# JEE Main 2024 Physics Question Paper April 4 Shift 2 with Solutions

| Time Allowed :3 Hours | Maximum Marks :300 | Total Questions :90 |
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## 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. Position of a particle performing SHM is given by $x = 100\sin(\omega t + \pi/3)$. Find its initial velocity if time period is 3.14 sec.**

**Solution:**

**Step 1: Given the equation of motion.**
The equation for the position of the particle in Simple Harmonic Motion (SHM) is:

$$x = 100\sin(\omega t + \pi/3)$$

**Step 2: Find the velocity.**
The velocity is the derivative of the displacement with respect to time:

$$v = \frac{dx}{dt} = [100\cos(\omega t + \pi/3)] \times \omega$$

**Step 3: Calculate the initial velocity.**
At $t = 0$, the velocity becomes:

$$v(0) = 100 \times \omega\cos(\pi/3) = 100 \times \omega/2 = 50\omega$$

**Step 4: Find the angular frequency $\omega$.**
The time period $T = 3.14$ sec, and the angular frequency $\omega$ is given by:

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{3.14} \approx 2$$

**Step 5: Final initial velocity.**
Thus, the initial velocity is:

$$v(0) = 50 \times 2 = 100\,\text{m/s}$$

Quick Tip

The initial velocity in SHM can be found by differentiating the displacement equation with respect to time and then substituting $t = 0$ to get the initial value.

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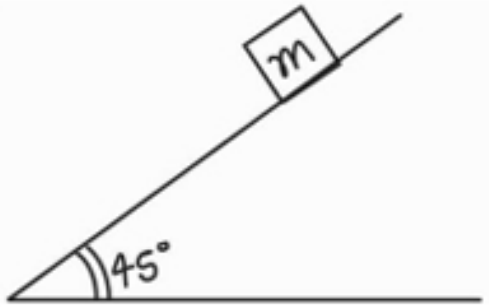
**2. Find the value of friction coefficient between block and the inclined for body to just start sliding.**




**Solution:**

**Step 1: Understanding the forces involved.**
The block starts sliding when the component of gravitational force parallel to the incline exceeds the force of friction. The forces are: - Gravitational force: $mg\sin\theta$ - Frictional force: $\mu mg\cos\theta$
**Step 2: Equating the forces.**
For the block to start sliding, the frictional force must be equal to the parallel component of gravitational force:

$$mg\sin\theta = \mu mg\cos\theta$$

**Step 3: Simplifying the equation.**
By canceling $mg$ from both sides, we get:

$$\tan\theta = \mu$$

**Step 4: Substituting $\theta = 45^\circ$.**
At $\theta = 45^\circ$, we know that $\tan 45^\circ = 1$, so:

$$\mu = 1$$

Quick Tip

For a body to just start sliding on an incline, the friction coefficient is equal to the tangent of the angle of inclination.

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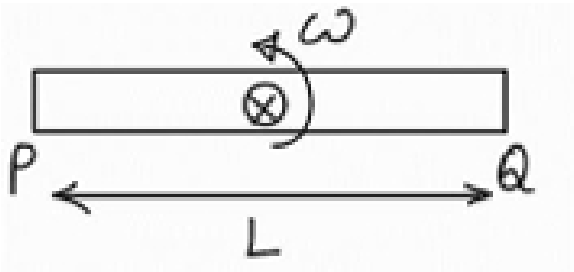
**3. Find potential difference between points P and Q in the given figure. Magnetic field is perpendicular to the plane of rotation.**




**Solution:**

**Step 1: Understanding the setup.**
The setup involves a rotating rod with magnetic field perpendicular to the plane of rotation. Points $P$ and $Q$ are at different locations on the rod, and we need to find the potential difference between them. Since the magnetic field is perpendicular to the plane of rotation, it causes a potential difference between these two points as the rod moves through the field.

**Step 2: Using Faraday's Law.**
In this case, the induced EMF is given by the equation:

$$\text{EMF} = Bl\omega$$

where $B$ is the magnetic field, $l$ is the length of the rod, and $\omega$ is the angular velocity of the rod. The potential difference between the points $P$ and $Q$ will be zero if they are at the same potential. Since $P$ and $Q$ are at the same potential, we conclude that:

$$V_P - V_Q = 0$$

Quick Tip

In a rotating conductor within a magnetic field, the potential difference between points on the conductor can be determined using Faraday's Law of induction. If the points are at the same potential, the difference will be zero.

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**4. In a YDSE setup, slit width are $d$ and $4d$, find the ratio of maximum intensity to minimum intensity.**

**Solution:**

**Step 1: Understanding the formula.**
In Young's Double Slit Experiment (YDSE), the intensity distribution depends on the slit width. The intensity at a point on the screen is given by:

$$I = I_{\max} \left( \frac{\sin \beta}{\beta} \right)^2$$

where $\beta = \frac{\pi d \sin \theta}{\lambda}$, $d$ is the slit width, and $\lambda$ is the wavelength of light. The maximum intensity occurs when the slits are in phase, and the minimum intensity occurs when the path difference is an odd multiple of $\lambda/2$.

**Step 2: Finding the ratio.**
Given the slit widths are $d$ and $4d$, the ratio of the maximum intensity to the minimum intensity is:

$$\frac{I_{\max}}{I_{\min}} = \left( \frac{\sqrt{4d} + \sqrt{4d}}{\sqrt{4d} - \sqrt{4d}} \right)^2 = \left( \frac{3}{1} \right)^2 = 9$$

**Step 3: Conclusion.**
Thus, the ratio of maximum intensity to minimum intensity is $9 : 1$.

**Quick Tip**

In YDSE, the intensity ratio of maximum to minimum intensity depends on the slit widths. Larger slit widths increase the intensity maxima and minima.

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**5. A bus moving with 72 km/hr stops in 4 seconds due to uniform retardation. Find the value of stopping distance.**

**Solution:**

**Step 1: Given data.**
The initial velocity of the bus $u = 72\,\text{km/hr}$. First, we need to convert this to meters per second:

$$u = 72 \times \frac{1000}{3600} = 20\,\text{m/s}$$

The final velocity $v = 0\,\text{m/s}$ since the bus stops. The time $t = 4\,\text{seconds}$.
**Step 2: Using the equation of motion.**
The stopping distance $s$ can be calculated using the equation:

$$s = \frac{u + v}{2} \times t$$

**Step 3: Calculating the stopping distance.**
Substituting the known values:

$$s = \frac{20 + 0}{2} \times 4 = 40\,\text{m}$$

Quick Tip

The stopping distance can be calculated using the equation $s = \frac{u+v}{2} \times t$, where $u$ is the initial velocity, $v$ is the final velocity, and $t$ is the time taken to stop.

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**6. Find the total flux through the cube if charge $Q$ is present at the centre of its one face.**

**Solution:**

**Step 1: Understanding the problem.**
We are given a cube with charge $Q$ placed at the centre of one of its faces. The total flux through the cube is calculated using Gauss's Law.

**Step 2: Applying Gauss's Law.**
By Gauss's Law, the total electric flux through a closed surface is given by:

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

where $q_{\text{enc}}$ is the charge enclosed by the surface and $\epsilon_0$ is the permittivity of free space.

**Step 3: Understanding the cube configuration.**
Since the charge $Q$ is placed at the centre of one face of the cube, the charge enclosed in the cube will be half of $Q$, because only half of the cube will contain the charge. Therefore, the charge enclosed is:

$$q_{\text{enc}} = \frac{Q}{2}$$

**Step 4: Calculating the flux.**
Thus, the total flux through the cube is:

$$\Phi = \frac{q_{\text{enc}}}{\epsilon_0} = \frac{Q}{2\epsilon_0}$$

Quick Tip

When using Gauss's Law, the flux through a surface depends on the charge enclosed within that surface. If a charge is placed on a face of a cube, only part of the cube will enclose the charge.

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**7. Two wires A and B of same length are made of same material. Radius of B is double of radius of A. Find resistance of B if resistance of A is 2 $\Omega$.**

**Solution:**

**Step 1: Understanding the formula for resistance.**
The resistance $R$ of a wire is given by the formula:

$$R = \rho \frac{L}{A}$$

where $\rho$ is the resistivity, $L$ is the length of the wire, and $A$ is the cross-sectional area of the wire. The area $A$ of a wire with radius $r$ is given by:

$$A = \pi r^2$$

**Step 2: Using the given data.**
Let the radius of wire A be $r_A$ and that of wire B be $r_B = 2r_A$. The resistance of A is given as $R_A = 2\,\Omega$. Using the formula for resistance, we can write the ratio of the resistances of wires B and A:

$$\frac{R_B}{R_A} = \frac{\rho \frac{L}{A_B}}{\rho \frac{L}{A_A}} = \frac{A_A}{A_B} = \frac{r_A^2}{r_B^2} = \frac{r_A^2}{(2r_A)^2} = \frac{1}{4}$$

**Step 3: Calculating the resistance of B.**
Since $R_A = 2\,\Omega$, we find:

$$R_B = R_A \times \frac{1}{4} = 2 \times 4 = 8\,\Omega$$

**Quick Tip**

Resistance of a wire is inversely proportional to the square of its radius. If the radius of a wire is doubled, the resistance increases by a factor of 4.

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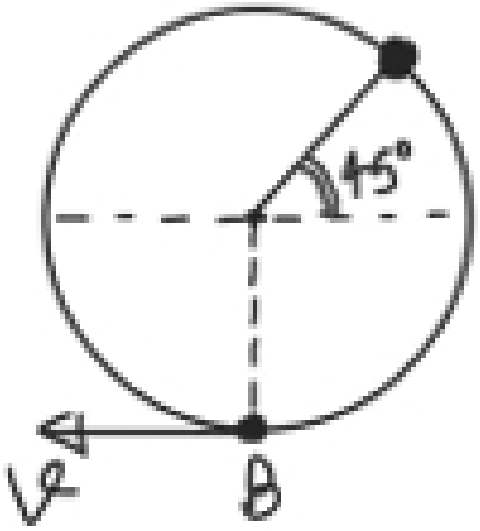
**8. A particle of mass 2 kg attached to a massless string is released from the given position. Find its velocity when it reaches point B. Length of the string is 14 m.**




**Solution:**

**Step 1: Using energy conservation.**
Since the particle is released from rest, we can use the principle of conservation of mechanical energy. The total mechanical energy at the initial position is equal to the total mechanical energy at the final position, neglecting air resistance. The equation for energy conservation is:

Initial Potential Energy+Initial Kinetic Energy = Final Potential Energy+Final Kinetic Energy

At the initial position, the kinetic energy is zero because the particle is at rest. So, the equation becomes:

$$mg(R + R\cos 45^\circ) = \frac{1}{2}mv^2$$

where $m = 2\,\text{kg}$, $g = 10\,\text{m/s}^2$, $R = 14\,\text{m}$, and $v$ is the velocity at point B.

**Step 2: Solving for velocity.**
Simplifying the equation:

$$2g\left(1 + \frac{1}{\sqrt{2}}\right) = v^2$$

Substitute the values:

$$2 \times 10 \times 14 \times \left(1 + \frac{1}{\sqrt{2}}\right) = v^2$$

$$= 280 + \frac{280}{\sqrt{2}}$$

$$= 280 + 200 = 480$$

Thus, the velocity at point B is:

$$v = \sqrt{480} = 4\sqrt{30}\,\text{m/s}$$

Quick Tip

In problems involving circular motion and energy conservation, the sum of potential and kinetic energies is constant, and you can use this principle to solve for unknown quantities such as velocity.

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**9. If power consumed by an electrical instrument is 500 watts at 200 volts, then find power consumed at 100 volts.**

**Solution:**

**Step 1: Using the power formula.**
The power consumed by an electrical instrument is related to the voltage and resistance by the formula:

$$P = \frac{V^2}{R} \quad \Rightarrow \quad P \propto V^2$$

**Step 2: Applying the formula for two different voltages.**
Let the power at 200 volts be $P_1 = 500\,\text{W}$ and the power at 100 volts be $P_2$. From the equation, we have:

$$\frac{P_2}{P_1} = \left(\frac{V_2}{V_1}\right)^2$$

Substitute $V_1 = 200$ and $V_2 = 100$:

$$\frac{P_2}{500} = \left(\frac{100}{200}\right)^2 = \frac{1}{4}$$

**Step 3: Calculating the power consumed at 100 volts.**
Thus, we find:

$$P_2 = \frac{500}{4} = 125\,\text{W}$$

Quick Tip

Power consumed by an electrical instrument is proportional to the square of the voltage applied.

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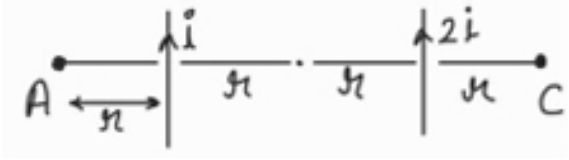
**10. Find the ratio of magnitude of magnetic field at point A and B if the wires are infinitely long.**



**Solution:**

**Step 1: Formula for magnetic field due to a current-carrying wire.**
The magnetic field at a distance $r$ from an infinitely long straight wire carrying current $I$ is given by:

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

where $\mu_0$ is the permeability of free space, and $r$ is the distance from the wire.

**Step 2: Applying the formula for points A and B.**
Let the distances from the wires to points A, B, and C be $r_A$, $r_B$, and $r_C$, respectively. The magnetic fields at points A and B are given by:

$$B_A = \frac{\mu_0 I}{2\pi r_A}, \quad B_B = \frac{\mu_0 I}{2\pi r_B}$$

The total magnetic field at point A and B is the sum of the contributions from the two wires. At point A, the field is due to the current in both wires, and similarly for point B.
**Step 3: Finding the ratio of magnetic fields.**
The total magnetic field at point A is:

$$B_A = \frac{\mu_0 I}{2\pi r_A} + \frac{\mu_0 I}{2\pi r_C}$$

And at point B:

$$B_B = \frac{\mu_0 I}{2\pi r_B} + \frac{\mu_0 I}{2\pi r_C}$$

Thus, the ratio $\frac{B_A}{B_C}$ is:

$$\frac{B_A}{B_B} = \frac{5 \times 3}{7 \times 3} = \frac{5}{7}$$

Quick Tip

The magnetic field at a point due to multiple current-carrying wires is the vector sum of the individual fields from each wire. The distance from each wire affects the magnitude of the field.

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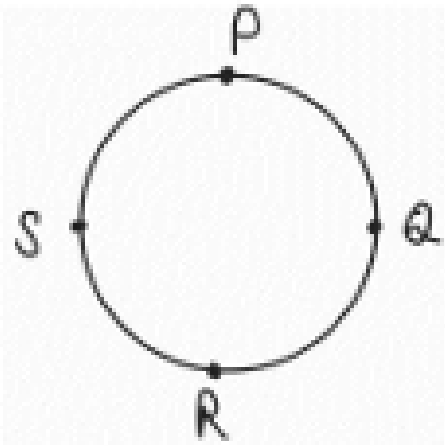
**11. A particle travels on a circle of radius 2m from P to S. Find the displacement of the particle.**




**Solution:**

**Step 1: Understanding the situation.**
The particle travels along a circular path from point P to point S. The radius of the circle is 2 meters. We are asked to find the displacement of the particle.

**Step 2: Calculating the displacement.**
The displacement is the shortest distance between the initial and final positions of the particle. Since the particle moves along a circle, the displacement is the straight line between points P and S, which is the chord of the circle.

**Step 3: Applying the formula.**
The displacement $\left|\overrightarrow{PS}\right|$ can be calculated using the Pythagorean theorem. The distance from P to S is the diagonal of a square formed by the radius of the circle. The formula for the displacement is:

$$|PS| = \sqrt{r^2 + r^2} = \sqrt{2r \times 2r} = \sqrt{2 \times 2 \times 2} = 2.82\,\text{m}$$

**Quick Tip**

When the particle moves along a circular path, the displacement is always the shortest distance between the starting and ending points, which is the chord of the circle.

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**12. Determine the weight of a man standing at a height of $2R$ (where $R$ is radius of Earth) from the Earth's surface. Given mass of the man = 90 kg.**

**Solution:**

**Step 1: Formula for gravity at height $h$.**
The gravitational force at height $h$ from the Earth's surface is given by:

$$g = g_s \left(\frac{1}{1 + \frac{h}{R}}\right)^2$$

where $g_s$ is the gravitational acceleration at the surface of the Earth, and $R$ is the radius of the Earth. The weight of the man at height $h = 2R$ is given by:

$$g = g_s \left( \frac{1}{1 + \frac{2R}{R}} \right)^2 = g_s \left( \frac{1}{3} \right)^2 = \frac{g_s}{9}$$

**Step 2: Calculating the weight of the man.**
Since the mass of the man is 90 kg, the weight at the height of $2R$ will be:

$$W = \frac{W_s}{9}$$

where $W_s = 90 \times 9.8 = 882\,\text{N}$, so:

$$W = \frac{882}{9} = 98\,\text{N}$$

**Step 3: Conclusion.**
Thus, the weight of the man at height $2R$ is 10 kg-wt.

Quick Tip

At a height $h$ above the Earth's surface, the weight of an object decreases as $g$ decreases with the square of the distance from the Earth's center.

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**13. 3 kg mass is displaced by 2 cm towards 2 kg mass. How much should 2 kg mass be displaced towards 3 kg such that the centre of mass remains at the same point?**

**Solution:**

**Step 1: Understanding the Center of Mass Formula.**
The center of mass $d_{\text{com}}$ of a system of particles is given by the equation:

$$d_{\text{com}} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

where: - $m_1 = 3\,\text{kg}$ (mass of first particle) - $m_2 = 2\,\text{kg}$ (mass of second particle) - $x_1 = 2\,\text{cm}$ (displacement of the 3 kg mass towards the 2 kg mass) - $x_2$ is the displacement of the 2 kg mass (to be calculated) towards the 3 kg mass such that the center of mass remains at the same point.
**Step 2: Apply the condition that the center of mass remains stationary.**
We want the center of mass to remain at the same point, which means:

$$d_{\text{com}} = 0$$

Substitute the values in the center of mass formula:

$$0 = \frac{3(2) + 2(-x)}{3 + 2}$$

Here, $x$ is the displacement of the 2 kg mass towards the 3 kg mass. We take the displacement as negative because it is towards the 3 kg mass.

**Step 3: Solve for $x$.**
Simplify the equation:

$$0 = \frac{6 - 2x}{5}$$

Multiply both sides by 5 to eliminate the denominator:

$$0 = 6 - 2x$$

Now solve for $x$:

$$2x = 6 \quad \Rightarrow \quad x = 3\,\text{cm}$$

**Quick Tip**

The center of mass is calculated by taking the weighted average of the positions of the masses. When the system is in equilibrium, the displacements must balance out such that the center of mass remains unchanged.

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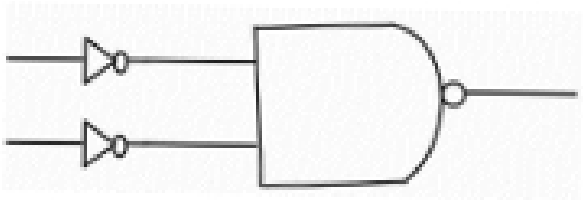
**14. Identify the logic gate.**



**Solution:**

**Step 1: Understanding the OR gate.**
An OR gate is a basic digital logic gate that outputs true (1) if at least one of its inputs is true. The Boolean expression for an OR gate is:

$$A + B = A + B$$

where $A$ and $B$ are the inputs, and $+$ denotes the OR operation. The OR gate outputs 1 if either $A$ or $B$ or both are 1, and 0 if both are 0.
**Step 2: Interpreting the given circuit.**
The given circuit diagram is that of an OR gate, which is typically represented by a symbol with two inputs (A and B) and one output. The symbol has a curved shape, differentiating it from other logic gates like AND or NOT gates.
**Step 3: Writing the Boolean expression for the gate.**
Based on the diagram and the given information, the Boolean expression for the OR gate is:

$$A + B$$

**Step 4: Conclusion.**
Thus, the logic gate shown in the diagram is an OR gate, and the corresponding Boolean expression is $A + B$.

**Quick Tip**

The OR gate outputs true (1) when at least one of the inputs is true. Its Boolean expression is the sum of the inputs, $A + B$.

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**15. In an thermodynamic process, the value of $\gamma$ is $\frac{3}{2}$. If 1 mol of gas is taken from volume 20 Litre to 60 Litre, then Find the value of work done in the process. Initial pressure is 5 atm.**

**Solution:**

**Step 1: Applying the equation for adiabatic process.**
The equation for an adiabatic process is given by:

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

Given that $\gamma = \frac{3}{2}$, initial volume $V_1 = 20\,\text{L}$, final volume $V_2 = 60\,\text{L}$, and initial pressure $P_1 = 5\,\text{atm}$, we can use the equation to find the final pressure $P_2$.
**Step 2: Calculate final pressure.**
Using the equation:

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$\Rightarrow 5(60)^{3/2} = P_2(20)^{3/2}$$

$$\Rightarrow P_2 = \frac{5(60)^{3/2}}{(20)^{3/2}} = 5 \times 3^{3/2}$$

$$\Rightarrow P_2 = 15\sqrt{3}\,\text{atm}$$

**Step 3: Calculating the work done.**
The work done in an adiabatic process is given by the formula:

$$W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1}$$

Substitute the values:

$$W = \frac{5 \times 60 - 15\sqrt{3} \times 20}{\frac{3}{2} - 1}$$

$$= \frac{300 - 15\sqrt{3} \times 20}{\frac{1}{2}} = 20 \times 5\left[3 - \sqrt{3}\right]$$

$$= 200 \times \left(3 - \sqrt{3}\right) = 600\left(1 - \sqrt{3}\right)\text{ atm Litre}$$

Quick Tip

In an adiabatic process, the work done is calculated using the relationship between pressure and volume, and the value of $\gamma$.

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**16. Find order of wavelength of X-rays, gamma rays, microwaves, and ultraviolet rays.**

**Solution:**

**Step 1: General understanding of the order of wavelengths.**
The electromagnetic spectrum includes a range of wavelengths for various types of radiation. The order of wavelengths is as follows:

$$\lambda_\gamma < \lambda_{\text{X-ray}} < \lambda_{\text{UV}} < \lambda_{\text{microwave}}$$

where: - $\lambda_\gamma$ is the wavelength of gamma rays - $\lambda_{\text{X-ray}}$ is the wavelength of X-rays - $\lambda_{\text{UV}}$ is the wavelength of ultraviolet rays - $\lambda_{\text{microwave}}$ is the wavelength of microwaves
**Step 2: Concluding the order.**
Thus, the order of the wavelengths is:

$$\lambda_\gamma < \lambda_{\text{X-ray}} < \lambda_{\text{UV}} < \lambda_{\text{microwave}}$$

Quick Tip

The order of wavelengths in the electromagnetic spectrum ranges from shortest to longest: gamma rays have the shortest wavelengths, followed by X-rays, ultraviolet rays, and microwaves.

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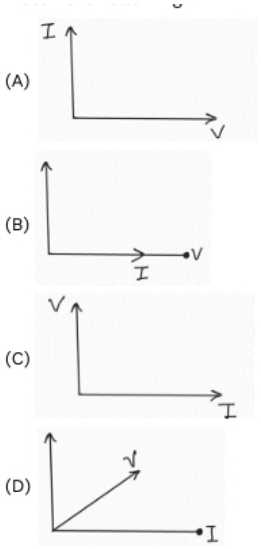
**17. Match the following:**




**Solution:**

**Step 1: Understanding the phase relationships.**
In AC circuits, the phase relationship between the current and voltage determines the behavior of the component. The four types of components are: - Capacitive: Current leads voltage by 90 degrees. - Inductive: Current lags voltage by 90 degrees. - Resistive: Current and voltage are in phase (i.e., no phase difference).

**Step 2: Matching the options.**
- (A) The first graph shows current leading voltage, which represents a capacitive circuit. - (B) The second graph shows current lagging voltage, representing an inductive circuit. - (C) The third graph shows current and voltage in phase, which corresponds to a resistive circuit. - (D) The fourth graph shows current lagging voltage again, which is inductive.

**Step 3: Final answer.**
The correct matching is:

$$A \to (i)\,\text{Capacitive}, \quad B \to (ii)\,\text{Inductive}, \quad C \to (iii)\,\text{Resistive}, \quad D \to (ii)\,\text{Inductive}$$

**Quick Tip**

In AC circuits: - Capacitive circuits have current leading voltage. - Inductive circuits have current lagging voltage. - Resistive circuits have current and voltage in phase.

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**18. Find out rotational and translational degree of freedom of $CH_4$ gas molecule.**

**Solution:**

**Step 1: Understanding degrees of freedom.**
In a molecule, the degrees of freedom refer to the number of independent ways in which it can move. A molecule can move in three ways: translational motion, rotational motion, and vibrational motion. The total degrees of freedom of a molecule is given by $3N$, where $N$ is the number of atoms in the molecule.
For methane ($CH_4$): - There are 5 atoms in the molecule (1 carbon and 4 hydrogen atoms). - Translational degree of freedom refers to the motion in three directions (x, y, and z), so the translational degree of freedom is 3. - Rotational degree of freedom for a linear molecule is 2, but for a non-linear molecule (such as methane), it is 3.
Thus, the total degrees of freedom for $CH_4$ are 6 (3 translational + 3 rotational).

**Step 2: Conclusion.**
Therefore, the translational and rotational degrees of freedom for methane are:

$$\text{Translational degree of freedom} = 3, \quad \text{Rotational degree of freedom} = 3$$

Quick Tip

For non-linear molecules, the rotational degrees of freedom are 3, and for linear molecules, they are 2. Translational degrees of freedom are always 3.

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**19. A spring mass system has a total energy $E$ and if mass is doubled then what is total energy?**

**Solution:**

**Step 1: Understanding the energy in the spring-mass system.**
The total energy in a spring-mass system is given by the sum of the kinetic and potential energies. The energy can be expressed as:

$$E = \frac{1}{2}m\omega^2 A^2$$

where $m$ is the mass, $\omega$ is the angular frequency, and $A$ is the amplitude.

**Step 2: Expression for energy when mass is doubled.**
When the mass $m$ is doubled, the total energy becomes:

$$E = \frac{1}{2}(2m)\omega^2 A^2 = 2 \times \left(\frac{1}{2}m\omega^2 A^2\right)$$

Thus, if the mass is doubled, the total energy becomes twice the original energy.

**Step 3: Conclusion.**
Therefore, the total energy remains the same as $E$.

Quick Tip

The total energy in a spring-mass system is directly proportional to the mass. When the mass is doubled, the total energy also doubles.

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**20. Find relation between $T$ (time period of satellite), $R$ (radius of satellite), $G$ (gravitational constant), $M$ (mass of satellite).**

**Solution:**

**Step 1: Starting with the formula for the time period of a satellite.**
The time period $T$ of a satellite in orbit is given by the formula:

$$T^2 \propto \frac{R^3}{GM}$$

where: - $R$ is the radius of the orbit (distance from the center of the Earth to the satellite), - $G$ is the gravitational constant, - $M$ is the mass of the Earth.

**Step 2: Dimensional analysis.**
From the dimensional formula of the time period $[T]$, we can use the relation:

$$[T] = [L] \left[\mathrm{m} \cdot \mathrm{L}^{-1} \cdot \mathrm{T}^{-2} \cdot [M]\right]^1$$

where the exponents of the dimensional formula give us the values to calculate the relation between $T$, $R$, $G$, and $M$.

**Step 3: Conclusion.**
Using dimensional analysis, we find that:

$$T^2 \propto \frac{R^3}{GM}$$

Quick Tip

The time period of a satellite is related to the radius of its orbit and the mass of the central body (Earth) by the equation $T^2 \propto \frac{R^3}{GM}$.

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**21. In a Bohr's atom an electron revolves in an orbit whose orbital number $n = 4$. Find out the value of angular momentum.**

**Solution:**

**Step 1: Using the formula for angular momentum.**
The angular momentum $L$ of an electron in orbit in Bohr's model is given by:

$$L = mvr = \frac{nh}{2\pi}$$

where $n$ is the principal quantum number (in this case, $n = 4$), $h$ is Planck's constant, and $m$ is the mass of the electron.

**Step 2: Substituting the values.**
For $n = 4$, we have:

$$L = \frac{4h}{2\pi} = \frac{2h}{\pi}$$

Quick Tip

In Bohr's model, the angular momentum of an electron is quantized and is given by $L = \frac{nh}{2\pi}$, where $n$ is the principal quantum number.

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**22. Assertion: The number of photons increases with increase in frequency of light. Reason: The maximum kinetic energy increases with increase in frequency of incident light.**

**Solution:**

**Step 1: Understanding the assertion.**
The assertion states that the number of photons increases with an increase in the frequency of light. However, this is not true. The number of photons depends on the intensity of light, not just its frequency. Higher frequency light does not necessarily increase the number of photons; it increases the energy per photon.

**Step 2: Understanding the reason.**
The reason given is true. According to the photoelectric equation, the maximum kinetic energy of the emitted electrons is given by:

$$K_{\max} = h\nu - \phi$$

where $h\nu$ is the energy of the incident photon and $\phi$ is the work function of the material. As the frequency of light increases, the kinetic energy of the emitted electrons increases, provided the frequency is above the threshold frequency.

**Step 3: Conclusion.**
Thus, the assertion is false, but the reason is true.

Quick Tip

The number of photons is related to the intensity of light, not its frequency. The energy of each photon increases with frequency, which in turn increases the kinetic energy of emitted electrons in the photoelectric effect.

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**23. Magnetic moment is 0.5 $\mathbf{A/m^2}$, strength of magnetic field $B = 0.8 \times 10^{-16}$ T, then find the work done for brining the magnet from most stable to least stable position.**

**Solution:**

**Step 1: Using the formula for work done.**
The work done to bring a magnetic moment $\mu$ in a magnetic field $B$ from one position to another is given by the formula:

$$W_{\text{ext}} = -\Delta U$$

where $U = -\mu \cdot B$ is the potential energy.

**Step 2: Calculating the change in potential energy.**
The work done is:

$$W_{\text{ext}} = -\left((\mu B)_{\text{final}} - (\mu B)_{\text{initial}}\right)$$

When the magnetic moment is in the most stable position, the angle $\theta = 0^\circ$, and when it is in the least stable position, the angle $\theta = 180^\circ$. Therefore:

$$W_{\text{ext}} = MB\left[\cos(180^\circ) - \cos(0^\circ)\right]$$

$$W_{\text{ext}} = 40 \times 10^{-18} \times (-1 - 1)$$

$$W_{\text{ext}} = 8 \times 10^{-17}\ \text{J}$$

Quick Tip

The work done to move a magnetic moment in a magnetic field depends on the change in potential energy, which is related to the angle between the magnetic moment and the magnetic field.

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**24. Statement 1: Contact angle in tube depends on both liquid and tube material. Statement 2: Height of the capillary is independent of its radius of curvature.**

**Solution:**

**Step 1: Analyzing Statement 1.**
The contact angle in a tube depends on the adhesive force between the liquid and the tube and the cohesive force between the liquid molecules. These forces are influenced by both the liquid and the tube material. Therefore, Statement 1 is true.

**Step 2: Analyzing Statement 2.**
The height of the liquid in a capillary tube is given by the formula:

$$h = \frac{2T \cos \theta}{r \rho g}$$

where $T$ is the surface tension of the liquid, $\theta$ is the contact angle, $r$ is the radius of the capillary, $\rho$ is the density of the liquid, and $g$ is the acceleration due to gravity. As we can see, the height $h$ is inversely proportional to the radius $r$, meaning that the height depends on the radius of curvature. Therefore, Statement 2 is false.

**Step 3: Conclusion.**
Thus, Statement 1 is true, and Statement 2 is false.

Quick Tip

The contact angle is determined by the interaction of cohesive and adhesive forces, and the height in a capillary tube depends on the radius of the tube.

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