JEE MAINS 2023 Physics 13 APRIL Shift 2 Question Paper with Solutions

Time Allowed :1 Hours	Maximum Marks :120	Total Questions :30

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 30 questions. All questions are compulsory.
2. This question paper contains only one section - Mathematics
3. In all sections, Questions are multiple choice questions (MCQs) and questions carry 4 mark each.

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31. Given below are two statements:

Statement I: An AC circuit undergoes electrical resonance if it contains either a capacitor or an inductor.

Statement II: An AC circuit containing a pure capacitor or a pure inductor consumes high power due to its non-zero power factor.

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

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

(3) Both Statement I and Statement II are false

(4) Both Statement I and Statement II are true

Correct Answer: (3)

Solution: Statement I: An AC circuit for resonance requires both inductor and capacitor. For resonance, $\phi = 0$, i.e., the current and voltage must be in phase. This cannot happen with just an inductor or capacitor alone. Thus, Statement I is false.

Statement II: In an AC circuit with a pure capacitor or pure inductor, the power factor is either zero (for a pure capacitor) or unity (for a pure inductor in certain conditions). A pure inductor or capacitor does not consume high power, contrary to what is stated in Statement II. Therefore, Statement II is also false.

Quick Tip

For resonance to occur in an AC circuit, both the inductor and capacitor are required. In the case of pure components, the circuit does not consume real power unless there is some resistance.

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32. A passenger sitting in a train A moving at 90 km/h observes another train B moving in the opposite direction for 8 s. If the velocity of the train B is 54 km/h, then the length of train B is:

(1) 120 m

(2) 200 m

(3) 320 m

(4) 80 m

Correct Answer: (3) 320 m

Solution: The velocity of train A (V_A) is given as 90 km/h.

$$V_A = 90\,\text{km/h} = 25\,\text{m/s}$$

The velocity of train B (V_B) is given as 54 km/h.

$$V_B = 54\,\text{km/h} = 15\,\text{m/s}$$

The relative velocity (V_{BA}) of train B with respect to train A is:

$$V_{BA} = V_B + V_A = 15 + 25 = 40\,\text{m/s}$$

Now, the time for crossing is given as 8 seconds, and we are asked to find the length of train B. Using the formula:

$$\text{Time of crossing} = \frac{\text{Length of train}}{\text{Relative velocity}}$$

$$8 = \frac{\ell}{40} \quad \Rightarrow \quad \ell = 8 \times 40 = 320\,\text{m}$$

Thus, the length of train B is 320 m.

Quick Tip

To solve relative motion problems, always start by calculating the relative velocity. Then, use the time and relative velocity to calculate the distance traveled.

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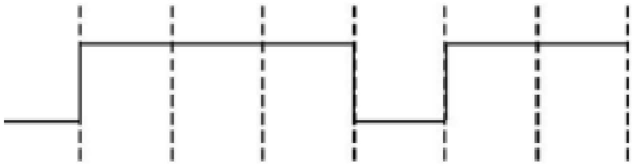
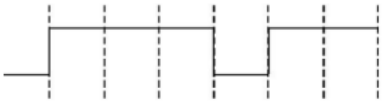
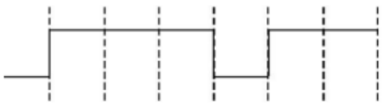
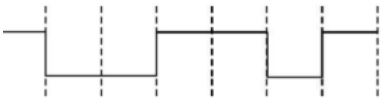
33. The output from a NAND gate having inputs A and B given below will be,



(1) 

(2) 

(3) 

(4) 

Correct Answer: (1)

Solution: Truth table for NAND gate is

A	B	$Y = A \cdot B$
0	0	1
1	0	1
0	1	1
1	1	0

On the basis of the given input A and B, the truth table is:

A	B	Y
1	1	0
0	1	1
1	0	1
0	0	1

Quick Tip

The NAND gate output is the opposite of the AND gate. If both inputs are 1, the output is 0, and in all other cases, the output is 1.

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34. The distance travelled by an object in time t is given by $s = (2.5)t^2$. The instantaneous speed of the object at $t = 5$ sec will be:

(1) 25 m/s

(2) 12.5 m/s

(3) 5 m/s

(4) 62.5 m/s

Correct Answer: (1)

Solution: The distance travelled is given by $s = 2.5t^2$. The speed v is the rate of change of distance with respect to time, which can be found by differentiating the distance equation with respect to time:

$$v = \frac{ds}{dt} = 5t$$

At $t = 5$ sec,

$$v = 5 \times 5 = 25\,\text{m/s}$$

Thus, the instantaneous speed at $t = 5$ sec is 25 m/s.

Quick Tip

Remember, instantaneous speed is the first derivative of the position function with respect to time.

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35. In a Young's double slits experiment, the ratio of amplitude of light coming from slits is $2:1$. The ratio of the maximum to minimum intensity in the interference pattern is:

(1) 9 : 1

(2) 9 : 4

(3) 2 : 1

(4) 25 : 9

Correct Answer:(1)

Solution: Given that the ratio of amplitude of light coming from slits is $\frac{A_1}{A_2} = \frac{2}{1}$, the intensity in the interference pattern is given by:

$$I_{\text{max}} = (A_1 + A_2)^2$$

$$I_{\text{min}} = (A_1 - A_2)^2$$

Substituting the given values:

$$I_{\text{max}} = (2+1)^2 = 9$$

$$I_{\text{min}} = (2-1)^2 = 1$$

Thus, the ratio of the maximum to minimum intensity is:

$$\frac{I_{\text{max}}}{I_{\text{min}}} = \frac{9}{1} = 9:1$$

Quick Tip

In Young's double slit experiment, the intensity at constructive points is the square of the sum of the amplitudes, and at destructive points, it is the square of the difference of the amplitudes.

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36. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R. Assertion A: The binding energy per nucleon is practically independent of the atomic number for nuclei of mass number in the range 30 to 170. Reason R: Nuclear force is short ranged.

(1) Both A and R are true but R is NOT the correct explanation of A

(2) Both A and R are true and R is the correct explanation of A

(3) A is true but R is false

(4) A is false but R is true

Correct Answer:(1)

Solution: The binding energy per nucleon is nearly constant for a wide range of atomic numbers. This is because the nuclear force is short-ranged and the force between nucleons in a nucleus is nearly constant for different nuclei, hence it is independent of the atomic number. However, the reason for this constancy is the short-range nature of the nuclear force. Therefore, both A and R are true, but R is NOT the correct explanation of A.

Quick Tip

The short-range nuclear force explains the constant binding energy per nucleon for large atomic mass numbers.

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37. Two planets A and B of radii R and 1.5R have densities ρ and $\rho/2$ respectively. The ratio of acceleration due to gravity at the surface of B to A is:

(1) 2 : 3

(2) 2 : 1

(3) 4 : 3

(4) 3 : 4

Correct Answer:(4)

Solution: The acceleration due to gravity g is given by:

$$g = \frac{GM}{R^2}$$

where G is the gravitational constant, M is the mass, and R is the radius of the planet. The mass M can be written in terms of the density ρ as:

$$M = \frac{4}{3}\pi R^3 \rho$$

Thus, the acceleration due to gravity at the surface of each planet is:

$$g = \frac{G\left(\frac{4}{3}\pi R^3 \rho\right)}{R^2}$$

$$g = \frac{4}{3}\pi G R \rho$$

For planet A, the acceleration due to gravity is:

$$g_A = \frac{4}{3}\pi G R \rho$$

For planet B, where $R_B = 1.5R$ and $\rho_B = \frac{\rho}{2}$, the acceleration is:

$$g_B = \frac{4}{3}\pi G(1.5R)\frac{\rho}{2} = \frac{4}{3}\pi G R \rho \times \frac{3}{8}$$

Thus, the ratio $\frac{g_B}{g_A}$ is:

$$\frac{g_B}{g_A} = \frac{3}{4}$$

Quick Tip

For comparing accelerations due to gravity, consider both the radius and density of the planet.

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38. The mean free path of molecules of a certain gas at STP is 1500d, where d is the diameter of the gas molecules. While maintaining the standard pressure, the mean free path of the molecules at 373 K is approximately:

(1) 750d

(2) 1500d

(3) 1098d

(4) 2049d

Correct Answer:(4)

Solution: The mean free path λ is related to the temperature T by the formula:

$$\lambda \propto \frac{T}{P}$$

Given that the temperature is increased from 273 K to 373 K, and the pressure remains constant, we can write:

$$\frac{\lambda_2}{\lambda_1} = \frac{T_2}{T_1}$$

Substituting the values:

$$\frac{\lambda_2}{\lambda_1} = \frac{373}{273} \approx 1.364$$

Thus, the new mean free path λ_2 is approximately:

$$\lambda_2 = 1.364 \times 1500d \approx 2049d$$

Quick Tip

The mean free path increases with temperature, as the molecules move faster and experience fewer collisions.

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39. To radiate an EM signal of wavelength λ with high efficiency, the antennas should have a minimum size equal to:

(1) λ

(2) $\frac{\lambda}{2}$

(3) 2λ

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

Correct Answer:(4)

Solution: To radiate EM signals efficiently, the minimum length of the antenna should be a quarter of the wavelength, i.e., $\frac{\lambda}{4}$.

Quick Tip

For efficient radiation, antennas are designed with dimensions related to the wavelength of the signal.

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40. A particle executes SHM of amplitude A. The distance from the mean position when its kinetic energy is equal to its potential energy is:

(1) $\sqrt{2}A$

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

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

(4) $2A$

Correct Answer:(3)

Solution: In SHM, when the kinetic energy is equal to the potential energy, the particle is at half its maximum displacement. Therefore, the distance from the mean position is $\frac{1}{\sqrt{2}}A$.

Quick Tip

In SHM, the total energy is the sum of kinetic and potential energies, and they are equal when the particle is at $\frac{1}{\sqrt{2}}$ of the amplitude.

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41. In an electromagnetic wave, at an instant and at a particular position, the electric field is along the negative z axis and magnetic field is along the positive x-axis. Then the direction of propagation of electromagnetic wave is:

(1) negative y-axis

(2) at 45° angle from positive y-axis

(3) positive y-axis

(4) positive z-axis

Correct Answer:(1)

Solution: In an electromagnetic wave, the direction of propagation of the wave is given by the cross product of the electric field $\vec{E}$ and the magnetic field $\vec{B}$. The direction of propagation is $\vec{E} \times \vec{B}$, which gives the direction along the negative y-axis.

Quick Tip

In electromagnetic waves, the direction of propagation is always perpendicular to both the electric and magnetic fields.

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42. Given below are two statements: Statement I: Out of microwaves, infrared rays and ultraviolet rays, ultraviolet rays are the most effective for the emission of electrons from a metallic surface. **Statement II:** Above the threshold frequency, the maximum kinetic energy of photoelectrons is inversely proportional to the frequency of the incident light.

(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:(3)

Solution: UV rays have maximum frequency hence are most effective for emission of electrons from the metallic surface. The kinetic energy of photoelectrons increases with frequency and is given by $KE_{\text{max}} = hf - \phi$, where h is Planck's constant and ϕ is the work function.

Quick Tip

UV rays are most effective for electron emission as they have the highest frequency, which provides greater energy.

43. Given below are two statements: Statement I: For a planet, if the ratio of mass of the planet to its radius increases, the escape velocity from the planet also increases. **Statement II:** Escape velocity is independent of the radius of the planet.

(1) Both Statement I and Statement II are correct

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

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

(4) Both Statement I and Statement II are incorrect

Correct Answer:(2)

Solution: The escape velocity is given by:

$$v_e = \sqrt{\frac{2GM}{R}}$$

Thus, if the ratio of mass to radius increases, the escape velocity increases. On the other hand, the escape velocity depends on both the mass and the radius of the planet, so Statement II is incorrect.

Quick Tip

Escape velocity depends on both the mass and the radius of a planet. As mass increases or radius decreases, escape velocity increases.

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44. A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with angular velocity of 0.2 rad/s. The centripetal force acting on the vehicle is: (1) 2800 N

(2) 560 N

(3) 2240 N

(4) 14 N

Correct Answer:(2)

Solution: The centripetal force is given by:

$$F_c = m \cdot r \cdot \omega^2$$

where m is the mass, r is the radius, and ω is the angular velocity. Substituting the values:

$$F_c = 200 \cdot 70 \cdot (0.2)^2 = 560\,\text{N}$$

> **Quick Tip**
>
> Centripetal force depends on the mass of the vehicle, the radius of the curve, and the square of the angular velocity.

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45. A 10 μC charge is divided into two parts and placed at 1 cm distance so that the repulsive force between them is maximum. The charges of the two parts are:

(1) 7 μC, 3 μC

(2) 8 μC, 2 μC

(3) 9 μC, 1 μC

(4) 5 μC, 5 μC

Correct Answer:(4)

Solution: Divide $q = 10\mu C$ into parts x and $(q - x)$. The repulsive force between them is given by:

$$F = \frac{k \cdot x \cdot (q - x)}{r^2}$$

To find the value of x for maximum force, differentiate F with respect to x and set it to zero:

$$\frac{dF}{dx} = 0$$

Solving for x, we get:

$$x = \frac{q}{2} = 5\mu C$$

Thus, $q - x = 5\mu C$. Therefore, the charges are 5 μC and 5 μC.

Quick Tip

To maximize the repulsive force, divide the charge into two equal parts.

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46. In the equation $[x + \frac{a}{y}][Y - b] = RT$, where X is pressure, Y is volume, R is universal gas constant and T is temperature. The physical quantity equivalent to the ratio $\frac{a}{b}$ is:

(1) Coefficient of viscosity

(2) Energy

(3) Impulse

(4) Pressure gradient

Correct Answer:(2)

Solution: Given that x and $\frac{a}{y}$ have the same dimensions, and y and b have the same dimensions, we know that:

$$[a] = [ML^{-1}T^{-2}]$$

$$[b] = [L^2]$$

Thus, the dimensions of the ratio $\frac{a}{b}$ are:

$$\frac{[a]}{[b]} = \frac{[ML^{-1}T^{-2}]}{[L^2]} = [MT^{-2}]$$

This corresponds to energy.

Quick Tip

The dimensions of energy are $[ML^2T^{-2}]$, which match the dimensions of $\frac{a}{b}$.

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47. An electron is moving along the positive x-axis. If the uniform magnetic field is applied parallel to the negative z-axis, then

(1) B and E only

(2) A and E only

(3) B and D only

(4) C and D only

Correct Answer:(1)

Solution: The force on a charged particle moving in a magnetic field is given by:

$$\vec{F} = q(\vec{v} \times \vec{B})$$

Since the electron is moving along the positive x-axis and the magnetic field is applied along the negative z-axis, the magnetic force will be perpendicular to both the velocity and the magnetic field, and it will be directed along the negative y-axis (according to the right-hand rule). Thus, the electron will experience a magnetic force along the negative y-axis.

Quick Tip

Remember that the force is always perpendicular to both the velocity of the particle and the magnetic field.

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48. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: A spherical body of radius (5 ± 0.1) mm having a particular density is falling through a liquid of constant density. The percentage error in the calculation of its terminal velocity is 4%.

Reason R: The terminal velocity of the spherical body falling through the liquid is inversely proportional to its radius.

(1) Both A and R are true but R is NOT the correct explanation of A

(2) Both A and R are true and R is the correct explanation of A

(3) A is false but R is true

(4) A is true but R is false

Correct Answer:(4)

Solution: The terminal velocity V_t of a spherical body in a liquid is given by:

$$V_t \propto \frac{1}{r^2}$$

where r is the radius. Since the error in the radius leads to a 4Thus, Assertion A is true, but Reason R is false because the terminal velocity is proportional to $\frac{1}{r^2}$, not inversely to r.

> **Quick Tip**
>
> For a spherical object falling through a fluid, the terminal velocity is inversely proportional to the square of the radius.

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49. The initial pressure and volume of an ideal gas are P_1 and V_1. The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_1}{4}$ will be:

(1) $P_1 \left(\frac{V_1}{4}\right)^{\gamma}$

(2) $4P_1$

(3) P_0

(4) $P_1 \left(\frac{V_1}{4}\right)^{\gamma-1}$

Correct Answer:(4)

Solution: Since the process is adiabatic, the equation for an adiabatic process is given by:

$$PV^{\gamma} = \text{constant}$$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

Substituting $V_2 = \frac{V_1}{4}$, we get:

$$P_2 = P_1 \left(\frac{V_1}{4}\right)^{\gamma-1}$$

> **Quick Tip**
>
> In an adiabatic process, the pressure and volume are related by $PV^{\gamma} = \text{constant}$, where γ is the ratio of specific heats.

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50. In the network shown below, the charge accumulated in the capacitor in steady state will be:

(1) 4.8

(2) 12

(3) 7.2

(4) 10.3

Correct Answer:(3)

Solution: In steady state, no current will pass through the capacitor since both capacitors behave as open circuits. Thus, the charge accumulated on the capacitor can be calculated as follows:

$$i_2 = 0 \quad \text{and} \quad i_1 = \frac{3V}{6\,\Omega + 4\,\Omega} = \frac{3}{10}\,\text{A}$$

The potential difference across the $6\,\Omega$ resistor is $V = i_1 \times 6\,\Omega = 1.8\,\text{V}$, and this will be the potential across the capacitor as well.

The charge on the capacitor is given by:

$$c = V \times 4\,\mu\text{F} = 1.8 \times 4 = 7.2\,\mu\text{C}$$

Quick Tip

In steady state, capacitors in DC circuits behave as open circuits, meaning no current flows through them.

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51. In an experiment with sonometer when a mass of 180 g is attached to the string, it vibrates with fundamental frequency of 30 Hz. When a mass m is attached, the string vibrates with fundamental frequency of 50 Hz. The value of m is ____________ g

(1) 25 g

(2) 40 g

(3) 50 g

(4) 60 g

Correct Answer:(1) 25 g

Solution: Fundamental frequency f of a vibrating string is given by:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

Where L is the length, T is the tension, and μ is the mass per unit length of the string. For the first condition:

$$f_1 = 30\,\text{Hz}, \quad m_1 = 180\,\text{g}$$

$$f_2 = 50\,\text{Hz}, \quad m_2 = m\,\text{g}$$

Using the formula for frequency and ratio of frequencies:

$$\frac{f_2}{f_1} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{50}{30} = \sqrt{\frac{m}{180}}$$

Squaring both sides and solving for m, we get:

$$\frac{25}{9} = \frac{m}{180} \quad \Rightarrow \quad m = 25\,\text{g}$$

Quick Tip

Use the relationship between frequency and mass to solve for unknown masses in vibrating strings.

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52. Two plates A and B have thermal conductivities 84 W/m·K and 126 W/m·K respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at $100C$ and $0C$ respectively, then the temperature of the surface of contact in steady state is __________$_C$

(1) 40°C

(2) 50°C

(3) 60°C

(4) 70°C

Correct Answer:(1) 40°C

Solution: The heat transferred by conduction is given by:

$$Q = \frac{kA(T_1 - T_2)}{d}$$

Where k is the thermal conductivity, A is the area, T_1, T_2 are the temperatures of the surfaces, and d is the thickness.

Given that the heat transferred through A is equal to that through B:

$$k_A(T_1 - T) = k_B(T - T_2)$$

Substituting the given values:

$$84(100 - T) = 126(T - 0)$$

Solving for T, we get:

$$8400 - 84T = 126T$$

$$8400 = 210T \quad \Rightarrow \quad T = 40C$$

> **Quick Tip**
>
> When two materials with different thermal conductivities are in contact, their heat flow rates must be equal at steady state.

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53. In the circuit shown below, the energy stored in the capacitor is $3\,\mu$J. The value of n is ______________.

(1) 75

(2) 100

(3) 125

(4) 150

Correct Answer:(3) 75

Solution: The energy stored in a capacitor is given by:

$$E = \frac{1}{2}CV^2$$

Where C is the capacitance and V is the voltage across the capacitor.

Given:

$$C = 6\,\mu F, \quad V = 12\,\text{V}$$

Substituting the values:

$$E = \frac{1}{2} \times 6 \times 10^{-6} \times (12)^2$$

$$E = 0.75\,\mu\text{J}$$

Quick Tip

To calculate the energy stored in a capacitor, use the formula $E = \frac{1}{2}CV^2$.

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54. A light rope is wound around a hollow cylinder of mass $5\,$kg and radius $70\,$cm. The rope is pulled with a force of $52.5\,$N. The angular acceleration of the cylinder will be ____________ rad/s^2

(1) 1.5 rad/s^2

(2) 5 rad/s^2

(3) 10 rad/s^2

(4) 15 rad/s^2

Correct Answer:(1) 1.5 rad/s^2

Solution: The rotational motion equation is given by:

$$\tau = I\alpha$$

Where τ is the torque, I is the moment of inertia, and α is the angular acceleration.

For a hollow cylinder, the moment of inertia is:

$$I = mr^2$$

The torque is the force applied at the radius:

$$\tau = Fr$$

Thus, we get:

$$Fr = mr^2\alpha$$

$$\alpha = \frac{F}{mr}$$

Substituting the given values:

$$\alpha = \frac{52.5}{5 \times 0.7} = 1.5\,\text{rad/s}^2$$

Quick Tip

To calculate angular acceleration, use the relation $\tau = I\alpha$ and substitute the known values for torque and moment of inertia.

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55. A straight wire AB of mass $40\,$g and length $50\,$cm is suspended by a pair of flexible leads in uniform magnetic field of magnitude $0.40\,$T. The magnitude of the current required in the wire to remove the tension in the supporting leads is ____________ A. (Take $g = 10\,$m/s^2)

(1) 1.5 A

(2) 2 A

(3) 3 A

(4) 4 A

Correct Answer:(2) 2 A

Solution: For equilibrium, the magnetic force acting on the wire must balance the weight:

$$Mg = IBl$$

Where M is the mass, g is acceleration due to gravity, I is the current, B is the magnetic field, and l is the length of the wire.

Substitute the known values:

$$(40 \times 10^{-3}) \times 10 = I \times 0.40 \times 0.50$$

Solving for I:

$$0.4 = 0.2I \quad \Rightarrow \quad I = 2\,\text{A}$$

Quick Tip

To find the current that removes tension, use the formula $Mg = IBl$ and solve for I.

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56. An insulated copper wire of 100 turns is wrapped around a wooden cylindrical core of the cross-sectional area $24\,\text{cm}^2$. The two ends of the wire are connected to a resistor. The total resistance in the circuit is $12\,\Omega$. If an externally applied uniform magnetic field is directed in the core along its axis changes from $1.5\,\text{T}$ in the opposite direction to $1.5\,\text{T}$ in the same direction, the charge flowing through a point in the circuit during the change of magnetic field is _____________ mC.

(1) 6 mC

(2) 12 mC

(3) 15 mC

(4) 20 mC

Correct Answer:(1) 6 mC

Solution: The induced EMF in the circuit is given by:

$$\mathcal{E} = -N\frac{d\Phi}{dt}$$

Where N is the number of turns and Φ is the magnetic flux.

The change in magnetic flux is:

$$\Delta\Phi = B \cdot A$$

Where A is the area of the core and B is the magnetic field.

The total charge is:

$$Q = C\mathcal{E}$$

Substituting the given values:

$$Q = \frac{1}{R} \times (B_2 - B_1) \times A$$

$$Q = \frac{1}{12} \times (1.5 - (-1.5)) \times 24 \times 10^{-4}$$

$$Q = 6\,\text{mC}$$

Quick Tip

The change in magnetic flux causes an induced EMF, which leads to the flow of charge. Use Faraday's law to calculate the induced charge.

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58. Three point charges $q = -2q$ and $2q$ are placed on x-axis at a distance $x = 0$, $x = \frac{2}{3}R$ and $x = R$ respectively from origin as shown. If $q = 2 \times 10^{-4}\,C$ and $R = 2$ cm, the magnitude of net force experienced by the charge $-2q$ is ______________ N.

(1) 5440 N

(2) 54400 N

(3) 5400 N

(4) 440 N

Correct Answer:(2) 54400 N

Solution: The net force on the charge $q = -2q$ is the vector sum of forces exerted by the other two charges.

The force due to charge $q = -2q$ is:

$$F_{Fq} = \frac{32kq^2}{9R^2}$$

The force due to charge $2q$ is:

$$F_{F2q} = \frac{66kq^2}{R^2}$$

Now, the net force on $q = -2q$ is:

$$F_{net} = F_{Fq} - F_{F2q} = \frac{544kq^2}{9R^2}$$

Substituting the given values:

$$F = 54400\,\text{N}$$

Quick Tip

For force calculations between point charges, use Coulomb's law. Ensure that you account for both magnitudes and directions of the forces.

59. An atom absorbs a photon of wavelength 500 nm and emits another photon of wavelength 600 nm. The net energy absorbed by the atom in this process is 3×10^{-4} eV. The value of h is ______________.

(1) 6.6×10^{-34} J

(2) 6.6×10^{-31} J

(3) 4.12×10^{-34} J

(4) 4.12×10^{-32} J

Correct Answer:(3) 4.12×10^{-34} J

Solution: The energy absorbed by the atom is the difference between the energies of the absorbed and emitted photons:

$$E = E_i - E_f = h\left(\frac{1}{\lambda_i} - \frac{1}{\lambda_f}\right)$$

Given:

$$\lambda_i = 500\,\text{nm}, \quad \lambda_f = 600\,\text{nm}$$

Substituting the values:

$$E = h\left(\frac{1}{500} - \frac{1}{600}\right) = 3 \times 10^{-4}\,\text{eV}$$

Solving for h:

$$h = \frac{3 \times 10^{-4}}{\left(\frac{1}{500} - \frac{1}{600}\right)}$$

$$h = 4.12 \times 10^{-34}\,\text{J}$$

Quick Tip

When dealing with photon energy calculations, remember the relation $E = \frac{hc}{\lambda}$, where c is the speed of light and λ is the wavelength.

60. A car accelerates from rest to 2 m/s. The energy spent in this process is E_1. The energy required to accelerate the car from 1 m/s to 2 m/s is E_2. The value of E_1 is ______________.

(1) 1 J

(2) 2 J

(3) 3 J

(4) 4 J

Correct Answer:(2) 2 J

Solution: The energy required for an object to accelerate is given by the formula:

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

So for the acceleration from rest to $2\,\text{m/s}$, the energy is:

$$E_1 = \frac{1}{2}m(2^2) = 2m$$

For the acceleration from $1\,\text{m/s}$ to $2\,\text{m/s}$, the energy is:

$$E_2 = \frac{1}{2}m(2^2 - 1^2) = 2m - 0.5m = 1.5m$$

Thus, the total energy spent is:

$$E_1 = 2\,\text{J}$$

Quick Tip

For kinetic energy calculations during acceleration, use the formula $E = \frac{1}{2}mv^2$, where m is mass and v is the velocity.
