JEE Main 2025 April 2 Shift 2 Physics
Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :300	Total Questions :75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Multiple choice questions (MCQs)
2. Questions with numerical values as answers.
3. There are three sections: **Mathematics, Physics, Chemistry**.
4. **Mathematics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
5. **Physics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory..
6. **Chemistry:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
7. Total: 75 Questions (25 questions each).
8. 300 Marks (100 marks for each section).
9. **MCQs:** Four marks will be awarded for each correct answer and there will be a negative marking of one mark on each wrong answer.
10. **Questions with numerical value answers:** Candidates will be given four marks for each correct answer and there will be a negative marking of 1 mark for each wrong answer.

Physics

SECTION-A

26. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Net dipole moment of a polar linear isotropic dielectric substance is not zero even in the absence of an external electric field.
Reason (R): In absence of an external electric field, the different permanent dipoles of a polar dielectric substance are oriented in random directions.
In the light of the above statements, choose the most appropriate answer from the options given below: (1) (A) is correct but (R) is not correct (2) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(3) Both (A) and (R) are correct and (R) is the correct explanation of (A) (4) (A) is not

correct but (R) is correct

Correct Answer: (4)

Solution:

(A): Since polar dielectrics are randomly oriented, $\mathbf{P}_{\text{net}} = \mathbf{0}$.
(R): If $\mathbf{E}$ is absent, polar dielectrics remain polar and are randomly oriented.

Quick Tip

When analyzing assertions and reasons in physics, remember that the reason should adequately explain the assertion. If not, mark them as correct but not the correct explanation.

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27. In a moving coil galvanometer, two moving coils M_1 and M_2 have the following particulars: $R_1 = 5\,\Omega$, $N_1 = 15$, $A_1 = 3.6 \times 10^{-3}\,\text{m}^2$, $B_1 = 0.25\,\text{T}$ $R_2 = 7\,\Omega$, $N_2 = 21$, $A_2 = 1.8 \times 10^{-3}\,\text{m}^2$, $B_2 = 0.50\,\text{T}$
Assuming that torsional constant of the springs are same for both coils, what will be the ratio of voltage sensitivity of M_1 and M_2?
(1) 1 : 1 (2) 1 : 4 (3) 1 : 3 (4) 1 : 2

Correct Answer: (1)

Solution:

The voltage sensitivity is given by:

$$\frac{\theta}{V} = \frac{NAB}{cR}$$

where N is the number of turns, A is the area, B is the magnetic field, c is the torsional constant, and R is the resistance.
Thus, the ratio of the voltage sensitivity of M_1 and M_2 is:

$$\text{Ratio} = \frac{N_1 A_1 B_1}{N_2 A_2 B_2} = \frac{15 \times 3.6 \times 10^{-3} \times 0.25}{21 \times 1.8 \times 10^{-3} \times 0.50} = \frac{1}{1}$$

Thus, the ratio of voltage sensitivity of M_1 and M_2 is 1 : 1.

Quick Tip

In moving coil galvanometers, the voltage sensitivity is directly proportional to the number of turns, the area of the coil, and the magnetic field strength, and inversely proportional to the resistance.

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28. The moment of inertia of a circular ring of mass M and diameter r about a tangential axis lying in the plane of the ring is:

(1) $\frac{1}{2}Mr^2$ (2) $\frac{3}{8}Mr^2$ (3) $\frac{3}{2}Mr^2$ (4) $2Mr^2$

Correct Answer: (2)

Solution:

Diameter is given as R.

$$\text{Radius} = \frac{R}{2}$$

The formula for the moment of inertia about a tangential axis is given by:

$$I_{\text{tangent}} = \frac{3}{2}m\left(\frac{R}{2}\right)^2 = \frac{3}{8}mR^2$$

Thus, the moment of inertia is:

$$I_{\text{tangent}} = \frac{3}{8}Mr^2$$

Quick Tip

For a circular ring, the moment of inertia about an axis tangent to the ring is derived from the parallel axis theorem by adjusting for the offset from the center.

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29. Two water drops each of radius r coalesce to form a bigger drop. If T is the surface tension, the surface energy released in this process is:
(1) $4\pi r^2 T\left[2^2 - 2^3\right]$ (2) $4\pi r^2 T\left[2^{-1} - 2^3\right]$ (3) $4\pi r^2 T\left[1 + \sqrt{2}\right]$ (4) $4\pi r^2 T\left[\sqrt{2} - 1\right]$

Correct Answer: (1)

Solution:

Let the radius of each drop be r and the radius of the bigger drop be R.
The volume of the two smaller drops:

$$V_{\text{small}} = 2 \times \frac{4}{3}\pi r^3$$

The volume of the larger drop:

$$V_{\text{big}} = \frac{4}{3}\pi R^3$$

Equating the volumes:

$$2 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow r = R^{2/3}$$

The surface energy for the smaller drops is:

$$U_i = 2 \times 4\pi r^2 T = 8\pi r^2 T$$

The surface energy for the bigger drop is:

$$U_f = 4\pi R^2 T = 4\pi R^{4/3} T$$

The heat lost in the process is:

$$\text{Heat lost} = U_i - U_f = 8\pi r^2 T - 4\pi R^{4/3} T = 4\pi r^2 T \left[2^2 - 2^3\right]$$

Thus, the energy released is:

$$\text{Energy released} = 4\pi r^2 T \left[2^2 - 2^3\right]$$

Quick Tip

To solve problems involving surface tension, always use the principle of volume conservation and the fact that energy is related to the surface area of the drop.

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30. An electron with mass m with an initial velocity $(t = 0)\, \vec{v} = \vec{v_0}\, (v_0 > 0)$ enters a magnetic field $\vec{B} = B\hat{j}$. If the initial de-Broglie wavelength at $t = 0$ is λ_0, then its value after time t would be:

(1) $\frac{\lambda_0}{\sqrt{1-\frac{e^2B^2t^2}{m^2}}}$ (2) $\frac{\lambda_0}{\sqrt{1+\frac{e^2B^2t^2}{m^2}}}$ (3) $\lambda_0\sqrt{1+\frac{e^2B^2t^2}{m^2}}$ (4) λ_0

Correct Answer: (4)

Solution:

Magnetic field does not work on the speed of the electron because magnetic forces only act perpendicular to the velocity.
Thus, the speed of the electron will not change, and consequently, its de-Broglie wavelength will remain the same.
The de-Broglie wavelength is given by:

$$\lambda = \frac{h}{mv}$$

Since the speed v does not change due to the magnetic field, the de-Broglie wavelength remains constant at λ_0.
Thus, the de-Broglie wavelength at time t is the same as at $t = 0$:

$$\lambda(t) = \lambda_0$$

Quick Tip

When dealing with an electron in a magnetic field, remember that the magnetic force only changes the direction of motion, not the speed. Thus, the de-Broglie wavelength remains unaffected.

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31. A sinusoidal wave of wavelength 7.5 cm travels a distance of 1.2 cm along the x-direction in 0.3 sec. The crest P is at $x = 0$ at $t = 0$ sec and maximum displacement of the wave is 2 cm. Which equation correctly represents this wave?
(1) $y = 2\cos(0.83x - 3.35t)$ cm (2) $y = 2\sin(0.83x - 3.5t)$ cm (3) $y = 2\cos(3.35x - 0.83t)$ cm (4) $y = 2\cos(0.13x - 0.5t)$ cm
Correct Answer: (1)

Solution:

The velocity v of the wave is given by:

$$v = \frac{\text{distance}}{\text{time}} = \frac{12\,\text{cm}}{0.3\,\text{s}} = 4\,\text{cm/s}$$

Next, the wave number k and angular frequency ω are related to the wavelength λ and frequency f as:

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{7.5} = 0.83\,\text{cm}^{-1}$$

$$\omega = vk = 4 \times 0.83 = 3.35\,\text{rad/s}$$

Thus, the wave equation is:

$$y = A\cos(kx - \omega t) = A\cos(0.83x - 3.35t)$$

Given that the amplitude A is 2 cm (maximum displacement), the equation becomes:

$$y = 2\cos(0.83x - 3.35t)\,\text{cm}$$

Quick Tip

Remember, the general form of the wave equation is $y = A\cos(kx - \omega t)$, where A is the amplitude, k is the wave number, and ω is the angular frequency. Use these relationships to derive the wave equation.

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32. Given a charge q, current I and permeability of vacuum μ_0. Which of the following quantity has the dimension of momentum?
(1) qI/μ_0 (2) $q\mu_0 I$ (3) $q^2\mu_0 I$ (4) $q\mu_0/I$
Correct Answer: (2)

Solution:

We are given:

$$Q = AT$$

$$I = A$$

$$\mu_0 = \text{ML}^3\text{T}^{-2}\text{A}^{-2}$$

Now, we need to find the dimensions of the product $P = Q\mu_0 I$.
The dimension of P is calculated as follows:

$$P = Q\mu_0 I = [AT][\mathrm{ML}^3\mathrm{T}^{-2}\mathrm{A}^{-2}][A]$$

This simplifies to:

$$P = [\mathrm{M}^1\mathrm{L}^1\mathrm{T}^{-2}\mathrm{A}^1]$$

Now, we check the dimensions of momentum:

$$\text{Momentum} = \mathrm{M} \cdot \mathrm{L} \cdot \mathrm{T}^{-1}$$

We find that the dimensions of P are the same as that of momentum. Therefore, the correct answer is:

$$q\mu_0 I$$

Quick Tip

To match the dimensions of momentum, use the fact that momentum has the dimensions $\mathrm{M} \cdot \mathrm{L} \cdot \mathrm{T}^{-1}$ and check for the correct expression.

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33. A solenoid having area A and length ℓ is filled with a material having relative permeability 2. The magnetic energy stored in the solenoid is:
(1) $\frac{B^2 A}{\mu_0}$ (2) $\frac{B^2 A}{2\mu_0}$ (3) $\frac{B^2 A}{\mu_0}$ (4) $\frac{B^2 A}{4\mu_0}$
Correct Answer: (4)

Solution:

We are given the energy stored in a solenoid U, and the relation for magnetic energy density U/V is:

$$U/V = \frac{B^2}{2\mu_0}$$

This implies that:

$$U = \frac{B^2}{2\mu_0} \times V$$

Where $V = A\ell$, the volume of the solenoid. Substituting:

$$U = \frac{B^2}{2\mu_0} \times A\ell$$

Thus, the magnetic energy stored in the solenoid is:

$$U = \frac{B^2 A\ell}{4\mu_0}$$

Hence, the correct answer is:

$$\frac{B^2 A\ell}{4\mu_0}$$

Quick Tip

For problems involving energy stored in a magnetic field, use the formula for the energy density in the magnetic field $U/V = \frac{B^2}{2\mu_0}$, and apply the volume of the solenoid to find the total energy.

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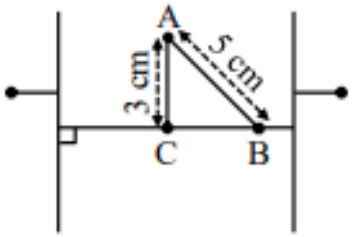
34. Two large plane parallel conducting plates are kept 10 cm apart as shown in figure. The potential difference between them is V. The potential difference between the points A and B (shown in the figure) is:



(1) $\frac{1}{4}V$ (2) $\frac{2}{5}V$ (3) $\frac{3}{4}V$ (4) $1V$
Correct Answer: (2)

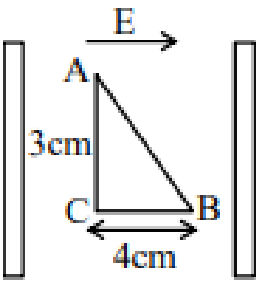


Figure 1: Diagram showing the arrangement of the plates and points A, B, and C.

Solution:

We are given the potential difference between two plates as V, and the separation between the plates is 10 cm. The distance between points A and B is 3 cm and 4 cm, respectively, with the total distance between the plates being 10 cm.
Using $\Delta V = E\Delta d$, where E is the electric field and Δd is the distance:

$$V = E \times 10\,\text{cm}$$

From the diagram, we know that $E = \frac{V}{10}$. The potential difference between points A and B is:

$$V_{AB} = E \times 4\,\text{cm} = \frac{V}{10} \times 4 = \frac{2V}{5}$$

Thus, the potential difference between points A and B is $\frac{2}{5}V$.

Quick Tip

To calculate potential difference in a parallel plate setup, use the relationship $V_{AB} = \frac{E \times d}{V}$, where d is the distance between the points of interest.

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35. Identify the characteristics of an adiabatic process in a monatomic gas.
(A) Internal energy is constant. (B) Work done in the process is equal to the change in internal energy. (C) The product of temperature and volume is a constant. (D) The product of pressure and volume is a constant. (E) The work done to change the temperature from T_1 to T_2 is proportional to $(T_2 - T_1)$.
Choose the correct answer from the options given below:
(1) (A), (C), (D) only (2) (A), (C), (E) only (3) (B), (E) only (4) (B), (D) only
Correct Answer: (3)

Solution:

For an adiabatic process, the heat exchanged $Q = 0$, hence, the change in internal energy is equal to the work done on or by the system:

$$Q = \Delta U + W = 0 \implies \Delta U = -W$$

For an adiabatic process, the work done W is proportional to the change in temperature. Also, we know that:

$$W = -nC_V\Delta T \quad \text{or} \quad |W| = nC_V\Delta T \propto T_2 - T_1$$

Thus, both (B) and (E) are correct, making option (3) the correct answer.

Quick Tip

In an adiabatic process, internal energy change is equal to the work done, and the work is proportional to the change in temperature.

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36. Assuming the validity of Bohr's atomic model for hydrogen-like ions, the radius of Li^{2+} ion in its ground state is given by $\frac{1}{X}a_0$, where a_0 is the first Bohr's radius.
(1) 2 (2) 1 (3) 3 (4) 9
Correct Answer: (3)

Solution:

The radius for a hydrogen-like ion is given by the formula:

$$r = r_0 \frac{n^2}{z}$$

where r_0 is the radius for hydrogen, n is the principal quantum number, and z is the atomic number. For Li^{2+}, we have $n = 1$ and $z = 3$, so the radius is:

$$r = r_0 \frac{1^2}{3} = \frac{r_0}{3}$$

Thus, $X = 3$.

Quick Tip

For hydrogen-like ions, the radius decreases as the atomic number increases, following the formula $r = r_0 \frac{n^2}{z}$.

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37. Energy released when two deuterons (H_2) fuse to form a helium nucleus (He_4) is:
(1) 8.1 MeV (2) 5.9 MeV (3) 23.6 MeV (4) 26.8 MeV
Correct Answer: (3)

Solution:

Given: - Binding energy per nucleon of $H_2^1 = 1.1$ MeV - Binding energy per nucleon of $He_4^2 = 7.0$ MeV
The energy released Q is the difference between the binding energy of the reactants and products:

$$E_B = \text{BE}_{\text{reactant}} - \text{BE}_{\text{product}}$$

$$E_B = 1.1 \times 2 + 1.1 \times 2 - 7 \times 4 = 23.6\,\text{MeV}$$

Thus, the energy released is:

$$Q = 23.6\,\text{MeV}$$

Quick Tip

The energy released in a nuclear fusion reaction can be calculated using the binding energy per nucleon of the reactants and products.

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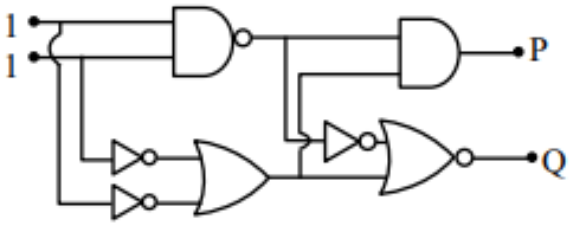
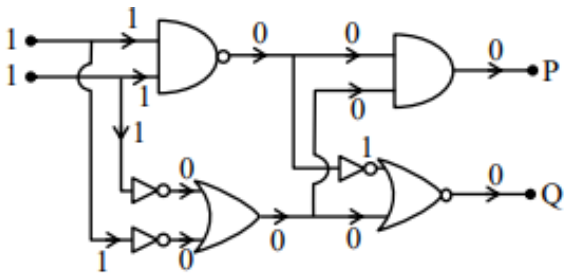
38. In the digital circuit shown in the figure, for the given inputs the P and Q values are:



(1) $P = 1, Q = 1$ (2) $P = 0, Q = 0$ (3) $P = 0, Q = 1$ (4) $P = 1, Q = 0$
Correct Answer: (2)

Solution:



For the given digital circuit, follow the logic gates step by step. Using the inputs $P = 0$ and $Q = 1$, we compute the outputs as follows:
- The AND gate gives 0 - The NOT gate inverts the inputs appropriately.
Hence, the correct output for the given circuit is:

$$P = 0, Q = 0$$

Quick Tip

When analyzing logic circuits, work step by step through each gate (AND, OR, NOT) to determine the final outputs.

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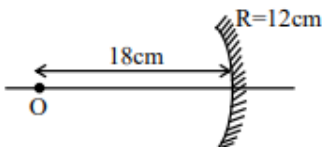
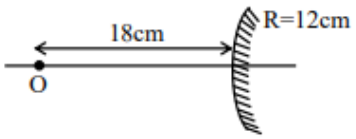
39. Two identical objects are placed in front of convex mirror and concave mirror having same radii of curvature of 12 cm, at same distance of 18 cm from the respective mirrors. The ratio of sizes of the images formed by convex mirror and by concave mirror is:
(1) $\frac{1}{2}$ (2) 2 (3) 3 (4) $\frac{1}{3}$
Correct Answer: (1)



Solution:



Using the magnification formula for mirrors:

$$m = \frac{f}{u - f}$$

For the concave mirror, the object distance is $u = -18\,\text{cm}$, and the focal length is $f = \frac{R}{2} = 6\,\text{cm}$, where $R = 12\,\text{cm}$:

$$m_1 = \frac{6}{18 - 6} = \frac{1}{2}$$

For the convex mirror, the object distance is the same, and the focal length is positive:

$$m_2 = \frac{6}{18 + 6} = \frac{1}{4}$$

Hence, the ratio of the sizes of the images formed by the convex mirror and the concave mirror is:

$$\frac{m_2}{m_1} = \frac{1/4}{1/2} = \frac{1}{2}$$

Thus, the correct answer is:

$$\boxed{\frac{1}{2}}$$

Quick Tip

Remember, the magnification formula for mirrors relates the image size to the object distance and the focal length. For concave mirrors, the object distance is negative, while for convex mirrors it is positive.

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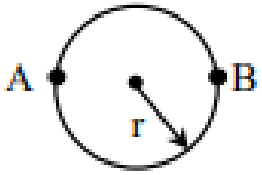
40. A sportsman runs around a circular track of radius r such that he traverses the path ABAB. The distance travelled and displacement, respectively, are:



(1) $2r, 3\pi r$ (2) $3\pi r, \pi r$ (3) $\pi r, 3r$ (4) $3\pi r, 2r$

Correct Answer: (4)

Solution:

Displacement is the straight-line distance from the initial point to the final point. Since the sportsman runs around the circular track and ends up at the same position (A), the displacement is the straight-line distance through the circle's center. Therefore:

$$\text{Displacement} = 2r$$

The distance travelled is the total path length covered by the sportsman, which consists of two complete laps around the circular track. Thus, the total distance is:

$$\text{Distance} = 2\pi r + \pi r = 3\pi r$$

Thus, the correct answer is:

$$\boxed{3\pi r, 2r}$$

Quick Tip

When dealing with circular motion, remember that the displacement is the straight-line distance from start to end, and the distance is the total path length travelled.

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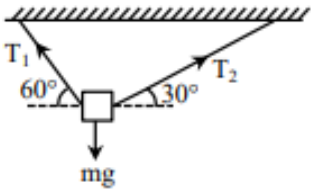
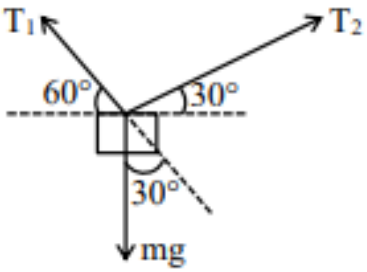
41. A body of mass 1kg is suspended with the help of two strings making angles as shown in the figure. Magnitude of tensions T_1 and T_2, respectively, are (in N):
(1) 5, $5\sqrt{3}$ (2) $5\sqrt{3}$, 5 (3) $5\sqrt{3}$, $5\sqrt{3}$ (4) 5, 5



Correct Answer: (2)

Solution:



Given that the body is in equilibrium, we can resolve the forces in the vertical and horizontal directions. The weight of the body is $mg = 1 \times 9.8 = 9.8\,\text{N}$.
For the vertical direction:

$$T_1 \sin 30^\circ + T_2 \sin 30^\circ = mg$$

For the horizontal direction:

$$T_1 \cos 30^\circ = T_2 \cos 30^\circ$$

Thus:

$$T_1 = T_2$$

Now, solving for the tensions using the vertical direction equation:

$$T_1 \sin 30^\circ + T_1 \sin 30^\circ = 9.8\,\text{N}$$

$$2T_1 \sin 30^\circ = 9.8$$

$$2T_1 \times \frac{1}{2} = 9.8$$

$$T_1 = 5\,\text{N},\ T_2 = 5\sqrt{3}\,\text{N}$$

Thus, the correct answer is:

$$\boxed{T_1 = 5\,\text{N},\ T_2 = 5\sqrt{3}\,\text{N}}$$

Quick Tip

When dealing with problems of forces in equilibrium, remember to resolve the forces into vertical and horizontal components and apply the equilibrium conditions.

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42. A bi-convex lens has radius of curvature of both the surfaces same as $\frac{1}{6}$ cm. If this lens is required to be replaced by another convex lens having different radii of curvatures on both sides ($R_1 \neq R_2$), without any change in lens power then possible combination of R_1 and R_2 is:
(1) $\frac{1}{3}$ cm and $\frac{1}{3}$ cm (2) $\frac{1}{5}$ cm and $\frac{1}{7}$ cm
(3) $\frac{1}{3}$ cm and $\frac{1}{7}$ cm (4) $\frac{1}{6}$ cm and $\frac{1}{9}$ cm
Correct Answer: (2)

Solution:

This will happen when

$$\frac{1}{f_1} = \frac{1}{f_2}$$

$$(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (\mu - 1)\left(\frac{2}{R}\right)$$

$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{2}{R}$$

Thus, the possible combination for R_1 and R_2 is $\frac{1}{5}$ cm and $\frac{1}{7}$ cm.

Quick Tip

When dealing with lens formulas, always ensure that the radii of curvature for both sides of the lens match the conditions for the required lens power.

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43. If μ_0 and ϵ_0 are the permeability and permittivity of free space, respectively, then the dimension of $\left(\frac{1}{\mu_0\epsilon_0}\right)$ is :
(1) LT^2 (2) L^2T^2
(3) T^2/L (4) T^2/L^2
Correct Answer: (2)

Solution:

Using the formula,

$$C = \frac{1}{\sqrt{\mu_0\epsilon_0}} \Rightarrow 1 = C^2 = LT^{-2}$$

Thus, the dimension of $\frac{1}{\mu_0\epsilon_0}$ is L^2T^2.

Quick Tip

The dimensions of permeability and permittivity help determine the speed of light in a vacuum, and their relationship is key in electromagnetic theory.

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44. Match List-I with List-II: **List-I** **List-II**
(A) Heat capacity of body (I) $J\,kg^{-1}$
(B) Specific heat capacity of body (II) JK^{-1}
(C) Latent heat (III) $J\,kg^{-1}K^{-1}$
(D) Thermal conductivity (IV) $Jm^{-1}k^{-1}s^{-1}$

Choose the correct answer from the options given below: (1) (A)-(III), (B)-(I), (C)-(II), (D)-(IV)
(2) (A)-(I), (B)-(III), (C)-(II), (D)-(IV)
(3) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
(4) (A)-(I), (B)-(III), (C)-(I), (D)-(IV)

Correct Answer: (4)

Solution:

$$C' = \frac{\Delta Q}{\Delta T} = JK^{-1}$$

$$S = \frac{\Delta Q}{m\Delta T} = Jkg^{-1}K^{-1}$$

$$L = \frac{\Delta Q}{m} = Jkg^{-1}$$

$$\Delta Q = \frac{KA\Delta T}{L} \Rightarrow K = \frac{\Delta Q}{A\Delta T} = Jm^{-1}k^{-1}s^{-1}$$

Quick Tip

The formulae for heat capacity, specific heat, and thermal conductivity can be used to relate physical properties of substances.

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45. Consider a circular loop that is uniformly charged and has a radius $\sqrt{2}$. Find the position along the positive z-axis of the cartesian coordinate system where the electric field is maximum if the ring was assumed to be placed in the xy-plane at the origin:
(1) $\frac{a}{\sqrt{2}}$
(2) $\frac{a}{2}$
(3) a
(4) 0

Correct Answer: (3) a

Solution:

$$E = \frac{KQr}{(x^2 + R^2)^{3/2}}$$

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

$$x = \frac{R}{\sqrt{2}} = \sqrt{\frac{2a}{\sqrt{2}}} = a$$

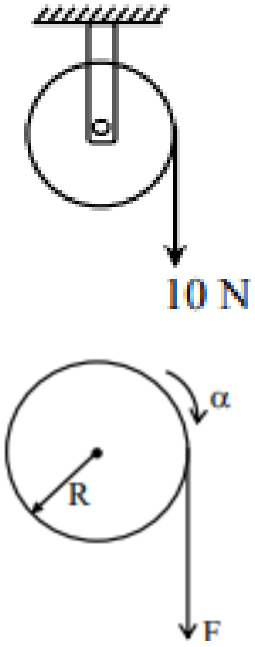
Thus, the value of x is a, which corresponds to option (3).

Quick Tip

For maximum electric field along the axis of a charged circular loop, set the derivative of the electric field with respect to x to zero.

SECTION-B

46. A wheel of radius 0.2 m rotates freely about its center when a string that is wrapped over its rim is pulled by a force of 10 N as shown in the figure. The established torque produces an angular acceleration of 2 rad/s^2. Moment of inertia of the wheel is..... kg m^2.
(1) 1 kg m^2
(2) 2 kg m^2
(3) 3 kg m^2
(4) 4 kg m^2



Correct Answer: (1) $1\,\text{kg}\,\text{m}^2$

Solution:

$$FR = I\alpha$$

$$\Rightarrow I = \frac{FR}{\alpha} = \frac{10 \times 0.2}{2} = 1\,\text{kg}\,\text{m}^2$$

Quick Tip

In problems involving rotational motion, torque and moment of inertia are related by the equation Torque $= I\alpha$, where I is the moment of inertia and α is the angular acceleration.

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47. The internal energy of air in $4\,\text{m} \times 4\,\text{m} \times 3\,\text{m}$ sized room at 1 atmospheric pressure will be $\_\_ \times 10^6$ J. (Consider air as a diatomic molecule)

Correct Answer: (12)

Solution:

To find the internal energy of gas in the room.

$$U = nC_vT = \frac{5}{2}RT$$

$$= \frac{5}{2} \times PV = \frac{5}{2} \times 10^5 \times 48 = 12 \times 10^6\,\text{J}$$

Quick Tip

For a diatomic molecule, the internal energy is calculated using the formula $U = \frac{5}{2}PV$, where P is pressure and V is volume.

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48. A ray of light suffers minimum deviation when incident on a prism having angle of the prism equal to 60°. The refractive index of the prism material is $\sqrt{2}$. The angle of incidence (in degrees) is _____ .

Correct Answer: (45)

Solution:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}, \text{ since } A = 60^\circ$$

$$\delta_m = 30^\circ$$

$$\delta_m = 2i - A \,[\text{as } i = e]$$

$$i = 45^\circ$$

Quick Tip

For minimum deviation, the angle of incidence is equal to the angle of emergence. The relationship between the refractive index and the minimum deviation is given by the formula $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$.

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49. The length of a light string is 1.4 m when the tension on it is 5 N. If the tension increases to 7 N, the length of the string is 1.56 m. The original length of the string is _____ m.

Correct Answer: (1)

Solution:

$$T = K(\ell - \ell_0)$$

$$\Rightarrow 5 = K(1.4 - \ell_0)$$

$$\Rightarrow 7 = K(1.56 - \ell_0)$$

$$\Rightarrow \frac{5}{1.4 - \ell_0} = \frac{7}{1.56 - \ell_0}$$

$$\ell_0 = 1\,\text{m}$$

Quick Tip

In problems related to the elongation of strings due to tension, the relationship between tension and elongation is often linear, and the constant of proportionality (spring constant) can be used to find the original length.

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50. A satellite of mass 1000 kg is launched to revolve around the earth in an orbit at a height of 270 km from the earth's surface. Kinetic energy of the satellite in this orbit is _____ x 10^{10} J.
(Mass of earth = 6×10^{24} kg, Radius of earth = 6.4×10^{6} m, Gravitational constant = 6.67×10^{-11} Nm^2 kg^{-2})

Correct Answer: (3)

Solution:

$$KE = \frac{1}{2}mv^2 = \frac{GMm}{2r}$$

$$KE = \frac{GMm}{2(r_e + h)}$$

$$KE = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1000 \times 6.4 \times 10^{6}}{2(6.4 \times 10^{6} + 2.7 \times 10^{5})}$$

$$KE = 3 \times 10^{10}\,\text{J}$$

Quick Tip

The formula for the kinetic energy of a satellite in orbit can be derived from the gravitational potential energy, where the radius includes both the radius of the Earth and the height of the satellite above the surface.
