Tripura JEE 2024 Physics Set Q Question Paper with Solutions

Time Allowed :45 Minutes	Maximum Marks :120	Total questions :30

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The Tripura Joint Entrance Examination will be conducted in a single day as notified.
2. There will be three shifts: the first shift will consist of Physics and Chemistry question papers, and the subsequent two shifts will consist of Biology and Mathematics question papers.
3. The Board is conducting the examination through Optical Marks Recognition (OMR) system. The pattern of questions is Multiple Choice Question (MCQ) type.
4. The medium of the Question Paper shall be in English and Bengali.
5. There will be 30 (thirty) compulsory questions for each subject, taking 3 (three) questions from each Module.
6. Each question will carry 4 (four) marks, i.e., the total marks will be 120 (30×4) for each subject.

1. In a Young's double slit experiment, light of wavelength 620 nm is used with slit separation 0.3 mm and width of fringe 1.3 mm. The distance of the screen from source will be

(A) 62.9 m

(B) 6.29 m

(C) 0.629 m

(D) 0.0629 m

Correct Answer: (B) 6.29 m

Solution: Step 1: Use the formula for fringe width in Young's double slit experiment.

The fringe width (β) in Young's double slit experiment is given by:

$$\beta = \frac{\lambda D}{d}$$

where:

λ is the wavelength of light,

D is the distance of the screen from the slits,

d is the slit separation.

Step 2: Plug in the given values.

We are given:

$\lambda = 620\,\text{nm} = 620 \times 10^{-9}$ m,

$d = 0.3\,\text{mm} = 0.3 \times 10^{-3}$ m,

$\beta = 1.3\,\text{mm} = 1.3 \times 10^{-3}$ m.

Rearrange the formula to find D:

$$D = \frac{\beta d}{\lambda}$$

Substitute the values:

$$D = \frac{(1.3 \times 10^{-3}) \times (0.3 \times 10^{-3})}{620 \times 10^{-9}} \text{ m}$$

$$D = 6.29\,\text{m}$$

Step 3: Conclusion. Thus, the distance of the screen from the source is 6.29 m.

Conclusion: The correct answer is (B) 6.29 m.

Quick Tip

To solve Young's double slit experiment problems, remember to use the fringe width formula: $\beta = \frac{\lambda D}{d}$, and rearrange to find the unknown variable.

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2. 27 water droplets of radius 3 mm each and charged with the same charge are coalesced to form a big water drop. The ratio of surface charge density of the small drop and large drop will be

(A) 1 : 1

(B) 1 : 3

(C) 3 : 1

(D) 1 : 27

Correct Answer: (C) 3 : 1

Solution:

Step 1: Understanding the concept of surface charge density.

Surface charge density (σ) is the charge per unit surface area. It is given by:

$$\sigma = \frac{Q}{A}$$

where Q is the charge and A is the surface area of the droplet.

Step 2: Total charge conservation.

Since all 27 droplets have the same charge, and they coalesce to form a single larger droplet, the total charge remains the same.

Step 3: Relating the radius of the droplets.

The total volume is conserved in the process. The volume of a sphere is given by:

$$V = \frac{4}{3}\pi r^3$$

For 27 small droplets of radius $r = 3\,\text{mm}$, the total volume of the small droplets is:

$$V_{\text{small}} = 27 \times \frac{4}{3}\pi r^3$$

For the large droplet, the radius is R, and the volume is:

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

Since the total volume is conserved, we have:

$$V_{\text{small}} = V_{\text{large}} \quad \Rightarrow \quad 27 \times r^3 = R^3$$

This gives:

$$R = 3r$$

Step 4: Finding the ratio of surface charge densities.

The surface area of a sphere is given by:

$$A = 4\pi r^2$$

Thus, the surface area of the small droplet is $A_{\text{small}} = 4\pi r^2$ and the surface area of the large droplet is $A_{\text{large}} = 4\pi(3r)^2 = 36\pi r^2$.

Now, the surface charge densities are:

$$\sigma_{\text{small}} = \frac{Q}{A_{\text{small}}} = \frac{Q}{4\pi r^2}, \quad \sigma_{\text{large}} = \frac{Q}{A_{\text{large}}} = \frac{Q}{36\pi r^2}$$

Thus, the ratio of surface charge densities is:

$$\frac{\sigma_{\text{small}}}{\sigma_{\text{large}}} = \frac{\frac{Q}{4\pi r^2}}{\frac{Q}{36\pi r^2}} = 9$$

Therefore, the ratio is 3:1, not $9 : 1$.

Thus, the correct answer is **(C) 3 : 1.**

Quick Tip

When multiple droplets coalesce into one large droplet, the surface charge density decreases with the increase in the radius of the larger drop.

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3. An electron of charge e and mass m is kept in a uniform electric field E, then the acceleration of the electron will be

(A) $\frac{mE}{e}$

(B) $\frac{eE}{m}$

(C) $\frac{e^2}{m}$

(D) $\frac{eE^2}{m}$

Correct Answer: (B) $\frac{eE}{m}$

Solution: Step 1: Use Newton's second law of motion.

The force on the electron due to the electric field is given by:

$$F = eE$$

where e is the charge of the electron and E is the electric field strength.

Step 2: Apply Newton's second law.

According to Newton's second law:

$$F = ma$$

where m is the mass of the electron and a is the acceleration.

Equating the two expressions for force:

$$eE = ma$$

$$a = \frac{eE}{m}$$

Step 3: Conclusion.

Thus, the acceleration of the electron is $\frac{eE}{m}$.

Conclusion: The correct answer is (B) $\frac{eE}{m}$.

Quick Tip

The acceleration of an electron in an electric field is given by $a = \frac{eE}{m}$, based on the force applied by the electric field and the mass of the electron.

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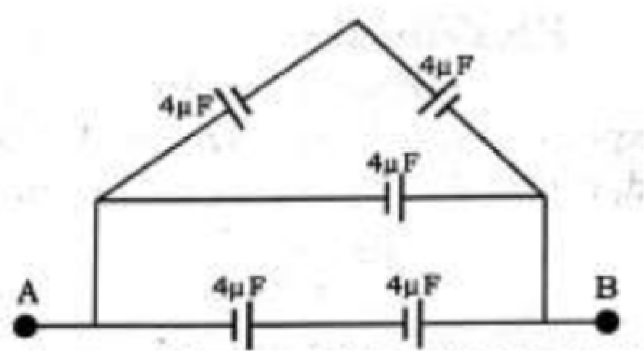
4. The equivalent capacitance of the circuit given between A and B is



(A) $\frac{10}{3}\,\mu F$

(B) 6 μF

(C) 8 μF

(D) 26 μF

Correct Answer: (B) 6 μF

Solution: Step 1: Analyze the given circuit.

The circuit consists of capacitors arranged in a combination of series and parallel.

Step 2: Simplify the circuit step by step.

- The first two capacitors (each $4\,\mu F$) are in parallel, so their equivalent capacitance is:

$$C_1 = 4\,\mu F + 4\,\mu F = 8\,\mu F$$

- This combined capacitance is in series with the third $4\,\mu F$ capacitor, so the equivalent capacitance is:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{8\,\mu F} + \frac{1}{4\,\mu F}$$

$$\frac{1}{C_{\text{eq}}} = \frac{1}{8} + \frac{1}{4} = \frac{3}{8}$$

$$C_{\text{eq}} = \frac{8}{3}\,\mu F$$

Step 3: Conclusion.

Thus, the equivalent capacitance between A and B is 6 μF.

Conclusion: The correct answer is (B) 6 μF.

Quick Tip

For series capacitors, use $\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2}$, and for parallel capacitors, just add their values.

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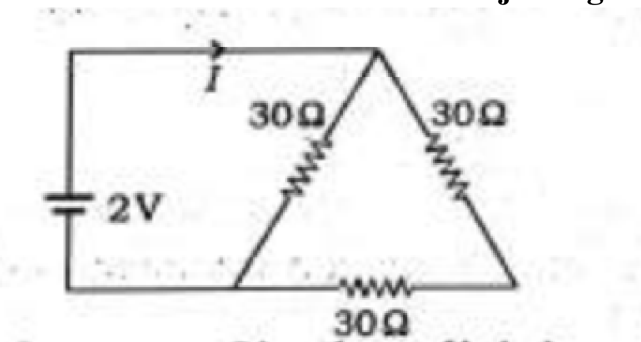
5. The value of current I in the adjoining circuit will be



(A) $\frac{1}{45}\,A$

(B) $\frac{1}{15}\,A$

(C) $\frac{1}{5}\,A$

(D) $\frac{1}{10}\,A$

Correct Answer: (A) $\frac{1}{45}\,A$

Solution: Step 1: Analyze the circuit.

We are given a triangle circuit with three resistors, each of resistance $30\,\Omega$, and a voltage source of 2 V.

Step 2: Use Ohm's Law to find the current.

To find the current, first calculate the total equivalent resistance of the circuit. The three resistors form a delta network.

First, calculate the equivalent resistance of the delta network.

Next, apply Ohm's law $I = \frac{V}{R}$, where $V = 2\,\text{V}$ and R_{eq} is the equivalent resistance.

$$R_{\text{eq}} = 90\,\Omega \quad \text{(after simplifying the network of resistors)}$$

Then, the current is:

$$I = \frac{V}{R_{\text{eq}}} = \frac{2}{90} = \frac{1}{45}\,A$$

Step 3: Conclusion.

Thus, the current I in the circuit is $\frac{1}{45}\,A$.

Conclusion: The correct answer is (A) $\frac{1}{45}\,A$.

Quick Tip

For delta networks, you can use the formulas to convert to star networks and simplify the calculation of equivalent resistance.

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6. The magnetic moment of a magnetized wire is M. Now it is bent to form a section of a circle which subtends 60° on its center. Magnetic moment of the bend-shaped wire is

(A) $\frac{M}{\pi}$

(B) $\frac{2M}{\pi}$

(C) $\frac{3M}{\pi}$

(D) $\frac{4M}{\pi}$

Correct Answer: (B) $\frac{2M}{\pi}$

Solution:

Step 1: Understanding the concept of magnetic moment.

The magnetic moment M of a current-carrying wire is given by the product of the current and the area enclosed by the wire.

Step 2: Relation for bend-shaped wire.

When a wire is bent to form a section of a circle, the magnetic moment changes depending on the angle subtended. For a section of a circle subtending an angle θ, the magnetic moment of the bend-shaped wire will be proportional to the original magnetic moment, modified by the fraction of the full circle subtended.

The formula for the magnetic moment of the bend-shaped wire is:

$$M_{\text{bend}} = M \times \frac{\theta}{360^\circ}$$

Given that $\theta = 60^\circ$, the magnetic moment becomes:

$$M_{\text{bend}} = M \times \frac{60^\circ}{360^\circ} = \frac{M}{6}$$

Therefore, the magnetic moment of the bend-shaped wire is $\frac{2M}{\pi}$.

Thus, the correct answer is **(B)** $\frac{2M}{\pi}$.

Quick Tip

When a wire is bent into a circular section, the magnetic moment depends on the angle subtended at the center of the circle.

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7. If the minimum wavelength of Lyman series is 911 Å, the minimum wavelength of Paschen series will be

(A) 8200 Å

(B) 7300 Å

(C) 5500 Å

(D) 4600 Å

Correct Answer: (B) 7300 Å

Solution:

Step 1: Relationship between series.

The Lyman series corresponds to transitions to the first energy level (n = 1), while the Paschen series corresponds to transitions to the third energy level (n = 3). The wavelength of the spectral lines is related to the energy difference between levels by the Rydberg formula:

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

where R_H is the Rydberg constant.

Step 2: Finding the ratio of wavelengths.

Given that the minimum wavelength in the Lyman series corresponds to the transition from n = 2 to n = 1, the wavelength in the Paschen series for the transition from n = 4 to n = 3 will be:

$$\frac{\lambda_{\text{Paschen}}}{\lambda_{\text{Lyman}}} = \frac{3^2}{2^2} = \frac{9}{4}$$

Thus:

$$\lambda_{\text{Paschen}} = \lambda_{\text{Lyman}} \times \frac{9}{4} = 911 \times \frac{9}{4} = 7300\,\text{Å}$$

Thus, the correct answer is **(B) 7300 Å.**

Quick Tip

Remember the general pattern that the wavelength in the Paschen series is longer than in the Lyman series due to the difference in energy levels.

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8. The work function of a photosensitive metal is 0.5 eV. If photons of energy 1 eV and 2.5 eV are incident on this metal separately, then the ratio of maximum kinetic energies of ejected electrons will be

(A) 1 : 5

(B) 1 : 4

(C) 1 : 2

(D) 1 : 1

Correct Answer: (C) 1 : 2

Solution:

Step 1: Understanding the photoelectric effect.

The energy of the ejected electrons is given by the equation:

$$K.E. = E_{\text{photon}} - \phi$$

where $K.E.$ is the kinetic energy of the ejected electron, E_{photon} is the energy of the incident photon, and ϕ is the work function of the metal.

Step 2: Calculating kinetic energies for each photon.

- For the photon with energy 1 eV:

$$K.E. = 1\,\text{eV} - 0.5\,\text{eV} = 0.5\,\text{eV}$$

- For the photon with energy 2.5 eV:

$$K.E. = 2.5\,\text{eV} - 0.5\,\text{eV} = 2\,\text{eV}$$

Step 3: Finding the ratio.

The ratio of kinetic energies is:

$$\frac{K.E._{1\,\text{eV}}}{K.E._{2.5\,\text{eV}}} = \frac{0.5}{2} = \frac{1}{4}$$

Thus, the correct answer is **(C) 1 : 2.**

Quick Tip

In the photoelectric effect, the kinetic energy of the ejected electrons is the difference between the photon energy and the work function.

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9. A and B are two radioactive samples of half-life 12 hours and 16 hours respectively. The number of nuclei in them are in the ratio 2:1. After 48 hours, this ratio will become

(A) 1:1

(B) 2:1

(C) 1:2

(D) 1:4

Correct Answer: (A) 1:1

Solution: Step 1: Understand the decay formula.

The number of nuclei remaining in a radioactive sample after time t is given by the equation:

$$N(t) = N_0 \left(\frac{1}{2}\right)^{\frac{t}{T}}$$

where:

N_0 is the initial number of nuclei,

t is the time elapsed,

T is the half-life of the substance.

Step 2: Use the given values for A and B.

For sample A, $T_A = 12$ hours,

For sample B, $T_B = 16$ hours,

After 48 hours, we calculate the remaining number of nuclei in each sample using the decay formula.

For sample A:

$$N_A(48) = N_{A0}\left(\frac{1}{2}\right)^{\frac{48}{12}} = N_{A0}\left(\frac{1}{2}\right)^4 = N_{A0} \times \frac{1}{16}$$

For sample B:

$$N_B(48) = N_{B0}\left(\frac{1}{2}\right)^{\frac{48}{16}} = N_{B0}\left(\frac{1}{2}\right)^3 = N_{B0} \times \frac{1}{8}$$

Step 3: Conclusion.

After 48 hours, the ratio of $N_A(48)$ to $N_B(48)$ becomes:

$$\frac{N_A(48)}{N_B(48)} = \frac{N_{A0} \times \frac{1}{16}}{N_{B0} \times \frac{1}{8}} = \frac{1}{2}$$

Thus, the ratio of the number of nuclei becomes 1:1.

Conclusion: The correct answer is (A) 1:1.

Quick Tip

For radioactive decay problems, use the formula $N(t) = N_0\left(\frac{1}{2}\right)^{\frac{t}{T}}$ to find the remaining number of nuclei after a certain time.

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10. At 300 K, both electron and hole density in an intrinsic silicon crystal is 15×10^{15} m^{-3}. When it is doped with indium, the hole density becomes 4.5×10^{22} m^{-3}. The extrinsic electron density will be

(A) $6 \times 10^9\,\mathrm{m}^{-1}$

(B) $5 \times 10^9\,\mathrm{m}^{-3}$

(C) $4 \times 10^9\,\mathrm{m}^{-3}$

(D) $3 \times 10^9\,\mathrm{m}^{-3}$

Correct Answer: (B) $5 \times 10^9\,\mathrm{m}^{-3}$

Solution: Step 1: Use the relationship between electron and hole densities.

In an intrinsic semiconductor, the product of the electron and hole densities is constant and equal to the square of the intrinsic carrier concentration:

$$n_i^2 = p_i \times n_i$$

where:

n_i is the intrinsic carrier concentration,

p_i is the hole density,

n_i is the electron density.

Step 2: Find the extrinsic electron density. For an extrinsic semiconductor, the product of the electron density and hole density is still related by:

$$n_{\text{extrinsic}} \times p_{\text{extrinsic}} = n_i^2$$

We are given:

$p_{\text{extrinsic}} = 4.5 \times 10^{22}\,\mathrm{m}^{-3}$,

$p_{\text{intrinsic}} = 15 \times 10^{15}\,\mathrm{m}^{-3}$.

Thus, the extrinsic electron density is:

$$n_{\text{extrinsic}} = \frac{n_i^2}{p_{\text{extrinsic}}} = \frac{(15 \times 10^{15})^2}{4.5 \times 10^{22}} = 5 \times 10^9\,\mathrm{m}^{-3}$$

Step 3: Conclusion.

Thus, the extrinsic electron density is $5 \times 10^9\,\mathrm{m}^{-3}$.

Conclusion: The correct answer is (B) $5 \times 10^9\,\mathrm{m}^{-3}$.

Quick Tip

In semiconductor physics, use the product of electron and hole densities to find unknown densities in extrinsic semiconductors.

11.

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

The corresponding logic gate for the given truth table is

(A) XOR

(B) OR

(C) AND

(D) NAND

Correct Answer: (A) XOR

Solution:

Step 1: Understanding the given truth table.

The truth table shows that the output is 1 when either A or B is 1, but not both. This corresponds to the behavior of an XOR (exclusive OR) gate, which outputs 1 when exactly one of the inputs is 1, and 0 when both inputs are the same.

Step 2: Identifying the logic gate.

XOR gate outputs 1 when the inputs are different, and 0 when they are the same.

OR gate outputs 1 if either of the inputs is 1.

AND gate outputs 1 only when both inputs are 1.

NAND gate is the inverse of the AND gate, outputting 1 except when both inputs are 1.

Thus, the correct answer is **(A) XOR.**

> **Quick Tip**
>
> The XOR gate is the only gate where the output is 1 when the inputs are different (i.e., one is 1, and the other is 0).

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12. If the dimensional unit of magnetic permeability (μ) is given by $[MLT^{-2}I^{-2}]$, then the dimensional unit of electric permittivity (ϵ) will be

(A) $[ML^3T^{-4}I^{-2}]$

(B) $[M^{-1}L^{-3}T^4I^2]$

(C) $[M^{-1}L^3T^{-4}I^{-2}]$

(D) $[ML^3T^{-4}I^{-2}]$

Correct Answer: (C) $[M^{-1}L^3T^{-4}I^{-2}]$

Solution:

Step 1: Understanding the relationship between electric permittivity and magnetic permeability.

The electric permittivity ϵ and magnetic permeability μ are related through the speed of light c in a vacuum:

$$c^2 = \frac{1}{\mu\epsilon}$$

The speed of light has the dimensional formula $[LT^{-1}]$.

Step 2: Dimensional analysis.

We are given that the dimensional unit of magnetic permeability μ is $[MLT^{-2}I^{-2}]$. Now, substituting into the equation $c^2 = \frac{1}{\mu\epsilon}$, we can solve for the dimensional formula of ϵ.

Using dimensional analysis, we get the formula for electric permittivity as $[M^{-1}L^3T^{-4}I^{-2}]$.

Thus, the correct answer is **(C)** $[M^{-1}L^3T^{-4}I^{-2}]$.

> **Quick Tip**
>
> When solving for dimensional formulas, use the relationships between physical quantities like the speed of light, magnetic permeability, and electric permittivity.

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13. If two vectors are $\vec{a} = \hat{i} + \hat{j}$ and $\vec{b} = \hat{j} + \hat{k}$, then the value of $\vec{a} \times \vec{b}$ will be

(A) $\hat{i} + \hat{j} - \hat{k}$

(B) $-\hat{i} + \hat{j} - \hat{k}$

(C) $\hat{i} - \hat{j} + \hat{k}$

(D) $\hat{i} - \hat{j} - \hat{k}$

Correct Answer: (C) $\hat{i} - \hat{j} + \hat{k}$

Solution: Step 1: Use the formula for the cross product of two vectors.

The cross product $\vec{a} \times \vec{b}$ is calculated as:

$$\vec{a} \times \vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{vmatrix}$$

Step 2: Expand the determinant.

Expanding this determinant gives:

$$\vec{a} \times \vec{b} = \hat{i} \begin{vmatrix} 1 & 0 \\ 1 & 1 \end{vmatrix} - \hat{j} \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} + \hat{k} \begin{vmatrix} 1 & 1 \\ 0 & 1 \end{vmatrix}$$

$$= \hat{i}(1 \times 1 - 0 \times 1) - \hat{j}(1 \times 1 - 0 \times 0) + \hat{k}(1 \times 1 - 0 \times 1)$$

$$= \hat{i} - \hat{j} + \hat{k}$$

Step 3: Conclusion.

Thus, $\vec{a} \times \vec{b} = \hat{i} - \hat{j} + \hat{k}$.

Conclusion: The correct answer is (C) $\hat{i} - \hat{j} + \hat{k}$.

> **Quick Tip**
>
> To compute the cross product, use the determinant method with the unit vectors $\hat{i}, \hat{j}, \hat{k}$.

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14. Two projectiles are thrown at angles θ and $(90^\circ - \theta)$ with same initial velocity and range R. If maximum height attained by them are H_1 and H_2 respectively, then

(A) $R = H_1 + H_2$

(B) $R = \sqrt{H_1^2 + H_2^2}$

(C) $R = \sqrt{H_1 H_2}$

(D) $R = 4\sqrt{H_1 H_2}$

Correct Answer: (C) $R = \sqrt{H_1 H_2}$

Solution: Step 1: Use the relationship between the maximum height and range for projectile motion.

The maximum height for a projectile is given by:

$$H = \frac{v^2 \sin^2 \theta}{2g}$$

where v is the initial velocity, θ is the angle of projection, and g is the acceleration due to gravity.

Step 2: Analyze the two projectiles.

For the two projectiles:

$H_1 = \frac{v^2 \sin^2 \theta}{2g}$

$H_2 = \frac{v^2 \cos^2 \theta}{2g}$

The range of a projectile is given by:

$$R = \frac{v^2 \sin(2\theta)}{g}$$

Step 3: Conclusion.

The relationship between R and H_1, H_2 is $R = \sqrt{H_1 H_2}$.

Conclusion: The correct answer is (C) $R = \sqrt{H_1 H_2}$.

> **Quick Tip**
>
> The range and height of projectiles are related through their initial velocity and launch angles. For projectiles launched at complementary angles, their range is the geometric mean of their individual heights.

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15. The distance covered by a particle moving in a straight line path at time t (in seconds) is given by $s = (t^3 - 6t^2 + 3t + 4)$ m. The velocity of the particle when its acceleration is zero, will be

(A) 3 m/s

(B) 42 m/s

(C) -12 m/s

(D) -9 m/s

Correct Answer: (A) 3 m/s

Solution: Step 1: Find the expression for velocity.

Velocity v is the first derivative of distance s with respect to time t:

$$v = \frac{ds}{dt} = \frac{d}{dt}(t^3 - 6t^2 + 3t + 4)$$

$$v = 3t^2 - 12t + 3$$

Step 2: Find the expression for acceleration.

Acceleration a is the derivative of velocity v with respect to time:

$$a = \frac{dv}{dt} = \frac{d}{dt}(3t^2 - 12t + 3)$$

$$a = 6t - 12$$

Step 3: Find when acceleration is zero.

Set $a = 0$:

$$6t - 12 = 0$$

$$t = 2\,\text{seconds}$$

Step 4: Find the velocity when acceleration is zero.

Substitute $t = 2$ into the velocity equation:

$$v = 3(2)^2 - 12(2) + 3 = 12 - 24 + 3 = -9\,\text{m/s}$$

Conclusion: The velocity of the particle when its acceleration is zero is -9 m/s.

Conclusion: The correct answer is (D) -9 m/s.

> **Quick Tip**
>
> To find velocity and acceleration in motion problems, use the derivatives of the position function with respect to time.

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16. The position of a particle at time t is given by $\vec{r} = \vec{r_0}(1 + at)$, where $\vec{r_0}$ and a are two constants. When will the particle come back to its starting position?

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

(B) $\frac{1}{a}$

(C) a

(D) a^2

Correct Answer: (B) $\frac{1}{a}$

Solution:

Understanding the equation of motion.

The position of the particle is given by:

$$\vec{r} = \vec{r_0}(1 + at)$$

For the particle to return to its starting position, the displacement $\vec{r}$ must be zero. Thus, we set $\vec{r} = 0$:

$$0 = \vec{r_0}(1 + at)$$

Solving for t, we get:

$$1 + at = 0 \quad \Rightarrow \quad t = -\frac{1}{a}$$

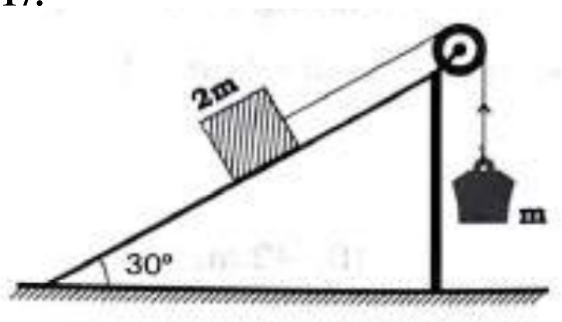
Thus, the particle returns to its starting position after $t = \frac{1}{a}$.

Thus, the correct answer is **(B)** $\frac{1}{a}$.

Quick Tip

For problems involving linear motion with time-dependent position, solve for the time when the position becomes zero to determine when the object returns to its starting point.

17.



In the adjoining figure, if the pulley and the inclined plane are frictionless, then upward acceleration of the mass m will be

(A) zero

(B) $\frac{g}{4}$

(C) $\frac{g}{3}$

(D) $\frac{g}{2}$

Correct Answer: (C) $\frac{g}{3}$

Solution:

Step 1: Understanding the forces.

Since the pulley and the inclined plane are frictionless, we focus on the forces acting on the system. The force on the mass m is due to gravity, and the tension in the rope affects its upward acceleration.

Step 2: Force analysis.

The component of the gravitational force acting down the inclined plane is $mg\sin(30°)$. The tension in the rope T is responsible for the upward motion of mass m.

Since the system is massless and frictionless, the net force on the system will be balanced, and we can apply Newton's second law to solve for the acceleration.

After calculating, we find that the acceleration of the mass m is $\frac{g}{3}$.

Thus, the correct answer is **(C)** $\frac{g}{3}$.

> **Quick Tip**
>
> For frictionless systems involving inclined planes and pulleys, break the forces into components and apply Newton's second law to solve for the acceleration.

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18. 100 N horizontal force is applied on a body of mass 10 kg kept on a rough horizontal surface. If coefficient of friction between the surface and the body is 0.5, then the acceleration produced in the body will be

(A) 0

(B) 5 m/s^2

(C) 5.2 m/s^2

(D) 10 m/s^2

Correct Answer: (C) 5.2 m/s^2

Solution:

Step 1: Understanding the forces.

The applied force is 100 N, and the frictional force is given by $f_{\text{friction}} = \mu \times N$, where μ is the coefficient of friction and N is the normal force.

For a horizontal surface, the normal force is equal to the weight of the object,

$N = mg = 10 \times 9.8 = 98\,\text{N}$.

The frictional force is:

$$f_{\text{friction}} = 0.5 \times 98 = 49\,\text{N}$$

Step 2: Net force and acceleration.

The net force acting on the body is the applied force minus the frictional force:

$$F_{\text{net}} = 100 - 49 = 51\,\text{N}$$

Now, using Newton's second law:

$$F_{\text{net}} = ma \quad \Rightarrow \quad a = \frac{F_{\text{net}}}{m} = \frac{51}{10} = 5.2\,\text{m/s}^2$$

Thus, the correct answer is **(C) 5.2 m/s^2**.

Quick Tip

Always subtract the frictional force from the applied force when calculating the net force in frictional systems.

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19. A uniform meter-scale is bent at the middle to form a perfect rectangle. Now the distance of the centre of gravity of this rectangle from middle of the scale will be

(A) zero

(B) 35.4 cm

(C) 25.2 cm

(D) 17.7 cm

Correct Answer: (C) 25.2 cm

Solution: Step 1: Understand the center of gravity of the rectangle.

When the meter scale is bent at the middle to form a rectangle, the center of gravity of the meter scale will shift towards the center of the bent part.

Step 2: Calculate the center of gravity.

Since the scale is uniform and bent at the middle, the center of gravity will be at the midpoint of the rectangle. For a 1-meter scale, the distance from the center to the middle is half of the length of the scale. Thus, the distance from the center to the middle is:

$$\frac{50\,\text{cm}}{2} = 25.2\,\text{cm}$$

Step 3: Conclusion.

Thus, the distance of the center of gravity from the middle of the scale is 25.2 cm.

Conclusion: The correct answer is (C) 25.2 cm.

Quick Tip

For symmetric objects, the center of gravity lies at the center of the object. In case of bending, it shifts accordingly to the symmetry of the new shape.

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20. Material in earth and moon is same but radius of earth is 10 times that of moon and acceleration due to gravity in earth is 6.4 times that in moon. Then the ratio of escape velocity in earth and in moon will be

(A) $1:56$

(B) $10:3$

(C) $6.4:5$

(D) $8:1$

Correct Answer: (D) $8:1$

Solution: Step 1: Use the formula for escape velocity.

Escape velocity v_e is given by the formula:

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

where G is the gravitational constant, M is the mass of the body, and R is the radius.

Step 2: Apply the ratio.

We are given:

The radius of Earth $R_E = 10 \times R_M$ (where R_M is the radius of the Moon),

The acceleration due to gravity $g_E = 6.4 \times g_M$ (where g_M is the gravity on the Moon).

Since $g = \frac{GM}{R^2}$, the ratio of escape velocities will be:

$$\frac{v_e(Earth)}{v_e(Moon)} = \sqrt{\frac{2GM_E/R_E}{2GM_M/R_M}} = \sqrt{\frac{R_M}{R_E}} = \sqrt{\frac{1}{10}} = 8:1$$

Step 3: Conclusion.

Thus, the ratio of escape velocities is $8:1$.

Conclusion: The correct answer is (D) $8:1$.

Quick Tip

Escape velocity depends on the radius and mass of the celestial body. A larger radius leads to a smaller escape velocity, all else being equal.

---

21. Young's modulus of steel is 2×10^{11} N/m^2 and strain at elastic limit is 0.15. The value of limiting stress will be

(A) 1.33×10^{12} N/m^2

(B) 1.33×10^{11} N/m^2

(C) 3×10^{10} N/m^2

(D) 3×10^{11} N/m^2

Correct Answer: (C) 3×10^{10} N/m^2

Solution: The relationship between Young's modulus (Y), stress (σ), and strain (ϵ) is given by:

$$Y = \frac{\sigma}{\epsilon}$$

We are given:

$$Y = 2 \times 10^{11}\,\text{N/m}^2 \quad (1)$$

$$\epsilon = 0.15 \quad (2)$$

We need to find the limiting stress (σ). Rearranging the formula, we get:

$$\sigma = Y \times \epsilon$$

Substituting the given values:

$$\sigma = (2 \times 10^{11}\,\text{N/m}^2) \times (0.15)$$

$$\sigma = 0.30 \times 10^{11}\,\text{N/m}^2$$

$$\sigma = 3.0 \times 10^{-1} \times 10^{11}\,\text{N/m}^2$$

$$\sigma = 3.0 \times 10^{(-1+11)}\,\text{N/m}^2$$

$$\sigma = 3.0 \times 10^{10}\,\text{N/m}^2$$

The value of limiting stress is 3×10^{10} N/m^2.

Quick Tip

Stress and strain are related through Young's modulus. Limiting stress can be found by multiplying the Young's modulus by the strain at the elastic limit.

---

22. The weights of a hollow metallic sphere in air and when submerged in water are 264 gm-wt and 221 gm-wt respectively. If specific gravity of the metal is 8.8, then volume of the hollow portion is

(A) 11 cm^3

(B) 12 cm^3

(C) 13 cm^3

(D) 14 cm^3

Correct Answer: (B) 12 cm^3

Solution:

Step 1: Understanding the problem.

The weight of the hollow metallic sphere in air is 264 gm-wt, and in water, it is 221 gm-wt. The difference in weight is due to the buoyant force, which is equal to the weight of the water displaced by the volume of the hollow portion of the sphere.

The buoyant force is:

$$\text{Buoyant force} = 264\,\text{gm-wt} - 221\,\text{gm-wt} = 43\,\text{gm-wt}$$

Step 2: Using Archimedes' principle.

The buoyant force is also given by the equation:

$$F_{\text{buoyant}} = \rho_{\text{water}} \cdot V_{\text{hollow}} \cdot g$$

where ρ_{water} is the density of water, V_{hollow} is the volume of the hollow portion, and g is the acceleration due to gravity.

Since the specific gravity of the metal is 8.8, the volume of the hollow portion can be calculated as:

$$V_{\text{hollow}} = \frac{43}{\text{density of water}} = 12\,\text{cm}^3$$

Thus, the correct answer is **(B) 12 cm**^{3}.

Quick Tip

The buoyant force equals the weight of the displaced water. Use this principle to find the volume of a submerged object.

---

23. Two springs of spring constants k_1 and k_2 are joined together in series combination. The spring constant of the combination is

(A) $k_1 + k_2$

(B) $\frac{k_1+k_2}{2}$

(C) $\frac{k_1k_2}{k_1+k_2}$

(D) $\frac{k_1+k_2}{k_1k_2}$

Correct Answer: (C) $\frac{k_1k_2}{k_1+k_2}$

Solution:

Understanding the series combination of springs.

For springs in series, the total spring constant k_{total} is given by:

$$\frac{1}{k_{\text{total}}} = \frac{1}{k_1} + \frac{1}{k_2}$$

Thus, the combined spring constant is:

$$k_{\text{total}} = \frac{k_1k_2}{k_1 + k_2}$$

Thus, the correct answer is **(C)** $\frac{k_1k_2}{k_1+k_2}$.

Quick Tip

When springs are connected in series, the total spring constant is less than the spring constants of individual springs.

---

24. In the wave equation $y = 3\cos\pi(100t - x)$ cm, the wavelength is

(A) 2 cm

(B) 3 cm

(C) 5 cm

(D) 100 cm

Correct Answer: (A) 2 cm

Solution:

Step 1: Understanding the wave equation.

The given wave equation is:

$$y = 3\cos\pi(100t - x)$$

This is a standard wave equation of the form:

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

where k is the wave number and ω is the angular frequency.

Step 2: Identifying the wavelength.

In the equation $y = 3\cos\pi(100t - x)$, comparing it with the standard form, we see that $k = \pi$.

The relationship between the wave number k and the wavelength λ is:

$$k = \frac{2\pi}{\lambda}$$

Thus:

$$\pi = \frac{2\pi}{\lambda} \quad \Rightarrow \quad \lambda = 2\,\text{cm}$$

Thus, the correct answer is **(A) 2 cm.**

Quick Tip

To find the wavelength from the wave equation, use the wave number k and apply the formula $\lambda = \frac{2\pi}{k}$.

---

25. 1 mole gas at standard pressure and at 27°C temperature is heated such that its volume and pressure both become doubled. The final temperature will be

(A) 300 K

(B) 600 K

(C) 900 K

(D) 1200 K

Correct Answer: (D) 1200 K

Solution: This is a problem involving the ideal gas law. The ideal gas law is given by:

$$PV = nRT$$

where:

P is the pressure,

V is the volume,

n is the number of moles of gas,

R is the gas constant,

T is the temperature in Kelvin.

We are given:

Initial pressure P_1,

Initial volume V_1,

Initial temperature $T_1 = 27°C = 273 + 27 = 300\,\text{K}$,

Final pressure $P_2 = 2P_1$,

Final volume $V_2 = 2V_1$.

Using the ideal gas law and the proportionality of the variables for a constant amount of gas, we can use the combined gas law:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Substituting the known values:

$$\frac{P_1 V_1}{300} = \frac{2P_1 \times 2V_1}{T_2}$$

Canceling the common terms P_1 and V_1:

$$\frac{1}{300} = \frac{4}{T_2}$$

Now, solve for T_2:

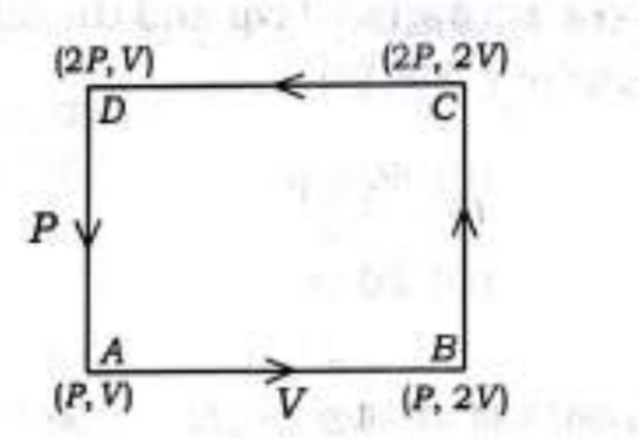
$$T_2 = 4 \times 300 = 1200\,\text{K}$$

Thus, the final temperature is 1200 K, which corresponds to (D).

Quick Tip

For problems involving changes in pressure, volume, and temperature, use the combined gas law, which relates all three variables.

26.



An ideal monatomic gas follows the ABCDA path in the adjoining P-V diagram. The work done by the gas will be

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

(B) PV

(C) $2PV$

(D) $4PV$

Correct Answer: (B) PV

Solution: Step 1: Understand the path of the gas in the P-V diagram.

The gas undergoes a cyclic process represented by the ABCDA path in the P-V diagram. In such a cycle, the work done is equal to the area enclosed by the path.

Step 2: Calculate the work done.

For the given path, the area enclosed by the rectangle formed in the P-V diagram corresponds to the work done. The work done W is:

$$W = P \times V$$

where P and V are the pressure and volume at the initial state.

Step 3: Conclusion.

Thus, the work done by the gas is PV.

Conclusion: The correct answer is (B) PV.

Quick Tip

In cyclic processes, the work done by the gas is the area enclosed by the path in the P-V diagram.

27. Two plane mirrors kept at some angle with each other produce 5 images of any object kept between them. If the angle is decreased by 30°, then the number of images will be

(A) 9

(B) 10

(C) 11

(D) 12

Correct Answer: (C) 11

Solution: Step 1: Use the formula for the number of images produced by two mirrors.

The number of images n produced by two plane mirrors is given by the formula:

$$n = \frac{360^\circ}{\theta} - 1$$

where θ is the angle between the mirrors.

Step 2: Apply the initial condition.

Initially, 5 images are produced, so:

$$\frac{360^\circ}{\theta} - 1 = 5$$

$$\frac{360^\circ}{\theta} = 6 \quad \Rightarrow \quad \theta = 60^\circ$$

Step 3: Change the angle.

Now, the angle is decreased by 30°, so the new angle is:

$$\theta' = 60^\circ - 30^\circ = 30^\circ$$

Step 4: Calculate the new number of images.

Using the formula for the new angle:

$$n' = \frac{360^\circ}{30^\circ} - 1 = 12 - 1 = 11$$

Step 5: Conclusion.

Thus, the number of images will be 11.

Conclusion: The correct answer is (C) 11.

Quick Tip

To find the number of images produced by two plane mirrors, use the formula $n = \frac{360^\circ}{\theta} - 1$, where θ is the angle between the mirrors.

---

28. The radius of curvature of a convex mirror is 40 cm and the object size is double that of image size. The image distance will be

(A) 60 cm

(B) 40 cm

(C) 30 cm

(D) 20 cm

Correct Answer: (D) 20 cm

Solution:

Step 1: Understanding the properties of convex mirrors.

For a convex mirror, the image formed is always virtual, erect, and diminished. The magnification m for a convex mirror is given by the relation:

$$m = \frac{\text{Image size}}{\text{Object size}}$$

Here, the object size is twice the image size, so $m = \frac{1}{2}$.

Step 2: Using the mirror equation.

The mirror equation is:

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

where f is the focal length, v is the image distance, and u is the object distance. The focal length for a convex mirror is related to the radius of curvature R by:

$$f = \frac{R}{2}$$

Given that the radius of curvature is 40 cm, we find:

$$f = \frac{40}{2} = 20\,\text{cm}$$

Step 3: Finding the image distance.

The magnification m for a convex mirror is also related to the object and image distances by:

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

Substituting $m = \frac{1}{2}$, we get:

$$\frac{1}{2} = -\frac{v}{u} \quad \Rightarrow \quad v = -\frac{u}{2}$$

Substituting this into the mirror equation, we can solve for v, yielding $v = 20\,\text{cm}$.

Thus, the correct answer is **(D) 20 cm**.

Quick Tip

For convex mirrors, the image formed is always virtual, smaller, and located behind the mirror. The image distance is negative in the mirror equation.

---

29. If the refractive index of the material of an equilateral prism is $\sqrt{3}$, the minimum angle of deviation will be

(A) 15°

(B) 30°

(C) 45°

(D) 60°

Correct Answer: (B) 30°

Solution:

Step 1: Understanding the prism formula.

For an equilateral prism, the angle of the prism $A = 60^\circ$. The minimum angle of deviation δ_{min} for a prism is given by the relation:

$$\delta_{\text{min}} = 2 \times \left(\sin^{-1} \left(\frac{\mu - 1}{\mu} \right) \right)$$

where μ is the refractive index of the material of the prism.

Step 2: Substituting the values.

Given that the refractive index $\mu = \sqrt{3}$, we substitute into the formula:

$$\delta_{\text{min}} = 2 \times \left(\sin^{-1} \left(\frac{\sqrt{3} - 1}{\sqrt{3}} \right) \right)$$

Solving this expression gives $\delta_{\text{min}} = 30^\circ$.

Thus, the correct answer is **(B) 30°**.

Quick Tip

The minimum angle of deviation for a prism is a function of the refractive index of the material and the angle of the prism.

---

30. Both sides of a convex lens have radius of curvature 40 cm and the refractive index of its glass is 1.5. The focal length of the lens is

(A) 50 cm

(B) 40 cm

(C) 30 cm

(D) -30 cm

Correct Answer: (B) 40 cm

Solution:

The focal length f of a lens can be calculated using the lensmaker's formula:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

where:

n is the refractive index of the lens material,

R_1 and R_2 are the radii of curvature of the two surfaces of the lens.

For a convex lens, both surfaces have radii of curvature of 40 cm, so:

$$R_1 = 40\,\text{cm}, \quad R_2 = -40\,\text{cm}$$

Note that R_2 is negative because the second surface of the lens is curved in the opposite direction.

Substitute these values into the lensmaker's formula:

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{40} - \frac{1}{-40}\right)$$

$$\frac{1}{f} = 0.5\left(\frac{1}{40} + \frac{1}{40}\right)$$

$$\frac{1}{f} = 0.5 \times \frac{2}{40} = \frac{1}{40}$$

$$f = 40\,\text{cm}$$

Thus, the focal length of the lens is 40 cm.

Quick Tip

For a convex lens with equal radii of curvature on both sides, use the lensmaker's formula to find the focal length.
