JEE Main 2024 Physics Question Paper April 5 Shift 2 with Solutions

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

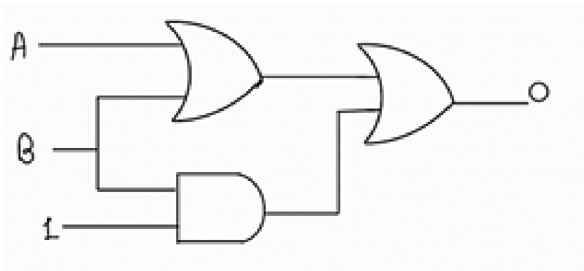
General Instructions

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. In the given figure, find out A and B so that output will be 0.



Correct Answer: 0, 0

Solution:

Step 1: Understanding the circuit.
The given circuit involves two gates: an OR gate and an AND gate. To ensure that the output is 0, we need to check the combination of inputs A and B that will lead to this result.

Step 2: Simplifying the circuit expression.
The OR gate produces an output of $A + B$, and the AND gate receives the output from the

OR gate and B as inputs, so the expression becomes $(A + B) \cdot B$.

Step 3: Determining the correct values.
To get the output as 0, we analyze the following possibilities: - When $A = 0$ and $B = 0$, the expression simplifies to $(0 + 0) \cdot 0 = 0$, which satisfies the condition for the output being 0.

Step 4: Conclusion.
Thus, the correct values for A and B are 0, 0.

> **Quick Tip**
>
> In logical circuits, always simplify the Boolean expressions to find the combination of inputs that will yield the desired output.

---

2. In real gas equation $\left[P + \frac{an^2}{v^2}\right][v - nb] = nRT$, find dimensional formula of ab^{-1}.

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

Solution:

Step 1: Write the given equation.
The given equation is:

$$\left[P + \frac{an^2}{v^2}\right][v - nb] = nRT$$

Step 2: Dimensional analysis of each term.
For the term a, we have the equation:

$$a = P \cdot v^2$$

$$[a] = [MLT^{-2}] \cdot [L^2] = [ML^2T^{-2}]$$

For the term b, we have:

$$b = [L]$$

Step 3: Find the dimensional formula of ab^{-1}.

$$[ab^{-1}] = [ML^2T^{-2}] \cdot [L^{-1}] = [ML^2T^{-2}L^{-1}] = [MLT^{-2}]$$

> **Quick Tip**
>
> In dimensional analysis, break down each term using fundamental dimensions like mass (M), length (L), and time (T) to find the dimensional formula.

3. A man revolving in a circle has completed 120 rev in 3 minutes. Find the centripetal acceleration of the monkey sitting on the shoulder of the man if the radius of the circle is 9 m. (Constant angular velocity)

Correct Answer: 160 m/s^2

Solution:

Step 1: Calculate total distance.
The total distance traveled by the man is:

$$\text{Total distance} = 2\pi \times 120 = 240\pi$$

Step 2: Find angular velocity ω.

$$\omega = \frac{240\pi}{3 \times 60} = \frac{4\pi}{3}$$

Step 3: Calculate centripetal acceleration.

$$a_c = \omega^2 \cdot R = \left(\frac{4\pi}{3}\right)^2 \cdot 9 = 160\,\text{m/s}^2$$

> **Quick Tip**
>
> Centripetal acceleration can be calculated using $a_c = \omega^2 R$, where ω is the angular velocity and R is the radius.

---

4. A constant power P is delivered to a particle of mass m. If motion starts from rest at $t = 0$, find the distance travelled by the particle as a function of time t.

Correct Answer: $x = \frac{2}{3}\sqrt{\frac{2P}{m}}t^{3/2}$

Solution:

Step 1: Power and velocity relation.
The power delivered is related to the velocity by the equation:

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

Solving for v, we get:

$$v = \sqrt{\frac{2Pt}{m}}$$

Step 2: Relating distance and velocity.
The distance travelled is the integral of velocity:

$$\frac{dx}{dt} = v = \sqrt{\frac{2Pt}{m}}$$

Step 3: Integration.
Integrating both sides from $t = 0$ to t, and from $x = 0$ to x, we get:

$$x = \int_0^t \sqrt{\frac{2Pt}{m}}\, dt$$

$$x = \frac{2}{3}\sqrt{\frac{2P}{m}} t^{3/2}$$

Quick Tip

To find distance travelled under constant power, use the velocity equation and integrate over time.

---

5. A particle is projected from horizontal at an angle such that maximum possible range is 64 m. Keeping angle of projection same, if velocity of projection becomes half, then calculate new value of maximum possible range.

Correct Answer: 16 m

Solution:

Step 1: Maximum range formula.
The maximum range for projectile motion is given by:

$$R_{\text{max}} = \frac{u^2}{g}$$

where u is the initial velocity and g is the acceleration due to gravity.
Step 2: Effect of halving velocity.
When the velocity is halved, the new maximum range becomes:

$$R'_{\text{max}} = \frac{(u/2)^2}{g} = \frac{R_{\text{max}}}{4}$$

$$R'_{\text{max}} = \frac{64}{4} = 16\,\text{m}$$

Quick Tip

When the initial velocity is halved, the range of a projectile decreases by a factor of 4.

6. A uniform wire having resistance 20Ω is divided into 10 equal parts. Now each part is connected in parallel. Find equivalent resistance of the new combination.

Correct Answer: 0.2Ω

Solution:

Step 1: Resistance of each part.
The total resistance of the wire is 20Ω, and it is divided into 10 equal parts, so the resistance of each part is:

$$R = \frac{20}{10} = 2\Omega$$

Step 2: Using the formula for parallel resistors.
The resistances are connected in parallel, and the formula for equivalent resistance R_{eq} of parallel resistors is:

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R} + \frac{1}{R} + \cdots (10 \text{ times})$$

$$\frac{1}{R_{\text{eq}}} = \frac{10}{R} = \frac{10}{2} = 5$$

Step 3: Calculate the equivalent resistance.
Thus,

$$R_{\text{eq}} = \frac{2}{10} = 0.2\Omega$$

Quick Tip

When resistors are connected in parallel, the total resistance is always smaller than the smallest individual resistance.

---

7. If there is a charge q travelling in an electric field E and magnetic field B with speed v. Find out force due to electric field and magnetic field on the charge.

Correct Answer:

$$\text{Force due to Electric field: } \vec{F_1} = q\vec{E} \text{Force due to Magnetic field: } \vec{F_2} = q(\vec{v} \times \vec{B})$$

Solution:

Step 1: Electric force.
The force on the charge due to the electric field is given by:

$$\vec{F_1} = q\vec{E}$$

Step 2: Magnetic force.
The force on the charge due to the magnetic field is given by:

$$\vec{F_2} = q(\vec{v} \times \vec{B})$$

> **Quick Tip**
>
> The electric force on a charge is given by $\vec{F} = q\vec{E}$, and the magnetic force is given by $\vec{F} = q(\vec{v} \times \vec{B})$, where $\vec{v}$ is the velocity vector and $\vec{B}$ is the magnetic field.

---

8. If λ_{min} of Lyman series is 915 Å, find the λ_{max} of Balmer series.

Correct Answer: 6588Å

Solution:

Step 1: Relating λ_{min} and λ_{max}.
For Lyman series, the minimum wavelength corresponds to the transition from $n = \infty$ to $n = 1$, and for Balmer series, the maximum wavelength corresponds to the transition from $n = 3$ to $n = 2$.
Step 2: Use the Rydberg formula.
The Rydberg formula for the wavelengths is given by:

$$\frac{hc}{\lambda} = RZ^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Step 3: Find λ_{min} and λ_{max}.
For λ_{min}, when $n = \infty \to n = 1$:

$$\lambda_{\text{min}} = \frac{RZ^2}{1^2} = RZ^2$$

For λ_{max}, when $n = 2 \to n = 3$:

$$\lambda_{\text{max}} = \frac{RZ^2}{2^2 - 3^2} = RZ^2 \times \frac{5}{36}$$

Step 4: Calculate λ_{max}.

$$\lambda_{\text{max}} = \frac{915 \times 36}{5} = 6588\,\text{Å}$$

> **Quick Tip**
>
> In spectral series, the wavelengths for various transitions are related through the Rydberg formula. Use this to calculate the desired wavelength.

9. If 20 division of vernier scale coincide with 19th division of main scale then find out main scale division (given 0.1 mm is the least count of vernier callipers).

Correct Answer: 2 mm

Solution:

Step 1: Use the formula for least count.
The least count of the vernier scale is given as:

$$\text{LC} = 1\,\text{MSD} - 1\,\text{VSD}$$

Step 2: Calculate main scale division (MSD).
Given that 1 VSD = $\frac{19}{20}$ MSD, we have:

$$1\,\text{VSD} = \frac{19}{20}\,\text{MSD}$$

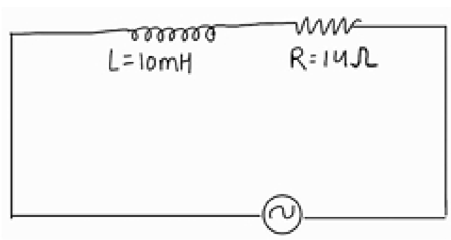
Step 3: Find the least count.
Since 1 VSD = 0.1 mm,

$$1\ \text{MSD} = \frac{20}{19} \times 0.1\,\text{mm} = 2\,\text{mm}$$

> **Quick Tip**
>
> The least count of a Vernier caliper can be calculated by subtracting 1 VSD from 1 MSD. The main scale division gives the value of one unit of measurement.

---

10. In a series RL circuit having resistance 14Ω and an inductance of 10mH, applied source voltage is 220 V having frequency 50Hz. Find RMS value of current in the circuit.



Correct Answer: 15.33 A

Solution:

Step 1: Calculate inductive reactance.
The inductive reactance X_L is given by:

$$X_L = 2\pi f L = 2\pi \times 50 \times 10 \times 10^{-3} = \pi\,\Omega$$

Step 2: Calculate impedance of the circuit.
The total impedance Z of the series RL circuit is:

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{14^2 + \pi^2} = \sqrt{196 + 9.87} = \sqrt{205.87} \approx 14.36\,\Omega$$

Step 3: Calculate RMS current.
The RMS value of the current I_{rms} is given by:

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{220}{\sqrt{14^2 + \pi^2}} = \frac{220}{14.36} \approx 15.33\,\text{A}$$

Quick Tip

In an RL circuit, the RMS value of current can be found using the formula $I_{\text{rms}} = \frac{V_{\text{rms}}}{Z}$, where $Z = \sqrt{R^2 + X_L^2}$ is the impedance.

---

11. Which of the following is incorrect -

(1) Stopping potential depends on frequency of incident light
(2) Stopping potential increases by increasing intensity
(3) Stopping potential depends on nature of material
(4) Stopping potential is equal to $\frac{K.E}{e}$

Correct Answer: (2)

Solution:

Step 1: Understanding the equation for stopping potential.
The stopping potential is given by:

$$K.E_{\text{max}} = hv - \phi$$

$$\Rightarrow ev_s = hv - \phi$$

$$\Rightarrow v_s = \frac{h}{e}\left(\frac{v}{c}\right) - \frac{\phi}{e}$$

Thus, stopping potential depends on frequency of light and the nature of the material, but it does not depend on intensity.

Quick Tip

The stopping potential in the photoelectric effect is independent of light intensity, but it depends on the frequency of the incident light and the nature of the material.

---

12. Current flowing in a coil depends on time t given by $i = 3t + 2$, where t is in sec. If induced emf in the coil is 12mV, then find self inductance (in mH) of the coil.

Correct Answer: 4 mH

Solution:

Step 1: Formula for induced emf.
The induced emf E is related to the rate of change of current $\frac{di}{dt}$ by:

$$E = L\frac{di}{dt}$$

Given that $i = 3t + 2$, we have:

$$\frac{di}{dt} = 3$$

Step 2: Calculate self-inductance.
The induced emf is 12mV, so:

$$12 = L \times 3$$

$$L = \frac{12}{3} = 4\,\text{mH}$$

Quick Tip

The induced emf in a coil is directly proportional to the rate of change of current. Using the relationship $E = L\frac{di}{dt}$, you can calculate the self-inductance.

---

13. A geostationary satellite with time period of 6 hrs, orbiting around a planet of mass m_e (where m_e is the mass of the earth). If R_e is the radius of earth, then find the radius of orbit.

Correct Answer:

$$r = \left(\frac{Gm_eT^2}{4\pi^2}\right)^{1/3}$$

Solution:

The time period T of a satellite orbiting around a planet is given by:

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

For a geostationary satellite, we know the time period is 6 hrs, so:

$$T = 6\,\text{hrs} = 6 \times 60 \times 60\,\text{seconds}$$

Step 1: Solve for r.
Rearranging the formula, we get:

$$r = \left(\frac{Gm_eT^2}{4\pi^2}\right)^{1/3}$$

> **Quick Tip**
>
> The orbital radius of a satellite can be calculated using the formula derived from the universal law of gravitation and centripetal force.

---

14. It is given that $P \propto T^3$, then find the value of $\frac{C_p}{C_v}$ (process is adiabatic).

Correct Answer: $\frac{C_p}{C_v} = \frac{3}{2}$

Solution:

Step 1: Given relation.
We are given that:

$$P \propto T^3 \Rightarrow PT^{-3} = \text{constant}$$

Step 2: Use the ideal gas law.
From the ideal gas law $PV = nRT$, we know:

$$P \cdot V^{-3} = \text{constant}$$

Step 3: Adiabatic process.
For an adiabatic process, we have:

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

where $\gamma = \frac{C_p}{C_v}$. By comparing the relations, we find that:

$$\gamma = \frac{3}{2}$$

Quick Tip

In an adiabatic process, the value of $\frac{C_p}{C_v}$ (also called γ) can be found by comparing the equation of state with the adiabatic condition.

---

15. A hollow sphere is performing pure rolling on the ground, find the ratio of rotational kinetic energy and total kinetic energy.

Correct Answer: $\frac{2}{5}$

Solution:

Step 1: Expression for rotational kinetic energy.
The rotational kinetic energy is given by:

$$K_{\text{rot}} = \frac{1}{2} I \omega^2$$

where ω is the angular velocity. Using the relation $\omega = \frac{v}{R}$, where v is the linear velocity and R is the radius, we get:

$$K_{\text{rot}} = \frac{1}{2} I \left(\frac{v}{R}\right)^2 = \frac{1}{2} \frac{mR^2}{3} \cdot \frac{v^2}{R^2} = \frac{1}{6} mv^2$$

Step 2: Expression for total kinetic energy.
The total kinetic energy is the sum of the translational kinetic energy and rotational kinetic energy:

$$K_{\text{total}} = \frac{1}{2} mv^2 + \frac{1}{6} mv^2 = \frac{2}{3} mv^2$$

Step 3: Calculate the ratio.
The ratio of rotational kinetic energy to total kinetic energy is:

$$\frac{K_{\text{rot}}}{K_{\text{total}}} = \frac{\frac{1}{6} mv^2}{\frac{2}{3} mv^2} = \frac{1}{6} \times \frac{3}{2} = \frac{2}{5}$$

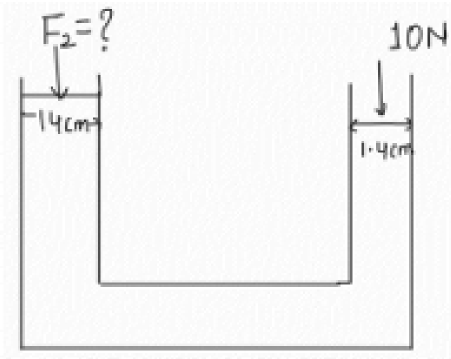
Quick Tip

For rolling motion, the total kinetic energy is the sum of the translational and rotational kinetic energies. The ratio of rotational kinetic energy to total kinetic energy for a rolling sphere is given by $\frac{2}{5}$.

---

16. If the small diameter of piston is $d_1 = 1.4\,\text{cm}$ and the larger diameter of piston is $d_2 = 14\,\text{cm}$. If force of 10N is applied on small piston, then find out F_2 required

to maintain the same level.



Correct Answer: 1000 N

Solution:

Using the formula for force and area of a piston:

$$\frac{F_2}{A_2} = \frac{F_1}{A_1}$$

Step 1: Calculate areas.
The area of a piston is given by:

$$A = \pi r^2$$

Thus,

$$A_1 = \pi \left(\frac{d_1}{2}\right)^2 = \pi \times 0.7^2$$

$$A_2 = \pi \left(\frac{d_2}{2}\right)^2 = \pi \times 7^2$$

Step 2: Solve for F_2.
Now, using the formula:

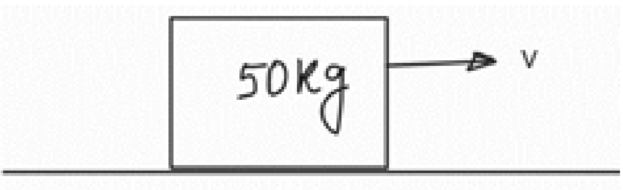
$$F_2 = F_1 \times \frac{A_2}{A_1} = 10 \times \frac{\pi \times 7^2}{\pi \times 0.7^2} = 1000\,\text{N}$$

Quick Tip

When dealing with hydraulic systems, the force is related to the areas of the pistons. The force on the large piston can be found using the ratio of areas.

---

17. A block having mass 50 kg moving with velocity v, if the coefficient of kinetic friction is 0.3, then find the force due to kinetic friction (take $g = 9.8\,\text{m/s}^2$).



Correct Answer: 147 N

Solution:

The force due to kinetic friction is given by:

$$f = \mu m g$$

Step 1: Substitute the values.
Given $\mu = 0.3$, $m = 50\,\text{kg}$, and $g = 9.8\,\text{m/s}^2$:

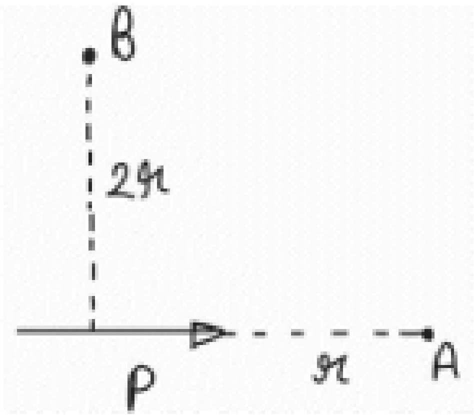
$$f = 0.3 \times 50 \times 9.8 = 147\,\text{N}$$

Quick Tip

The force of kinetic friction is calculated using the coefficient of friction, the mass of the object, and the acceleration due to gravity.

---

18. Find the ratio of electric field at points A and B, produced by an electric dipole.



Correct Answer: 16

Solution:

Step 1: Electric field at point A.
The electric field at point A due to the electric dipole is given by:

$$E_A = \frac{2kp}{r^3}$$

where k is Coulomb's constant, p is the dipole moment, and r is the distance from the dipole to point A.
Step 2: Electric field at point B.
The electric field at point B due to the dipole is given by:

$$E_B = \frac{kp}{(2r)^3} = \frac{kp}{8r^3}$$

Step 3: Find the ratio of electric fields.
The ratio of the electric field at point A to the electric field at point B is:

$$\frac{E_A}{E_B} = \frac{\frac{2kp}{r^3}}{\frac{kp}{8r^3}} = \frac{2}{\frac{1}{8}} = 16$$

Quick Tip

The electric field due to a dipole at any point depends on the distance from the dipole and the dipole moment. The field at point A is stronger than the field at point B due to the difference in distances.

---

19. Match the column of order of wavelength of infrared, γ-rays, X-rays, and UV rays.

List-I	List-II
(a) Infrared	(i) Less than 10^{-3} nm
(b) γ-rays	(ii) 10^{-3} to 1 nm
(c) X-rays	(iii) 1 to 300 nm
(d) UV-rays	(iv) 300 to 600 nm

Correct Answer: (a) → (iv), (b) → (i), (c) → (iii), (d) → (ii)

Solution:

Step 1: Understanding the wavelength ranges.
- Infrared has wavelengths greater than 10^{-3} nm, which corresponds to (iv). - γ-rays have the shortest wavelengths, less than 10^{-3} nm, corresponding to (i). - X-rays have wavelengths from 1 nm to 300 nm, corresponding to (iii). - UV rays have wavelengths from 300 nm to 600 nm, corresponding to (ii).

Thus, the matching is:

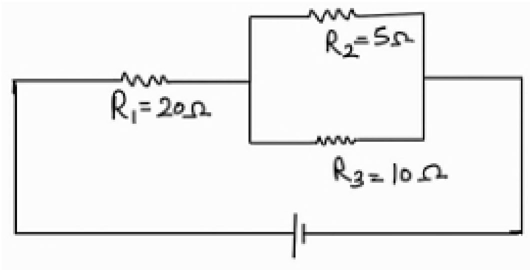
$$\gamma \to \text{(i)},\ \text{X-rays} \to \text{(iii)},\ \text{UV-rays} \to \text{(ii)},\ \text{Infrared} \to \text{(iv)}$$

Quick Tip

The wavelength ranges for various types of electromagnetic radiation vary and can be identified by matching them to the correct categories.

---

20. The ratio of heat dissipated per second through $5\,\Omega$ and $10\,\Omega$ will be –



Correct Answer: $\frac{2}{1}$

Solution:

Step 1: Using the formula for heat dissipation.
The heat dissipated in a resistor is given by:

$$H = \frac{V^2}{R}$$

Since the voltage drop is the same across both resistors, the heat dissipated is inversely proportional to the resistance.
Step 2: Applying the formula.
The ratio of heat dissipated by the two resistors is:

$$\frac{H_1}{H_2} = \frac{R_2}{R_1} = \frac{10}{5} = 2$$

Thus, the ratio is $\frac{2}{1}$.

Quick Tip

Heat dissipation is inversely proportional to the resistance when the voltage is constant across the resistors.

21. Why metal chain hangs at the rear part of tankers containing inflammable liquid.

(1) To make it look fancy
(2) To inform other vehicles about tanker
(3) So that extra electrons can be transferred to earth.
(4) To protect the Tyre from damage.

Correct Answer: (3)

Solution:

Step 1: Air drag on the tanker.
As the tanker moves, air drag causes charges to be induced on the surface of the tanker. This happens due to the friction between the tanker and the surrounding air.
Step 2: Electrostatic charge accumulation.
If the tanker is carrying inflammable liquid, the buildup of static charge can be hazardous, as it could lead to sparks that may ignite the flammable liquid.
Step 3: Role of the metal chain.
To neutralize the accumulated charge, a metal chain is suspended at the rear of the tanker. The chain touches the ground, allowing the extra electrons to flow from the tanker to the earth, thereby neutralizing the charge.

> Quick Tip
>
> Inflammable liquids in tankers can accumulate static charge, which can be neutralized by grounding the tanker using a metal chain.

---

22. A Force acts on a body such that momentum $\vec{p} = \cos(kt)\hat{i} - \sin(kt)\hat{j}$. Find the angle between $\vec{p}$ and $\vec{F}$.

Correct Answer: 90°

Solution:

Step 1: Given momentum.
We are given the momentum as a function of time:

$$\vec{p} = \cos(kt)\hat{i} - \sin(kt)\hat{j}$$

where k is a constant, and $\hat{i}$ and $\hat{j}$ are unit vectors along the x-axis and y-axis, respectively.
Step 2: Find force using the definition of force.
Force is the rate of change of momentum:

$$\vec{F} = \frac{d\vec{p}}{dt}$$

Taking the derivative of the given momentum:

$$\vec{F} = \frac{d}{dt}\left(\cos(kt)\hat{i} - \sin(kt)\hat{j}\right)$$

Using the chain rule:

$$\vec{F} = -k\sin(kt)\hat{i} - k\cos(kt)\hat{j}$$

Step 3: Calculate the dot product $\vec{p} \cdot \vec{F}$.
Now, we calculate the dot product between $\vec{p}$ and $\vec{F}$:

$$\vec{p} \cdot \vec{F} = \left(\cos(kt)\hat{i} - \sin(kt)\hat{j}\right) \cdot \left(-k\sin(kt)\hat{i} - k\cos(kt)\hat{j}\right)$$

Expanding the dot product:

$$\vec{p} \cdot \vec{F} = -k\left(\cos(kt)\sin(kt) + \sin(kt)\cos(kt)\right)$$

$$\vec{p} \cdot \vec{F} = -k\left(2\cos(kt)\sin(kt)\right)$$

Since the dot product is zero, this implies that:

$$\vec{p} \cdot \vec{F} = 0$$

Step 4: Conclusion.
The fact that the dot product is zero means the vectors $\vec{p}$ and $\vec{F}$ are perpendicular. Therefore, the angle θ between them is:

$$\theta = 90^\circ$$

Quick Tip

When the dot product of two vectors is zero, the vectors are perpendicular, meaning the angle between them is 90°.

---

23. A sonometer wire of length 90cm, whose fundamental frequency is 400Hz. Wire has the same tension and now, fundamental frequency changed to 600Hz. Find the new length of the wire.

Correct Answer: 60cm

Solution:

The fundamental frequency of a vibrating wire is given by the formula:

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

where L is the length of the wire, T is the tension, and m is the mass per unit length.
Since the tension remains constant, the frequency and length are inversely related. Therefore, we can use the ratio of the frequencies to the lengths:

$$f_1 L_1 = f_2 L_2$$

Step 1: Use the given frequencies and lengths.
We are given that: - $f_1 = 400\,\text{Hz}$, - $f_2 = 600\,\text{Hz}$, - $L_1 = 90\,\text{cm}$, - $L_2 = ?$.
Step 2: Apply the relation.
Using the equation $f_1 L_1 = f_2 L_2$, we substitute the known values:

$$400 \times 90 = 600 \times L_2$$

Solving for L_2:

$$L_2 = \frac{400 \times 90}{600} = 60\,\text{cm}$$

Quick Tip

When the tension in the wire is constant, the fundamental frequency is inversely proportional to the length of the wire.

---

24. A galvanometer having resistance 100Ω is connected in series with 400Ω resistance and measures a maximum of 10V, and now the galvanometer is converted into an ammeter. What should be the value of the shunt resistance so that it can measure a maximum current of 10A?

Correct Answer: 0.2Ω

Solution:

Step 1: Understanding the setup.
We are given the following: - Galvanometer resistance: $R_g = 100\,\Omega$ - Series resistance: $R = 400\,\Omega$ - The galvanometer is designed to measure a maximum voltage of 10V, and now it is being converted into an ammeter to measure a maximum current of 10A.
The goal is to find the value of the shunt resistance R_s that will allow the device to measure the current up to 10A.
Step 2: Formula for voltage across the galvanometer.
The voltage across the series combination of the galvanometer and the shunt resistance is given by the formula:

$$V = I_{\text{max}} \times (R_s + R_g)$$

Since the galvanometer is designed to measure a maximum voltage of 10V, the total voltage across the ammeter is also 10V. This voltage is dropped across both the galvanometer and the shunt resistance.

$$V = 10\,\text{V}$$

Step 3: Current through the galvanometer.
The current I_g through the galvanometer is related to the maximum current I_{max} by the following relation:

$$I_g = \frac{1}{50}\,\text{A}$$

This is because the galvanometer can measure a maximum of 1A, and the total current in the circuit is 10A. Thus, the current through the galvanometer will be 1/50 of the total current.
Step 4: Voltage across the galvanometer.
Now, using Ohm's law, the voltage across the galvanometer is:

$$V_g = I_g \times R_g = \frac{1}{50} \times 100 = 2\,\text{V}$$

Step 5: Voltage drop across the shunt resistance.
The remaining voltage, which is $10 - 2 = 8\,\text{V}$, is dropped across the shunt resistance R_s.
Step 6: Apply the formula for the shunt resistance.
Using Ohm's law for the shunt resistance, the voltage drop across R_s is related to the current through it:

$$V_s = I_s \times R_s$$

where $I_s = 10 - I_g = 10 - \frac{1}{50}$. Thus:

$$R_s = \frac{8}{I_s} = \frac{8}{10 - \frac{1}{50}} = 0.2\,\Omega$$

Quick Tip

To convert a galvanometer into an ammeter, use the shunt resistance in parallel with the galvanometer. The value of the shunt resistance is calculated by using the voltage drop across the shunt and the maximum current.

---

25. Find the expression for the mean free path of a gas molecule of number density n and diameter d of the molecule.

Correct Answer:

$$\lambda = \frac{1}{\sqrt{2}\,nd^2}$$

Solution:

Step 1: Understanding the concept of mean free path.
The mean free path λ is the average distance a gas molecule travels between collisions with other molecules. It depends on the number density n (the number of molecules per unit volume) and the diameter d of the molecules.
Step 2: Formula for mean free path.
The formula for the mean free path is derived from the kinetic theory of gases. It is given by:

$$\lambda = \frac{1}{\sqrt{2}\, n d^2}$$

where: - n is the number density of the gas molecules, - d is the diameter of the gas molecules, - $\sqrt{2}$ is a constant factor arising from the relative motion of the molecules.
Step 3: Explanation of the formula.
The mean free path is inversely proportional to the number density and the square of the molecular diameter. This means that as the number of molecules increases or the size of the molecules increases, the mean free path decreases, indicating more frequent collisions between molecules.

Quick Tip

The mean free path is an important quantity in understanding the behavior of gases. It is inversely proportional to the molecular density and the square of the molecular diameter.
