/m}^3.$$

Final Answer: The energy per unit volume is $5600\,\text{J/m}^3$.

Quick Tip

The energy density formula involves both stress and strain. Verify units for consistency.

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18. Given below are two statements:

Statement I: If heat is added to a system, its temperature must increase.

Statement II: If positive work is done by a system in a thermodynamic process, its volume must increase.

Options:

(1) Both Statement I and Statement II are true

(2) Both Statement I and Statement II are false

(3) Statement I is true but Statement II is false

(4) Statement I is false but Statement II is true

Correct Answer: (4)

Solution:

Step 1: Analyze Statement I.

- Heat can be added without a temperature increase in processes like phase transitions or isothermal processes.

- Hence, Statement I is false.

Step 2: Analyze Statement II.

- Work done $w = \int PdV$. Positive work implies an increase in volume.

- Hence, Statement II is true.

Final Answer: Statement I is false, but Statement II is true.

Quick Tip

Different thermodynamic processes can have heat transfer without a temperature change.

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19. An air bubble of volume 1 cm^3 rises from the bottom of a lake 40 m deep to the surface at a temperature of $12°$C. The atmospheric pressure is 1×10^5 Pa, the density of water is 1000 kg/m^3, and $g = 10$ m/s^2. The volume of the air bubble when it reaches the surface will be:

Options:

(1) $3\,\text{cm}^3$

(2) $4\,\text{cm}^3$

(3) $2\,\text{cm}^3$

(4) $5\,\text{cm}^3$

Correct Answer: (4)

Solution:

Step 1: Calculate pressures at the surface and depth.

- Pressure at the surface $P_1 = 10^5\,\text{Pa}$.

- Pressure at depth $P_2 = P_1 + \rho g h$.

$$P_2 = 10^5 + 1000 \cdot 10 \cdot 40 = 5 \times 10^5\,\text{Pa}.$$

Step 2: Apply Boyle's law.

- Given initial volume $V_1 = 1\,\text{cm}^3$ and constant temperature:

$$P_1 V_1 = P_2 V_2.$$

$$10^5 \cdot 1 = 5 \times 10^5 \cdot V_2.$$

$$V_2 = 5\,\text{cm}^3.$$

Final Answer: The volume of the air bubble is $5\,\text{cm}^3$.

Quick Tip

Use Boyle's law for isothermal processes where pressure and volume change.

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20. In a reflecting telescope, a secondary mirror is used to:

Options:

(1) Make chromatic aberration zero

(2) Reduce the problem of mechanical support

(3) Move the eyepiece outside the telescopic tube

(4) Remove spherical aberration

Correct Answer: (3)

Solution:

Step 1: Role of the secondary mirror.

- The secondary mirror in a reflecting telescope redirects light to move the eyepiece outside the tube.

Final Answer: The secondary mirror is used to move the eyepiece outside the telescopic tube.

Quick Tip

Reflecting telescopes eliminate chromatic aberration by using mirrors instead of lenses.

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21. The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is:

Correct Answer: 125%

Solution:

Step 1: Relation between kinetic energy and momentum.

- Kinetic energy $K = \frac{P^2}{2m}$, where P is momentum and m is mass.

Step 2: Calculate new kinetic energy.

- Initial momentum P_1, kinetic energy $K_1 = \frac{P_1^2}{2m}$.

- New momentum $P_2 = P_1 + 0.5P_1 = 1.5P_1$.

- New kinetic energy $K_2 = \frac{P_2^2}{2m} = \frac{(1.5P_1)^2}{2m} = \frac{2.25P_1^2}{2m} = 2.25K_1$.

Step 3: Calculate percentage increase in kinetic energy.

$$\text{Percentage increase} = \frac{K_2 - K_1}{K_1} \times 100 = \frac{2.25K_1 - K_1}{K_1} \times 100 = 125\%.$$

Final Answer: The percentage increase in kinetic energy is 125%.

Quick Tip

When momentum increases, kinetic energy increases quadratically since $K \propto P^2$.

---

22. A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into two fragments each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is:

Correct Answer: 121 MeV

Solution:

Step 1: Calculate initial and final binding energies.

- Initial binding energy $B_E^{\text{initial}} = 242 \times 7.6 = 1839.2\,\text{MeV}$.

- Final binding energy $B_E^{\text{final}} = 2 \times (121 \times 8.1) = 2 \times 980.1 = 1960.2\,\text{MeV}$.

Step 2: Calculate the gain in binding energy.

$$\text{Gain} = B_E^{\text{final}} - B_E^{\text{initial}} = 1960.2 - 1839.2 = 121\,\text{MeV}.$$

Final Answer: The total gain in binding energy is $121\,\text{MeV}$.

> Quick Tip
>
> Binding energy gain indicates increased stability after nuclear reactions.

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23. An electric dipole of dipole moment 6.0×10^{-6} C · m is placed in a uniform electric field of 1.5×10^3 N/C. The work done in rotating the dipole by 180° in this field will be:

Correct Answer: 18 mJ

Solution:

Step 1: Formula for work done.

- Work done $W_{\text{ext}} = U_f - U_i$, where $U = -\vec{P} \cdot \vec{E}$.

- Initial potential energy $U_i = -PE\cos 0 = -PE$.

- Final potential energy $U_f = -PE\cos 180 = +PE$.

Step 2: Substitute the values.

$$W_{\text{ext}} = U_f - U_i = PE - (-PE) = 2PE.$$

$$W_{\text{ext}} = 2 \cdot 6.0 \times 10^{-6} \cdot 1.5 \times 10^3 = 18\,\text{mJ}.$$

Final Answer: The work done is $18\,\text{mJ}$.

> Quick Tip
>
> Work done depends on the angle of rotation and the strength of the electric field.

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24. An organ pipe 40 cm long is open at both ends. The speed of sound in air is 360 m/s. The frequency of the second harmonic is:

Correct Answer: 900 Hz

Solution:

Step 1: Formula for frequency in an open organ pipe.

- Fundamental frequency $f_1 = \frac{v}{2L}$, where $v = 360\,\text{m/s}$, $L = 0.4\,\text{m}$.

- Frequency of second harmonic $f_2 = 2f_1$.

Step 2: Calculate the frequency.

$$f_1 = \frac{360}{2 \times 0.4} = 450\,\text{Hz}.$$

$$f_2 = 2 \times 450 = 900\,\text{Hz}.$$

Final Answer: The frequency of the second harmonic is $900\,\text{Hz}$.

> **Quick Tip**
>
> The second harmonic frequency is twice the fundamental frequency in open organ pipes.

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25. The moment of inertia of a semicircular ring about an axis, passing through the center and perpendicular to the plane of the ring, is $(1/x)MR^2$, where R is the radius and M is the mass of the semicircular ring. The value of x will be:

Correct Answer: 2

Solution:

Step 1: Formula for moment of inertia.

- Moment of inertia $I = \int R^2 dm$, where $dm = \frac{M}{\pi R}$.

- For a semicircular ring, $I = \frac{1}{2}MR^2$.

Step 2: Compare with given expression.

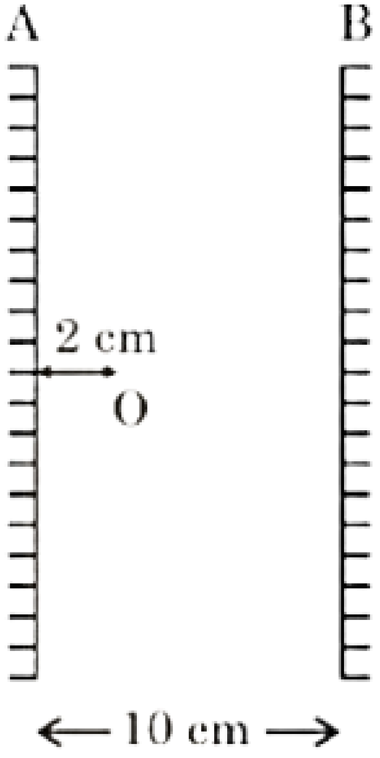
- Given $I = \frac{1}{x}MR^2$.

- Equating $\frac{1}{2}MR^2 = \frac{1}{x}MR^2$, we get $x = 2$.

Final Answer: The value of x is 2.

> **Quick Tip**
>
> Moment of inertia depends on the mass distribution and the axis of rotation.

26. Two vertical parallel mirrors A and B are separated by 10 cm. A point object O is placed at a distance of 2 cm from mirror A. The distance of the second nearest image behind mirror A from the mirror A is:



Correct Answer: 18cm

Solution:

Step 1: Calculate the positions of images formed by multiple reflections.

- The distance of the first image from mirror A is $2\,\text{cm}$.

- The distance of the first image from mirror B is $10 + 2 = 12\,\text{cm}$.

- The distance of the second image from mirror A is $10 + 12 = 22\,\text{cm}$.

- The distance of the second nearest image behind mirror A is $18\,\text{cm}$.

Final Answer: The distance of the second nearest image is $18\,\text{cm}$.

Quick Tip

For multiple reflections, calculate distances iteratively for each reflection.

27. The magnetic intensity at the center of a long current carrying solenoid is found to

be 1.6×10^3 A/m. If the number of turns is 8 per cm, then the current flowing through the solenoid is:

Correct Answer: 2A

Solution:

Step 1: Use the formula for magnetic intensity.

- Magnetic intensity $H = nI$, where n is the number of turns per meter and I is the current.

- Given $H = 1.6 \times 10^3$ A/m, $n = 8\,\text{turns/cm} = 800\,\text{turns/m}$.

Step 2: Solve for the current.

$$I = \frac{H}{n} = \frac{1.6 \times 10^3}{800} = 2\,\text{A}.$$

Final Answer: The current flowing through the solenoid is $2\,\text{A}$.

Quick Tip

Ensure consistent units for turns per meter and current when applying the formula.

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28. A current of 2 A through a wire of cross-sectional area $25.0\,\text{mm}^2$. The number of free electrons in a cubic meter is 2.0×10^{28}. The drift velocity of the electrons is ____ $\times 10^{-6}$ m/s (given, charge on electron $= 1.6 \times 10^{-19}$ C):

Correct Answer: 25

Solution:

Step 1: Use the formula for drift velocity.

- Drift velocity $V_d = \frac{I}{neA}$, where I is the current, n is the number of free electrons per unit volume, e is the electron charge, and A is the cross-sectional area.

Step 2: Substitute the values.

$$V_d = \frac{2}{(2 \times 10^{28}) \cdot (1.6 \times 10^{-19}) \cdot (25 \times 10^{-6})}.$$

$$V_d = \frac{2}{800 \times 10^{-6}} = 25 \times 10^{-6}\,\text{m/s}.$$

Final Answer: The drift velocity of the electrons is 25×10^{-6} m/s.

Quick Tip

Drift velocity is typically very small due to the high number of free electrons.

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29. An oscillating LC circuit consists of a $75\,$mH inductor and a $1.2\,\mu$F capacitor. If the maximum charge to the capacitor is $2.7\,\mu$C. The maximum current in the circuit will be:

Correct Answer: 9 mA

Solution:

Step 1: Use the energy conservation in LC circuits.

- Maximum energy in capacitor = Maximum energy in inductor.

$$\frac{1}{2}LI_{\text{max}}^2 = \frac{1}{2}\frac{q_{\text{max}}^2}{C}.$$

Step 2: Solve for I_{max}.

$$I_{\text{max}} = \frac{q_{\text{max}}}{\sqrt{LC}}.$$

$$I_{\text{max}} = \frac{2.7 \times 10^{-6}}{\sqrt{75 \times 10^{-3} \cdot 1.2 \times 10^{-6}}}.$$

$$I_{\text{max}} = 9 \times 10^{-3}\,\text{A} = 9\,\text{mA}.$$

Final Answer: The maximum current in the circuit is $9\,$mA.

Quick Tip

Energy conservation in LC circuits ensures smooth oscillations between capacitor and inductor.

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30. An air bubble of diameter $6\,$mm rises steadily through a solution of density $1750\,$kg/m^3 at the rate of $0.35\,$cm/s. The coefficient of viscosity of the solution (neglect density of air) is ____ Pas (given, $g = 10\,$m/s^2):

Correct Answer: 10

Solution:

Step 1: Apply Stokes' Law for terminal velocity.

- For uniform velocity, net force = 0.

- Buoyant force $= 6\pi\eta rv$.

$$\frac{4}{3}\pi r^3 \rho g = 6\pi\eta rv.$$

Step 2: Solve for η.

$$\eta = \frac{2r^2\rho g}{9v}.$$

- Given $r = \frac{6}{2} \times 10^{-3} = 3 \times 10^{-3}\,\text{m}$, $\rho = 1750\,\text{kg/m}^3$, $v = 0.35 \times 10^{-2}\,\text{m/s}$:

$$\eta = \frac{2 \cdot (3 \times 10^{-3})^2 \cdot 1750 \cdot 10}{9 \cdot 0.35 \times 10^{-2}}.$$

$$\eta = 10\,\text{Pas}.$$

Final Answer: The coefficient of viscosity is $10\,\text{Pas}$.

Quick Tip

Stokes' Law relates the drag force to viscosity and terminal velocity.
