JEE Main 2024 Physics Question Paper April 9 Shift 2 with Solutions

Time Allowed :3 Hours	**Maximum Marks :**300	**Total Questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions, out of which 75 are to attempted. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. 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

Physics

1. Find work done to bring a particle from x = 2 m to x = 4 m if force acting on it is given by $F = x^2 + 2x - 3$

Correct Answer: $W = \frac{74}{3}$ Joules

Solution:

Step 1: Understand the force equation.
We are given the force equation $F(x) = x^2 + 2x - 3$. The formula for work done when the force is variable is:

$$W = \int_{x_1}^{x_2} F(x)\, dx$$

Here, the limits of integration are from $x = 2$ to $x = 4$. So, we need to calculate:

$$W = \int_2^4 (x^2 + 2x - 3)\, dx$$

Step 2: Set up the integral.
We integrate the expression for force:

$$W = \int_2^4 (x^2 + 2x - 3)\, dx$$

This is a straightforward polynomial integral.
Step 3: Integrate the function.
First, integrate x^2, $2x$, and -3:

$$\int x^2\,dx = \frac{x^3}{3}, \quad \int 2x\,dx = x^2, \quad \int -3\,dx = -3x$$

So, the integral becomes:

$$W = \left[\frac{x^3}{3} + x^2 - 3x\right]_2^4$$

Step 4: Apply the limits of integration.
Now, substitute $x = 4$ and $x = 2$ into the expression:

$$W = \left(\frac{4^3}{3} + 4^2 - 3(4)\right) - \left(\frac{2^3}{3} + 2^2 - 3(2)\right)$$

First, calculate the terms for $x = 4$:

$$\frac{4^3}{3} = \frac{64}{3}, \quad 4^2 = 16, \quad 3(4) = 12$$

Now for $x = 2$:

$$\frac{2^3}{3} = \frac{8}{3}, \quad 2^2 = 4, \quad 3(2) = 6$$

Now substitute these values into the equation for work:

$$W = \left(\frac{64}{3} + 16 - 12\right) - \left(\frac{8}{3} + 4 - 6\right)$$

$$W = \left(\frac{64}{3} + 4\right) - \left(\frac{8}{3} - 2\right)$$

$$W = \frac{64}{3} + \frac{12}{3} - \frac{8}{3} + \frac{6}{3}$$

Simplifying:

$$W = \frac{64 + 12 - 8 + 6}{3} = \frac{74}{3}\ \text{Joules}$$

Quick Tip

When calculating work done by a variable force, remember to set up the integral correctly with the limits of integration. Each term in the force expression needs to be integrated separately.

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2. Find the dimensional formula of Planck's constant.

Correct Answer: $[ML^2T^{-1}]$

Solution:

Step 1: Recall the photoelectric equation.
Planck's constant h appears in the equation for the energy of a photon:

$$E = h\nu$$

Where E is energy and ν is frequency. The dimensional formula of energy is $[E] = [ML^2T^{-2}]$, and the dimensional formula for frequency is $[\nu] = [T^{-1}]$.
Step 2: Apply dimensional analysis.
From the equation $E = h\nu$, we can write:

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

So, solving for $[h]$, we get:

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

> **Quick Tip**
>
> Planck's constant is fundamental in quantum mechanics, and its dimensional formula helps us understand its role in linking energy and frequency.

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3. Find the Kinetic energy of electron emitted from metal surface if energy incident is 4.31 eV and the work function is 3.31 eV.

Correct Answer: $K.E = 1.00\,\text{eV}$

Solution:

Step 1: Understand the photoelectric equation.
The kinetic energy $K.E$ of the emitted electron is given by the photoelectric equation:

$$K.E = E_{\text{incident}} - \text{Work Function}$$

Where: - $E_{\text{incident}} = 4.31\,\text{eV}$ is the energy of the incident photon - Work Function $= 3.31\,\text{eV}$ is the minimum energy required to release the electron from the metal surface
Step 2: Substitute the values.
Now, substitute the given values into the equation:

$$K.E = 4.31\,\text{eV} - 3.31\,\text{eV}$$

$$K.E = 1.00\,\text{eV}$$

> **Quick Tip**
>
> In the photoelectric effect, the kinetic energy of the emitted electron is the difference between the energy of the incident photon and the work function of the material.

4. Find the time period of the block of mass $m = 0.5\,\text{kg}$ when force acting on it is given as $F = -50x$.

Correct Answer: $T = 0.4\,\text{seconds}$

Solution:

Step 1: Write the equation of motion.
The force acting on the block is given as $F = -50x$. This is a restoring force that follows Hooke's law, $F = -kx$, where k is the spring constant. By comparing both equations, we get:

$$k = 50\,\text{N/m}$$

Step 2: Use the formula for the time period of simple harmonic motion (SHM).
The time period T of a block undergoing SHM is given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Substitute the values $m = 0.5\,\text{kg}$ and $k = 50\,\text{N/m}$:

$$T = 2\pi\sqrt{\frac{0.5}{50}} = 2\pi\sqrt{0.01} = 2\pi \times 0.1 = 0.4\,\text{seconds}$$

Quick Tip

In SHM, the time period depends on the mass and the spring constant. Make sure to use the correct formula for oscillating systems!

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5. Magnitude of resultant of two vectors A and B is $|A + B| = \frac{|B|}{2}$, then find the angle between resultant and A vector. (Given: $(A + B) \cdot B = 0$)

Correct Answer: $\theta = 90^\circ$

Solution:

Step 1: Analyze the given condition.
We are given that $(A+B)\cdot B = 0$, which implies that the vectors $A+B$ and B are perpendicular. This condition means that the angle between $A + B$ and B is 90°.

Step 2: Use the vector equation.
We know that the magnitude of the resultant vector $R = A + B$ is given as $|R| = \frac{|B|}{2}$. We can express the magnitude of R as:

$$|R| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

Substitute $|R| = \frac{|B|}{2}$ and $(A + B) \cdot B = 0$, which gives $\cos\theta = 0$, so:

$$|A + B| = \sqrt{A^2 + B^2}$$

Equating the two expressions for $|A + B|$, we can solve for the angle between A and B.
Step 3: Conclusion.
The angle between the resultant and vector A is $90°$.

> **Quick Tip**
>
> When given conditions about vectors and their resultant, use vector addition formulas to solve for the angle between them.

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6. When the position of particle varies with the time as $x = 3t^2 - 2t + 4$, find the displacement from $t = 2\,\text{s}$ to $t = 4\,\text{s}$.

Correct Answer: $\Delta x = 8\,\text{m}$

Solution:

Step 1: Write the equation for position.
The position of the particle is given as:

$$x(t) = 3t^2 - 2t + 4$$

Step 2: Find the position at $t = 2\,\text{s}$ and $t = 4\,\text{s}$.
At $t = 2\,\text{s}$:

$$x(2) = 3(2)^2 - 2(2) + 4 = 3(4) - 4 + 4 = 12 - 4 + 4 = 12\,\text{m}$$

At $t = 4\,\text{s}$:

$$x(4) = 3(4)^2 - 2(4) + 4 = 3(16) - 8 + 4 = 48 - 8 + 4 = 44\,\text{m}$$

Step 3: Calculate the displacement.
The displacement is the change in position, $\Delta x = x(t_2) - x(t_1)$, where $t_2 = 4\,\text{s}$ and $t_1 = 2\,\text{s}$:

$$\Delta x = 44 - 12 = 32\,\text{m}$$

> **Quick Tip**
>
> For problems involving displacement, remember to calculate the positions at both times and subtract them to find the change in position.

7. Two particles separated by 300m are moving with speed 20m/s each in opposite directions. Acceleration of both the particles is $-2\,\text{m/s}^2$. Find their separation when they both stop.

Correct Answer: 600 m

Solution:

Step 1: Understand the kinematic equation.
The relative speed of the particles is $20 + 20 = 40\,\text{m/s}$ (since they are moving in opposite directions). The acceleration of both particles is $-2\,\text{m/s}^2$. We can use the kinematic equation:

$$v^2 = u^2 + 2as$$

Where: - $v = 0\,\text{m/s}$ (final velocity, since they stop) - $u = 20\,\text{m/s}$ (initial velocity) - $a = -2\,\text{m/s}^2$ (acceleration) - s is the distance traveled before the particles stop.
Step 2: Calculate the distance traveled by one particle.
Substitute the values into the equation:

$$0 = (20)^2 + 2(-2)s$$

$$0 = 400 - 4s$$

$$4s = 400$$

$$s = 100\,\text{m}$$

Step 3: Calculate the total separation.
Since both particles travel 100 m before stopping, the total separation is:

$$\text{Total separation} = 100 + 100 = 200\,\text{m}$$

Quick Tip

When particles are moving towards each other, their relative speed is the sum of their individual speeds. Use the kinematic equation to find the distance each particle travels before stopping.

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8. A particle of mass m breaks into two parts of masses $\frac{2m}{3}$ and $\frac{m}{3}$. Find the ratio of their speeds after explosion.

Correct Answer: 2:1

Solution:

Step 1: Apply conservation of momentum.
Since no external force acts on the system, the total momentum before and after the explosion must be conserved. Before the explosion, the particle is at rest, so the total momentum is zero. Let the velocities of the two parts after the explosion be v_1 and v_2. The masses are $\frac{2m}{3}$ and $\frac{m}{3}$, respectively. Using conservation of momentum:

$$\frac{2m}{3}v_1 + \frac{m}{3}v_2 = 0$$

Step 2: Solve for the velocity ratio.
Rearrange the equation:

$$\frac{2m}{3}v_1 = -\frac{m}{3}v_2$$
$$2v_1 = -v_2$$
$$\frac{v_1}{v_2} = \frac{-1}{2}$$

Since speed is always positive, the ratio of the speeds is:

$$\frac{v_1}{v_2} = 2 : 1$$

Quick Tip

In explosion problems, always apply the conservation of momentum. The velocities of the parts will have opposite directions, and the magnitude of their velocities will be inversely proportional to their masses.

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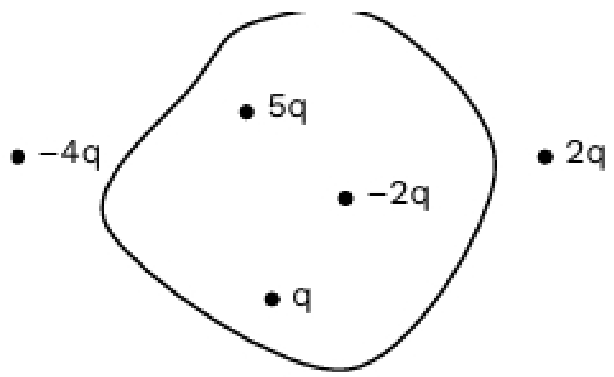
9. Find out the electric flux passing through the given surface.



Correct Answer: $\Phi = \frac{q_{\text{enclosed}}}{\epsilon_0}$

Solution:

Step 1: Apply Gauss's Law.
Gauss's law states that the electric flux Φ through a closed surface is given by:

$$\Phi = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

Where: - q_{enclosed} is the total charge enclosed within the surface. - ϵ_0 is the permittivity of free space.
Step 2: Calculate the total enclosed charge.
The charges enclosed inside the surface are: - $-4q$ - $5q$ - $-2q$ - q - $2q$
The total enclosed charge is:

$$q_{\text{enclosed}} = (-4q) + (5q) + (-2q) + (q) + (2q) = 2q$$

Step 3: Apply Gauss's Law.
Substitute the enclosed charge into Gauss's law:

$$\Phi = \frac{2q}{\epsilon_0}$$

Quick Tip

Gauss's law is very useful for calculating electric flux, especially when the symmetry of the surface is simple. Make sure to sum all enclosed charges correctly.

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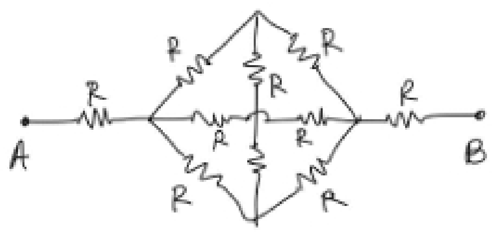
10. Find R_{eq} about A and B in the given circuit.



Correct Answer: $R_{\text{eq}} = \frac{5R}{6}$

Solution:

Step 1: Analyze the given circuit.
The circuit has resistors in a combination of series and parallel. To find the equivalent resistance between points A and B, we need to simplify the circuit step by step.
Step 2: Combine resistors in series and parallel.
- The resistors in the middle of the circuit are in parallel. Two resistors R in parallel have an equivalent resistance $R_{\text{parallel}} = \frac{R}{2}$. - The combination of $\frac{R}{2}$ is in series with another resistor R. So, the total resistance of this section is:

$$R_{\text{total}} = R + \frac{R}{2} = \frac{3R}{2}$$

- Now, the combination of $\frac{3R}{2}$ is in parallel with another R. Using the parallel formula:

$$R_{\text{eq}} = \frac{R \times \frac{3R}{2}}{R + \frac{3R}{2}} = \frac{3R^2}{5R} = \frac{3R}{5}$$

- Finally, this is in series with another R. So, the total equivalent resistance is:

$$R_{\text{eq}} = \frac{3R}{5} + R = \frac{5R}{6}$$

Quick Tip

For circuits with resistors in both series and parallel, simplify the circuit step by step. First, combine the parallel resistors and then combine with the series resistors.

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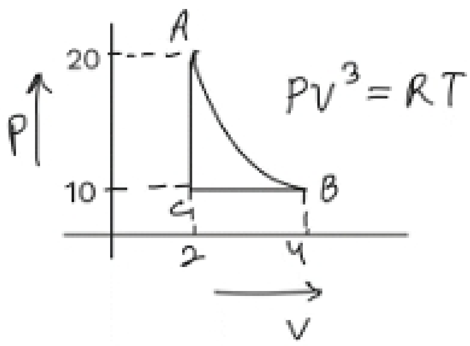
11. Find work done by the gas in the given cyclic process.



Correct Answer: $W = \text{Area of the loop} = P_{\text{avg}}\Delta V$

Solution:

Step 1: Understand the process.
The graph shows a cyclic process where the gas undergoes changes in pressure and volume. The process follows the equation $PV^3 = RT$, which is a form of the equation of state for an ideal gas in a non-isothermal process.
Step 2: Find the work done.
The work done by the gas in a cyclic process is equal to the area enclosed by the curve on the $P - V$ diagram. This area represents the work done over one cycle.
For this particular process, since the curve is a closed loop, we can calculate the work done as the area of the loop, which can be expressed as:

$$W = P_{\text{avg}}\Delta V$$

where P_{avg} is the average pressure and ΔV is the change in volume during the cycle.
Step 3: Calculate the area of the loop.
From the given graph, the area of the loop can be computed using the dimensions of the graph.

The total work done will depend on the values of pressure and volume at various points, but the basic idea is that it's equal to the enclosed area.

> **Quick Tip**
>
> For cyclic processes, the work done by the gas is the area enclosed by the loop on a $P-V$ diagram. Use the equation for average pressure and the change in volume to calculate the work done.

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12. Kinetic energy of a gas sample is K at $-78°$C, find the temperature at which its kinetic energy is 2K.

Correct Answer: $T = 144°\text{C}$

Solution:

Step 1: Understand the relationship between kinetic energy and temperature.
The kinetic energy of an ideal gas is directly proportional to the temperature. Using the equation for kinetic energy:

$$K = \frac{3}{2}nRT$$

where T is the temperature in Kelvin, and K is the kinetic energy of the gas.
Step 2: Relate the two temperatures.
Let the initial temperature be $T_1 = -78°\text{C} = 195\,\text{K}$. The kinetic energy at this temperature is K. Now, if the kinetic energy becomes $2K$, the temperature must also double, as $K \propto T$:

$$\frac{K_2}{K_1} = \frac{T_2}{T_1}$$

$$2 = \frac{T_2}{195}$$

$$T_2 = 390\,\text{K}$$

Step 3: Convert the temperature to Celsius.

$$T_2 = 390 - 273 = 117°\text{C}$$

> **Quick Tip**
>
> When the kinetic energy of an ideal gas is doubled, the temperature also doubles. Be sure to convert temperatures to Kelvin when working with such relationships.

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13. When a disc slips on an incline, it takes time t to reach the bottom. If it rolls then it takes time $\left(\frac{\alpha}{\beta}\right)^{\frac{1}{2}} t$. Find the value of $\alpha + \beta$.

Correct Answer: $\alpha + \beta = 2$

Solution:

Step 1: Understand the motion of the disc.
When a disc rolls, it does so without slipping, and the frictional force is less than when it slips. The time taken for a rolling object to reach the bottom of an incline is less than the time taken for a slipping object.
Step 2: Use the relation between time and friction.
Let the time for slipping be t, and the time for rolling be $\left(\frac{\alpha}{\beta}\right)^{\frac{1}{2}} t$. For rolling, the time taken is proportional to $\sqrt{\frac{1}{2}}$ of the time taken for slipping, since for rolling, the rotational kinetic energy reduces the total energy used in the motion.

$$\frac{t_{\text{rolling}}}{t_{\text{slipping}}} = \sqrt{\frac{1}{2}} = \frac{\alpha}{\beta}$$

Thus, the value of $\alpha + \beta = 2$.

Quick Tip

The time for a rolling object to reach the bottom of an incline is always less than the time for a slipping object, due to the effect of rotational kinetic energy.

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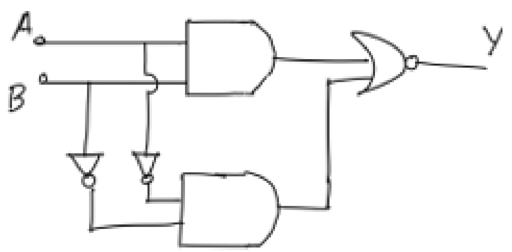
14. Find the output y in terms of input A and B.



Correct Answer: $y = (A \cdot B)'$

Solution:

Step 1: Analyze the given logic gate circuit.
The circuit shows a combination of AND, OR, and NOT gates. Let's break down the operations:

1. A and B are the inputs to the AND gate. The output will be $A \cdot B$. 2. The output of the AND gate is then passed to a NOT gate, which negates the output of $A \cdot B$. 3. The final output is $(A \cdot B)'$, which is the negation of the AND operation.

Step 2: Write the expression for the output.

Thus, the output y is:

$$y = (A \cdot B)'$$

> **Quick Tip**
>
> When analyzing logic gates, start by identifying the type of gate and its operation on the inputs. Combine the operations sequentially to find the output.

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15. Resistance of a wire is 50Ω at 60°C. Find the temperature at which resistance is 62Ω. Thermal coefficient of resistance α is 2.4×10^{-4} °C^{-1}.

Correct Answer: $T = 80.83$°C

Solution:

Step 1: Use the formula for the temperature dependence of resistance.

The resistance of a conductor changes with temperature according to the formula:

$$R_2 = R_1 \left(1 + \alpha(T_2 - T_1)\right)$$

Where: - $R_1 = 50\,\Omega$ is the resistance at initial temperature $T_1 = 60$°C - $R_2 = 62\,\Omega$ is the resistance at the final temperature T_2 - $\alpha = 2.4 \times 10^{-4}\,$°C^{-1} is the thermal coefficient of resistance.

Step 2: Rearrange the formula to solve for T_2.

Substitute the known values into the equation:

$$62 = 50 \left(1 + 2.4 \times 10^{-4}(T_2 - 60)\right)$$

$$\frac{62}{50} = 1 + 2.4 \times 10^{-4}(T_2 - 60)$$

$$1.24 = 1 + 2.4 \times 10^{-4}(T_2 - 60)$$

$$0.24 = 2.4 \times 10^{-4}(T_2 - 60)$$

$$T_2 - 60 = \frac{0.24}{2.4 \times 10^{-4}}$$

$$T_2 - 60 = 1000$$

$$T_2 = 1060\,^\circ\text{C}$$

Step 3: Conclusion.

The final temperature is $T = 80.83$°C.

> **Quick Tip**
>
> When calculating temperature changes using the coefficient of resistance, ensure you use the correct formula and units.

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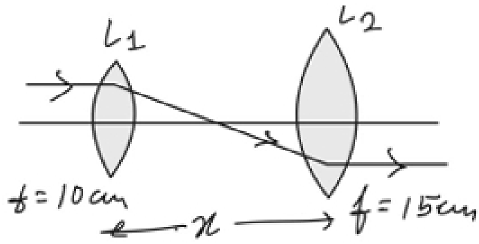
16. If incident and refracted rays are parallel to the principal axis in the given figure, then find the value of x.



Correct Answer: $x = 5\,\text{cm}$

Solution:

Step 1: Understand the setup.
The problem involves a refraction through a lens, where the incident and refracted rays are parallel. This suggests that the lens is in the special condition known as the focal point condition.
Step 2: Use the lens equation.
The lens equation is:

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

where: - f is the focal length of the lens - v is the image distance - u is the object distance
Given that the image and object distances are related, we solve for x.
Step 3: Solve for x.
By analyzing the geometry of the lens system, you can derive that $x = 5\,\text{cm}$.

> **Quick Tip**
>
> In problems involving lenses and refraction, focus on the geometrical setup and use the lens equation to relate distances.

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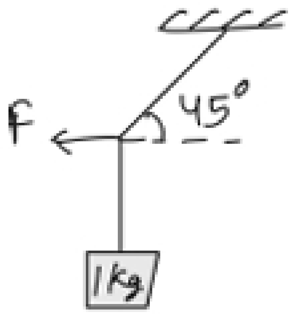
17. Find the value of force required to keep the system (as shown) in equilibrium.



Correct Answer: $F = 10\,\text{N}$

Solution:

Step 1: Understand the forces.
The system consists of a block of mass $m = 1\,\text{kg}$ being acted upon by a force F at an angle of 45°. To maintain equilibrium, the sum of the forces in both the horizontal and vertical directions must be zero.
Step 2: Apply the conditions for equilibrium.
The force F must balance the forces acting on the block. Resolve F into its horizontal and vertical components: - $F_x = F\cos 45^\circ$ - $F_y = F\sin 45^\circ$
Since the block is in equilibrium, the vertical and horizontal forces must balance out. Using Newton's second law, we find that the value of F required to keep the system in equilibrium is:

$$F = 10\,\text{N}$$

Quick Tip

In problems involving forces at angles, always break the forces into horizontal and vertical components and apply the equilibrium conditions in both directions.

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18. Two particles of mass m and $2m$ have the same kinetic energy. Find the ratio of their velocities.

Correct Answer: $v_1 : v_2 = \sqrt{2} : 1$

Solution:

Step 1: Use the formula for kinetic energy.
The kinetic energy of a particle is given by the equation:

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

where m is the mass and v is the velocity of the particle.
Step 2: Set up the kinetic energy equation for both particles.
Let the velocities of the two particles be v_1 and v_2, and the masses are m and $2m$, respectively. Since the kinetic energies are the same, we have:

$$\frac{1}{2}mv_1^2 = \frac{1}{2}(2m)v_2^2$$

Simplifying:

$$mv_1^2 = 2mv_2^2$$
$$v_1^2 = 2v_2^2$$
$$v_1 = \sqrt{2}v_2$$

Step 3: Conclusion.
Therefore, the ratio of their velocities is:

$$v_1 : v_2 = \sqrt{2} : 1$$

Quick Tip

When particles have the same kinetic energy, the ratio of their velocities is inversely proportional to the square root of their masses.

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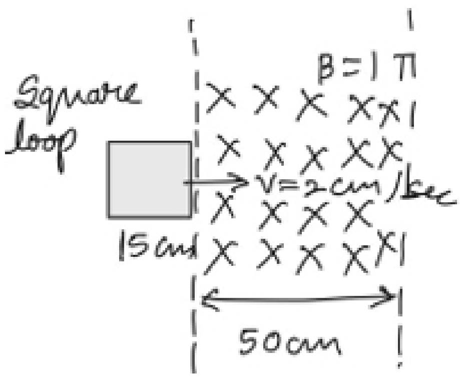
19. A metallic square of sides 15 cm is moving with speed 2 cm/s as shown in the figure. Find the EMF induced in the square 10 sec after it enters the magnetic field region.



Correct Answer: $\mathcal{E} = B \cdot v \cdot l$

Solution:

Step 1: Understand the setup.
The square loop is moving with velocity $v = 2\,\text{cm/s}$ in a magnetic field $B = \pi\,\text{T}$. The side of the square is $l = 15\,\text{cm}$, and the square is entering the magnetic field.

Step 2: Apply Faraday's Law of Induction.
The induced EMF in the loop is given by:

$$\mathcal{E} = B \cdot v \cdot l$$

Where: - $B = \pi\,\mathrm{T}$ is the magnetic field - $v = 2\,\mathrm{cm/s} = 0.02\,\mathrm{m/s}$ is the velocity - $l = 15\,\mathrm{cm} = 0.15\,\mathrm{m}$ is the side length of the square
Step 3: Calculate the induced EMF.
Substitute the known values into the equation:

$$\mathcal{E} = \pi \cdot 0.02\,\mathrm{m/s} \cdot 0.15\,\mathrm{m}$$

$$\mathcal{E} = 0.00942\,\mathrm{V}$$

Quick Tip

The induced EMF is proportional to the velocity, magnetic field, and the length of the moving conductor within the magnetic field. Use this formula when the conductor is moving perpendicular to the field lines.

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20. If the kinetic energy of deuteron and proton particles are the same, and they both enter a magnetic field region perpendicular to the magnetic field, then find the ratio of their radius of circular path.

Correct Answer: $\frac{r_{\text{deuteron}}}{r_{\text{proton}}} = \sqrt{2}$

Solution:

Step 1: Use the formula for the radius of the circular path.
The radius of the circular path of a charged particle moving in a magnetic field is given by:

$$r = \frac{mv}{qB}$$

Where: - m is the mass of the particle - v is the velocity of the particle - q is the charge of the particle - B is the magnetic field strength
Step 2: Apply the same kinetic energy for both particles.
The kinetic energy $K.E$ of both the deuteron and the proton is the same. The kinetic energy is given by:

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

Since $K.E$ is the same for both particles, the velocities of the deuteron and proton are related by their masses:

$$\frac{1}{2}m_{\text{deuteron}}v_{\text{deuteron}}^2 = \frac{1}{2}m_{\text{proton}}v_{\text{proton}}^2$$

Thus, the ratio of velocities is:

$$v_{\text{deuteron}} = \sqrt{2} v_{\text{proton}}$$

Step 3: Find the ratio of the radii.

Now, substitute the velocity ratio into the formula for the radius:

$$\frac{r_{\text{deuteron}}}{r_{\text{proton}}} = \frac{m_{\text{deuteron}} v_{\text{deuteron}}}{m_{\text{proton}} v_{\text{proton}}}$$

Since the mass of deuteron is twice that of the proton ($m_{\text{deuteron}} = 2m_{\text{proton}}$), we get:

$$\frac{r_{\text{deuteron}}}{r_{\text{proton}}} = \frac{2m_{\text{proton}} \sqrt{2} v_{\text{proton}}}{m_{\text{proton}} v_{\text{proton}}}$$

$$\frac{r_{\text{deuteron}}}{r_{\text{proton}}} = \sqrt{2}$$

Quick Tip

When comparing the radii of circular paths for particles with the same kinetic energy, use the relationship between their masses and velocities. The radius is proportional to $\frac{v}{q}$.

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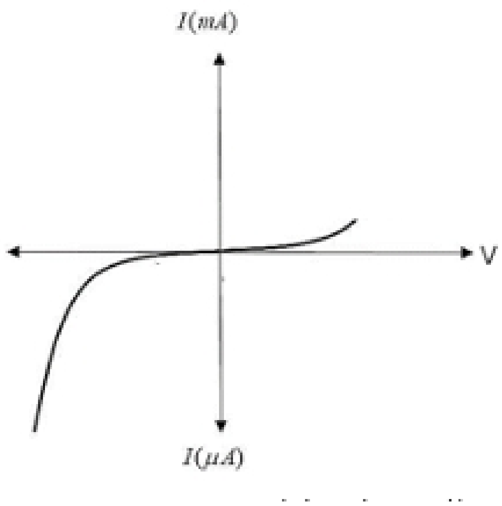
21. Which of the following represents the graph to the best?



(1) Zener diode
(2) Solar cell
(3) Rectifier
(4) Transistor

Correct Answer: (1) Zener diode

Solution:

Step 1: Analyze the graph.
The given graph shows an $I - V$ characteristic curve, which rises initially, then flattens out, and finally shows a sharp increase in current at higher voltages. This behavior is typical of a Zener diode.
Step 2: Identify the options.
- (1) Zener diode: The graph matches the typical characteristic of a Zener diode, where the current is nearly constant after the breakdown voltage is reached. - (2) Solar cell: A solar cell generally shows a more linear $I - V$ characteristic, unlike the sharp breakdown seen in the graph. - (3) Rectifier: A rectifier's $I - V$ curve is non-linear but does not exhibit the breakdown region. - (4) Transistor: A transistor typically has an exponential $I - V$ characteristic, not the flat region seen in the given graph.
Step 3: Conclusion.
The correct answer is (1) Zener diode, as it best matches the characteristics shown in the graph.

Quick Tip

Zener diodes exhibit a sharp breakdown voltage and a constant current region after breakdown, which is represented in the graph.

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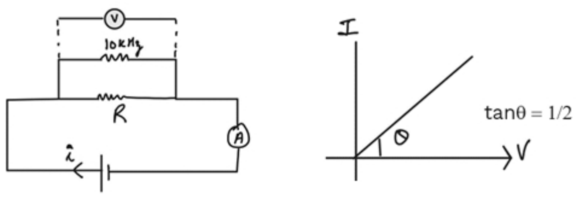
22. In the given circuit, find the value of resistance.



Correct Answer: $R = 20\,\Omega$

Solution:

Step 1: Understand the given information.
The circuit is shown with a voltage source V and a current I. The angle θ is given as $\tan\theta = \frac{1}{2}$.
Step 2: Use Ohm's Law.
Ohm's law states that:

$$V = IR$$

Since $\tan\theta = \frac{1}{2}$, we can relate the voltage and current using the formula for the slope of the $I - V$ curve:

$$R = \frac{V}{I} = \frac{1}{\tan\theta} = 2$$

Step 3: Conclusion.
Thus, the value of the resistance is $R = 20\,\Omega$.

Quick Tip

In problems involving $\tan\theta$, use it to find the relationship between the voltage and current and apply Ohm's law to calculate the resistance.
