

BITSAT Physics Sample Paper-11

Duration: 40 Minutes

Maximum Marks: 90

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. An ideal monoatomic gas expands isobarically from volume V to $3V$. The heat supplied to the gas is:

- (A) $3PV$
- (B) $5PV$
- (C) $6PV$
- (D) $\frac{15}{2}PV$

Q2. Two resistors of resistances 4Ω and 12Ω are connected in parallel across a battery of EMF 24 V . The total current drawn is:

- (A) 2 A
- (B) 6 A
- (C) 8 A
- (D) 12 A

Q3. The work done when a spring of force constant k is stretched from x to $2x$ is:

- (A) $\frac{1}{2}kx^2$
- (B) kx^2
- (C) $\frac{3}{2}kx^2$



(D) $2kx^2$

Q4. A proton enters perpendicular to a magnetic field and moves in a circular path of radius R . If its kinetic energy becomes four times, the new radius becomes:

(A) R

(B) $2R$

(C) $4R$

(D) $8R$

Q5. In Young's double slit experiment, if the wavelength is doubled and slit separation is halved, the fringe width becomes:

(A) Half

(B) Same

(C) Double

(D) Four times

Q6. A body projected vertically upward returns to the ground after 6 s. The maximum height reached is ($g = 10 \text{ m/s}^2$):

(A) 30 m

(B) 45 m

(C) 60 m

(D) 90 m

Q7. The de Broglie wavelength of a particle depends on:

(A) Charge only

(B) Momentum only

(C) Mass only

(D) Velocity only



- Q8.** A capacitor of $5\mu F$ is charged to 100 V. The stored energy is:
- (A) 0.025 J
 - (B) 0.05 J
 - (C) 0.1 J
 - (D) 0.5 J
- Q9.** The dimensional formula of magnetic flux is:
- (A) $[ML^2T^{-2}A^{-1}]$
 - (B) $[MLT^{-2}A^{-1}]$
 - (C) $[ML^2T^{-1}A^{-1}]$
 - (D) $[ML^2T^{-2}A^{-2}]$
- Q10.** A wire carries current I . If both current and radius are doubled, magnetic field at the surface becomes:
- (A) Same
 - (B) Double
 - (C) Half
 - (D) Four times
- Q11.** A satellite revolves close to Earth's surface. If Earth's mass becomes four times and radius remains same, orbital speed becomes:
- (A) Same
 - (B) Double
 - (C) Half
 - (D) Four times
- Q12.** Two identical capacitors are connected in series. Their equivalent capacitance is $2\mu F$. Each capacitor has capacitance:
- (A) $1\mu F$



- (B) $2\mu F$
- (C) $4\mu F$
- (D) $8\mu F$

Q13. The escape velocity from a planet depends upon:

- (A) Radius only
- (B) Mass only
- (C) Density only
- (D) Mass and radius both

Q14. A sound wave travels from air into water. Which quantity remains unchanged?

- (A) Speed
- (B) Frequency
- (C) Wavelength
- (D) Amplitude

Q15. A convex lens has power $+5D$. Its focal length is:

- (A) 5 cm
- (B) 10 cm
- (C) 20 cm
- (D) 50 cm

Q16. The current in an AC circuit is given by $I = 5 \sin(100\pi t)$. The frequency of the AC source is:

- (A) 25 Hz
- (B) 50 Hz
- (C) 100 Hz
- (D) 200 Hz



- Q17.** The moment of inertia of a thin ring about its diameter is:
- (A) MR^2
 - (B) $\frac{1}{2}MR^2$
 - (C) $\frac{1}{4}MR^2$
 - (D) $2MR^2$
- Q18.** The electric field inside a conductor in electrostatic equilibrium is:
- (A) Infinite
 - (B) Constant
 - (C) Zero
 - (D) Depends on charge
- Q19.** An object moving with uniform circular motion has:
- (A) Constant velocity
 - (B) Constant acceleration vector
 - (C) Variable velocity
 - (D) Zero acceleration
- Q20.** A radioactive substance has a half-life of 10 days. The fraction remaining after 30 days is:
- (A) $\frac{1}{2}$
 - (B) $\frac{1}{4}$
 - (C) $\frac{1}{8}$
 - (D) $\frac{1}{16}$
- Q21.** A potentiometer works on the principle that:
- (A) Current remains constant



- (B) Resistance remains constant
- (C) Potential drop is proportional to length
- (D) EMF decreases uniformly

Q22. The SI unit of self inductance is:

- (A) Weber
- (B) Henry
- (C) Tesla
- (D) Farad

Q23. A particle executes SHM with amplitude A . Its maximum velocity is:

- (A) $\frac{\omega}{A}$
- (B) ωA
- (C) $\frac{A}{\omega}$
- (D) $\omega^2 A$

Q24. A gas thermometer is more sensitive than a mercury thermometer because gas has:

- (A) Lower density
- (B) Higher specific heat
- (C) Greater expansion coefficient
- (D) Lower boiling point

Q25. A body rolls down an inclined plane without slipping. Which form of energy continuously increases during motion?

- (A) Potential energy
- (B) Rotational kinetic energy
- (C) Total mechanical energy
- (D) Rest energy



- Q26.** The phase difference between displacement and acceleration in SHM is:
- (A) 0°
 - (B) 45°
 - (C) 90°
 - (D) 180°
- Q27.** A transformer works on the principle of:
- (A) Coulomb's law
 - (B) Faraday's law
 - (C) Ohm's law
 - (D) Ampere's law
- Q28.** An electron and a proton have the same kinetic energy. Which particle has the smaller de Broglie wavelength?
- (A) Electron
 - (B) Proton
 - (C) Same for both
 - (D) Depends on charge
- Q29.** The drift velocity of electrons in a conductor is typically of the order:
- (A) 10^8 m/s
 - (B) 10^5 m/s
 - (C) 1 m/s
 - (D) 10^{-4} m/s
- Q30.** The average value of alternating current over one complete cycle is:
- (A) Maximum
 - (B) RMS value
 - (C) Zero
 - (D) Infinite



Detailed Solutions

Q1.

Solution

Concept: For an isobaric process (constant pressure), the heat supplied Q to an ideal gas is given by:

$$Q = nC_p\Delta T$$

where C_p is the molar heat capacity at constant pressure. For an ideal monoatomic gas, $C_p = \frac{5}{2}R$. Using the ideal gas equation $P\Delta V = nR\Delta T$, the expression for heat supplied can be rewritten in terms of volume change as:

$$Q = \frac{5}{2}P\Delta V$$

Solution: Step 1: Identify the initial and final volumes:

$$V_i = V, \quad V_f = 3V$$

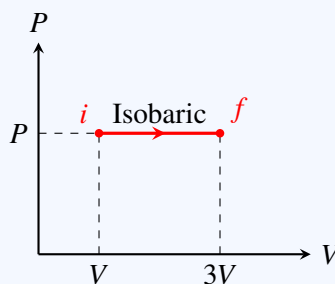
Step 2: Calculate the change in volume (ΔV):

$$\Delta V = V_f - V_i = 3V - V = 2V$$

Step 3: Substitute $\Delta V = 2V$ into the formula for heat supplied:

$$Q = \frac{5}{2}P(2V) = 5PV$$

Step 4: Verify with options. Option A ($3PV$) represents the heat supplied to a diatomic gas or incorrect work calculations. Option C ($6PV$) and Option D ($\frac{15}{2}PV$) are incorrect values resulting from using wrong degrees of freedom or incorrect volume changes.



Final Answer: $5PV$

Answer: (B)

[Go Back to Question 1](#)



Q2.

Solution

Concept: For resistors connected in parallel across a battery, the potential difference across each resistor is equal to the EMF of the battery. The total current drawn from the battery is the sum of the currents through each individual branch (Kirchhoff's Current Law), or it can be found using the equivalent resistance R_{eq} :

$$I = \frac{V}{R_{\text{eq}}}$$

where $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2}$.

Solution: Step 1: Find the equivalent resistance (R_{eq}) of the parallel combination:

$$R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2} = \frac{4 \times 12}{4 + 12} = \frac{48}{16} = 3 \Omega$$

Step 2: Calculate the total current (I) drawn from the 24 V battery using Ohm's law:

$$I = \frac{V}{R_{\text{eq}}} = \frac{24 \text{ V}}{3 \Omega} = 8 \text{ A}$$

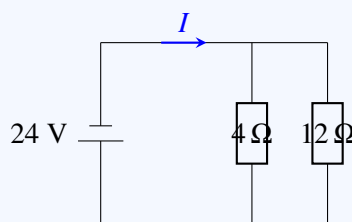
Step 3: Alternatively, calculate individual branch currents and sum them up:

$$I_1 = \frac{V}{R_1} = \frac{24 \text{ V}}{4 \Omega} = 6 \text{ A}$$

$$I_2 = \frac{V}{R_2} = \frac{24 \text{ V}}{12 \Omega} = 2 \text{ A}$$

$$I = I_1 + I_2 = 6 \text{ A} + 2 \text{ A} = 8 \text{ A}$$

Other options: Option A (2 A) is the current through the 12 Ω resistor alone. Option B (6 A) is the current through the 4 Ω resistor alone. Option D (12 A) is incorrect.



Final Answer:

Answer: (C)

[Go Back to Question 2](#)



Q3.

Solution

Concept: The work done in stretching a spring is equal to the change in its potential energy. The potential energy U stored in a spring of force constant k when stretched by a distance x from its equilibrium position is given by:

$$U = \frac{1}{2}kx^2$$

Thus, the work done W in stretching the spring from an initial extension x_1 to a final extension x_2 is:

$$W = U_f - U_i = \frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$$

Solution: Step 1: Identify the initial and final states:

$$x_1 = x, \quad x_2 = 2x$$

Step 2: Calculate the initial potential energy (U_i):

$$U_i = \frac{1}{2}kx^2$$

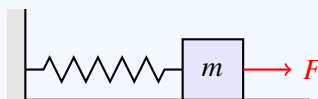
Step 3: Calculate the final potential energy (U_f):

$$U_f = \frac{1}{2}k(2x)^2 = \frac{1}{2}k(4x^2) = 2kx^2$$

Step 4: Find the work done by calculating the difference:

$$W = U_f - U_i = 2kx^2 - \frac{1}{2}kx^2 = \frac{3}{2}kx^2$$

Option A ($\frac{1}{2}kx^2$) is the work done to stretch the spring from 0 to x . Option B (kx^2) and Option D ($2kx^2$) do not correspond to the correct change in potential energy.



Final Answer: $\frac{3}{2}kx^2$

Answer: (C)

[Go Back to Question 3](#)



Q4.

Solution

Concept: When a charged particle of mass m and charge q enters a magnetic field B perpendicularly, the magnetic force acts as the centripetal force, making the particle move in a circular path. The radius R of this circle is given by:

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

Since momentum $p = mv = \sqrt{2mK}$ (where K is the kinetic energy), the radius can be expressed as:

$$R = \frac{\sqrt{2mK}}{qB}$$

Solution: Step 1: Set up the proportionality relation: Since the charge q , mass m , and magnetic field B are constant, the radius is directly proportional to the square root of the kinetic energy:

$$R \propto \sqrt{K}$$

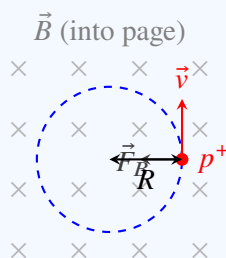
Step 2: Express the ratio of the new radius R' to the initial radius R :

$$\frac{R'}{R} = \sqrt{\frac{K'}{K}}$$

Step 3: Substitute the new kinetic energy $K' = 4K$:

$$\frac{R'}{R} = \sqrt{\frac{4K}{K}} = \sqrt{4} = 2 \implies R' = 2R$$

Option A (R) is incorrect since the radius must change. Option C ($4R$) would be the radius if $R \propto K$, and Option D ($8R$) is also incorrect.



Final Answer: 2R

Answer: (B)

[Go Back to Question 4](#)



Q5.

Solution

Concept: In Young's double-slit experiment, the fringe width β is the distance between two consecutive bright or dark fringes. It is given by the formula:

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

where:

- λ is the wavelength of light used,
- D is the distance between the slits and the screen,
- d is the distance between the two slits (slit separation).

Solution: Step 1: Write down the initial fringe width:

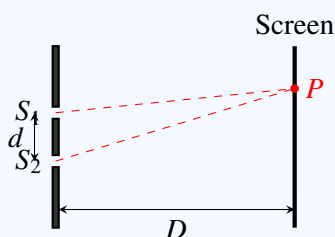
$$\beta_1 = \frac{\lambda D}{d}$$

Step 2: Identify the new parameters: - New wavelength: $\lambda' = 2\lambda$ - New slit separation: $d' = \frac{d}{2}$ - The distance to the screen D remains the same.

Step 3: Calculate the new fringe width β' :

$$\beta' = \frac{\lambda' D}{d'} = \frac{(2\lambda)D}{\left(\frac{d}{2}\right)} = 4 \left(\frac{\lambda D}{d}\right) = 4\beta_1$$

Step 4: Conclude that the fringe width becomes four times its original value. Options A, B, and C correspond to incorrect calculations.



Final Answer:

Answer: (D)

[Go Back to Question 5](#)



Q6.

Solution**Concept:** For a body projected vertically upward with an initial velocity u under gravity:1. The total time of flight T to return to the ground is:

$$T = \frac{2u}{g}$$

2. The maximum height H reached by the body is:

$$H = \frac{u^2}{2g}$$

Alternatively, because of symmetry, the time taken to reach the maximum height is $t = \frac{T}{2}$. From the highest point, the body falls freely for time t , covering a distance $H = \frac{1}{2}gt^2$.

Solution: Step 1: Find the time taken (t) to reach the maximum height from the total time of flight $T = 6$ s:

$$t = \frac{T}{2} = \frac{6}{2} = 3 \text{ s}$$

Step 2: Calculate the maximum height (H) using the free-fall formula from the peak:

$$H = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times (3)^2 = 5 \times 9 = 45 \text{ m}$$

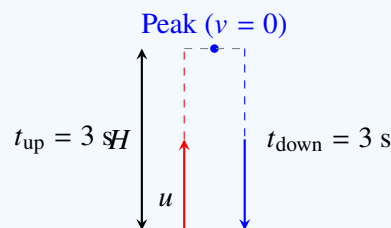
Step 3: Alternatively, find initial velocity u first:

$$T = \frac{2u}{g} \implies 6 = \frac{2u}{10} \implies u = 30 \text{ m/s}$$

Then find H :

$$H = \frac{u^2}{2g} = \frac{30^2}{2 \times 10} = \frac{900}{20} = 45 \text{ m}$$

Options A (30 m), C (60 m), and D (90 m) are incorrect.

**Final Answer:** **Answer: (B)**[Go Back to Question 6](#)

Q7.

Solution

Concept: According to de Broglie's hypothesis, a moving particle behaves as a wave. The de Broglie wavelength λ associated with a particle is given by:

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

where h is Planck's constant and p is the momentum of the particle ($p = mv$).

Solution: Step 1: Express the de Broglie wavelength formula:

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

Step 2: Determine the dependence of λ : The wavelength λ is inversely proportional to the momentum p of the particle:

$$\lambda \propto \frac{1}{p}$$

Since h is a universal constant, the wavelength is completely and uniquely determined by the momentum.

Step 3: Analyze other options: - Option A (Charge only) is incorrect as de Broglie waves are associated with all moving particles regardless of charge (e.g., neutral neutrons). - Option C (Mass only) and Option D (Velocity only) are incorrect because λ depends on the product of both mass and velocity (momentum), and not on either quantity in isolation.

Final Answer: Momentum only

Answer: (B)

[Go Back to Question 7](#)



Q8.

Solution

Concept: When a capacitor of capacitance C is charged to a potential difference V , electric energy is stored in the electric field between its plates. The electrostatic potential energy U stored is given by:

$$U = \frac{1}{2}CV^2$$

Solution: Step 1: Convert the given quantities into SI units: - Capacitance: $C = 5 \mu\text{F} = 5 \times 10^{-6} \text{ F}$
- Potential: $V = 100 \text{ V}$

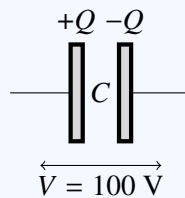
Step 2: Substitute the values into the energy formula:

$$U = \frac{1}{2} \times (5 \times 10^{-6}) \times (100)^2$$

Step 3: Solve the expression:

$$U = \frac{1}{2} \times 5 \times 10^{-6} \times 10^4 = 2.5 \times 10^{-2} = 0.025 \text{ J}$$

Options B (0.05 J), C (0.1 J), and D (0.5 J) represent common calculation errors, such as forgetting the $\frac{1}{2}$ factor or using incorrect powers of ten.



Final Answer:

Answer: (A)

[Go Back to Question 8](#)



Q9.

Solution

Concept: Magnetic flux Φ_B through a surface area A perpendicular to a uniform magnetic field B is given by:

$$\Phi_B = B \cdot A$$

The dimensional formula of area A is $[L^2]$. The magnetic field B is defined through the magnetic force on a moving charge $F = qvB$, which gives:

$$B = \frac{F}{qv}$$

Solution: Step 1: Write down the dimensions of Force (F), Charge (q), and Velocity (v): -
 $[F] = [MLT^{-2}]$ - $[q] = [AT]$ - $[v] = [LT^{-1}]$

Step 2: Substitute these to find the dimensions of Magnetic Field (B):

$$[B] = \frac{[MLT^{-2}]}{[AT][LT^{-1}]} = [MT^{-2}A^{-1}]$$

Step 3: Calculate the dimensions of Magnetic Flux (Φ_B):

$$[\Phi_B] = [B] \cdot [A] = [MT^{-2}A^{-1}] \cdot [L^2] = [ML^2T^{-2}A^{-1}]$$

Step 4: Match with the options and perform option analysis:

- Option A ($[ML^2T^{-2}A^{-1}]$) is correct.
- Option B ($[MLT^{-2}A^{-1}]$) represents the dimensions of the magnetic field B .
- Option C ($[ML^2T^{-1}A^{-1}]$) represents the dimensions of magnetic vector potential.
- Option D ($[ML^2T^{-2}A^{-2}]$) represents the dimensions of self or mutual inductance.

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

Answer: (A)

[Go Back to Question 9](#)



Q10.

Solution

Concept: Using Ampere's Law, the magnetic field B at the surface of a long, straight cylindrical wire of radius R carrying a steady current I is given by:

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

Solution: Step 1: Write down the expression for the initial magnetic field (B_1) at the surface:

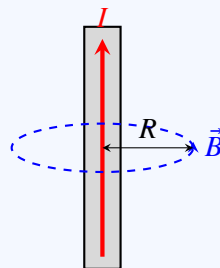
$$B_1 = \frac{\mu_0 I}{2\pi R}$$

Step 2: Determine the parameters of the modified wire: - New current: $I' = 2I$ - New radius: $R' = 2R$

Step 3: Calculate the new magnetic field (B_2) at the surface:

$$B_2 = \frac{\mu_0 I'}{2\pi R'} = \frac{\mu_0 (2I)}{2\pi (2R)} = \frac{\mu_0 I}{2\pi R} = B_1$$

Step 4: Conclude that the magnetic field remains the same (unchanged). Thus, Option A is correct, whereas Options B, C, and D are incorrect.



Final Answer:

Answer: (A)

[Go Back to Question 10](#)



Q11.

Solution

Concept: The orbital speed v_0 of a satellite revolving in a circular orbit close to the surface of a planet of mass M and radius R is given by:

$$v_0 = \sqrt{\frac{GM}{R}}$$

where G is the universal gravitational constant.

Solution: Step 1: Set up the expression for initial orbital speed:

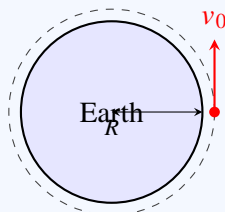
$$v_i = \sqrt{\frac{GM}{R}}$$

Step 2: Define the modified parameters: - New Earth mass: $M' = 4M$ - New Earth radius: $R' = R$

Step 3: Calculate the new orbital speed v_f :

$$v_f = \sqrt{\frac{GM'}{R'}} = \sqrt{\frac{G(4M)}{R}} = 2\sqrt{\frac{GM}{R}} = 2v_i$$

Thus, the orbital speed becomes double its original value. Option A is incorrect since a change in mass changes the orbital speed. Option C and Option D do not correspond to the square root relationship.



Final Answer:

Answer: (B)

[Go Back to Question 11](#)



Q12.

Solution

Concept: For capacitors connected in series, the reciprocal of the equivalent capacitance is the sum of the reciprocals of the individual capacitances:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

For two identical capacitors connected in series ($C_1 = C_2 = C$), the equivalent capacitance simplifies to:

$$C_{\text{eq}} = \frac{C}{2}$$

Solution: Step 1: Identify the given value:

$$C_{\text{eq}} = 2 \mu\text{F}$$

Step 2: Relate individual capacitance C to equivalent capacitance:

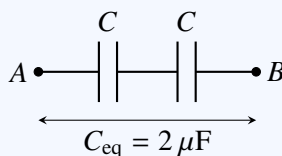
$$C_{\text{eq}} = \frac{C}{2} \implies 2 \mu\text{F} = \frac{C}{2}$$

Step 3: Calculate the value of C :

$$C = 4 \mu\text{F}$$

Thus, each individual capacitor has a capacitance of $4 \mu\text{F}$.

- Option A ($1 \mu\text{F}$) is incorrect as two $1 \mu\text{F}$ in series would yield $0.5 \mu\text{F}$.
- Option B ($2 \mu\text{F}$) is incorrect as two $2 \mu\text{F}$ in series would yield $1 \mu\text{F}$.
- Option D ($8 \mu\text{F}$) is incorrect as two $8 \mu\text{F}$ in series would yield $4 \mu\text{F}$.



Final Answer: $4 \mu\text{F}$

Answer: (C)

[Go Back to Question 12](#)



Q13.

Solution

Concept: The escape velocity v_e is the minimum speed needed for a free, non-propelled object to escape from the gravitational influence of a primary body. For a spherical planet of mass M and radius R , it is calculated using conservation of energy:

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

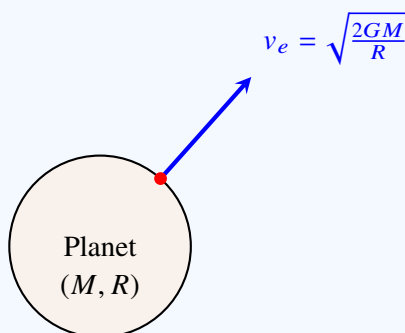
where G is the universal gravitational constant.

Solution: Step 1: Write down the formula for escape velocity:

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

Step 2: Observe the parameters present in the formula: - Mass of the planet, M - Radius of the planet, R

Step 3: Analyze the dependencies: The escape velocity depends directly on both the mass of the planet and its radius. Since it requires both variables to be uniquely defined, Options A, B, and C are incomplete or incorrect.



Final Answer:

Answer: (D)

[Go Back to Question 13](#)



Q14.

Solution

Concept: When a wave travels from one medium to another, its speed changes because speed depends on the physical properties of the medium (such as elasticity and density). The wavelength changes as a consequence, according to the relation:

$$v = f\lambda$$

However, the frequency (f) of a wave is determined solely by the source that produces the vibration and remains unchanged during transmission across different media.

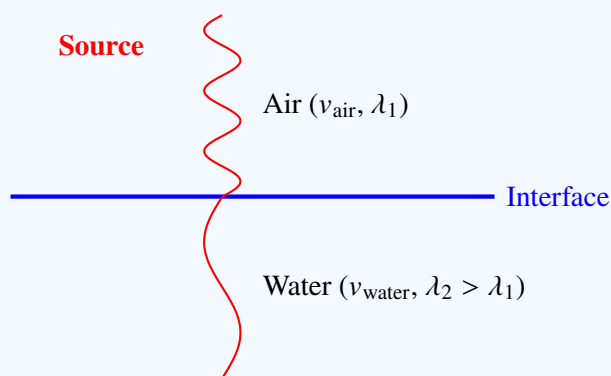
Solution: Step 1: Establish the behavior of sound waves in different media: - The speed of sound in air is approximately 343 m/s. - The speed of sound in water is much higher, around 1480 m/s. Thus, speed changes across the boundary.

Step 2: Analyze the wave relation: Since the frequency (f) must remain constant (it is a property of the source):

$$\frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2} = f$$

Because speed v increases from air to water, the wavelength λ must also increase.

Step 3: Analyze other options: - Option A (Speed) changes because elasticity of water is much higher than that of air. - Option C (Wavelength) changes proportionally with the speed. - Option D (Amplitude) changes because of reflection and transmission losses at the air-water boundary.



Final Answer:

Answer: (B)

[Go Back to Question 14](#)



Q15.

Solution

Concept: The power P of a lens is the measure of its ability to converge or diverge light and is mathematically defined as the reciprocal of its focal length f (in meters):

$$P = \frac{1}{f \text{ (in meters)}}$$

To obtain focal length directly in centimeters, the relation is:

$$f \text{ (in cm)} = \frac{100}{P}$$

Solution: Step 1: Identify the given power of the convex lens:

$$P = +5 \text{ D}$$

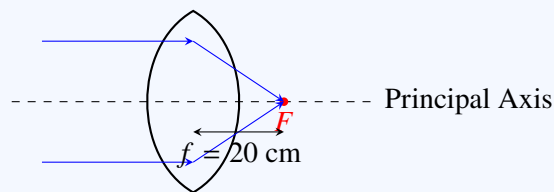
Step 2: Use the formula to find the focal length in meters:

$$f = \frac{1}{P} = \frac{1}{5} = 0.2 \text{ m}$$

Step 3: Convert meters into centimeters:

$$f = 0.2 \times 100 = 20 \text{ cm}$$

Options A (5 cm), B (10 cm), and D (50 cm) are incorrect. A positive focal length is consistent with a converging (convex) lens.



Final Answer:

Answer: (C)

[Go Back to Question 15](#)



Q16.

Solution

Concept: The standard mathematical equation representing an alternating current as a function of time t is:

$$I = I_0 \sin(\omega t)$$

where:

- I_0 is the peak value (amplitude) of the current,
- ω is the angular frequency related to the linear frequency f by the equation $\omega = 2\pi f$.

Solution: Step 1: Write down the given expression of current:

$$I = 5 \sin(100\pi t)$$

Step 2: Compare the given expression with the standard form:

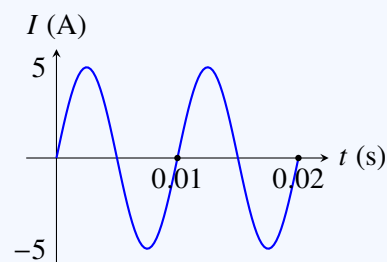
$$I_0 = 5 \text{ A}, \quad \omega = 100\pi \text{ rad/s}$$

Step 3: Solve for the linear frequency (f):

$$\omega = 2\pi f \implies 100\pi = 2\pi f$$

$$f = \frac{100\pi}{2\pi} = 50 \text{ Hz}$$

Options A (25 Hz), C (100 Hz), and D (200 Hz) are mathematically inconsistent with $\omega = 100\pi$.



Final Answer: 50 Hz

Answer: (B)

[Go Back to Question 16](#)



Q17.

Solution

Concept: The moment of inertia of a flat circular ring of mass M and radius R about a central axis perpendicular to its plane is:

$$I_{zz} = MR^2$$

According to the perpendicular axis theorem, for a flat object in the xy -plane:

$$I_{zz} = I_{xx} + I_{yy}$$

Since the ring is symmetric, its moment of inertia about any diameter is the same ($I_{xx} = I_{yy} = I_{\text{diameter}}$).

Solution: Step 1: Set up the equation using the perpendicular axis theorem:

$$I_{zz} = I_{\text{diameter}} + I_{\text{diameter}} = 2I_{\text{diameter}}$$

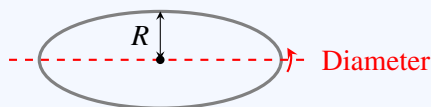
Step 2: Solve for I_{diameter} :

$$I_{\text{diameter}} = \frac{1}{2}I_{zz}$$

Step 3: Substitute the value of $I_{zz} = MR^2$:

$$I_{\text{diameter}} = \frac{1}{2}MR^2$$

- Option A (MR^2) is the moment of inertia about a central axis perpendicular to its plane. - Option C ($\frac{1}{4}MR^2$) represents the moment of inertia of a uniform circular disc about its diameter. - Option D ($2MR^2$) is the moment of inertia of a ring about a tangent in its plane.



Final Answer: $\frac{1}{2}MR^2$

Answer: (B)

[Go Back to Question 17](#)



Q18.

Solution

Concept: Under electrostatic equilibrium conditions, the free electric charges inside a conductor experience no net force and do not drift. This implies that the net electric field \vec{E} at every point inside the bulk of the conductor must be zero:

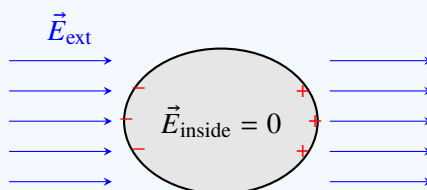
$$\vec{E}_{\text{inside}} = 0$$

Solution: Step 1: Analyze the motion of charges inside a conductor: If there were a non-zero electric field inside the conductor, the free electrons would experience an electric force ($F = qE$) and immediately begin to move, establishing a current.

Step 2: Apply the equilibrium condition: Since the system is in electrostatic equilibrium, no net currents exist. This means all internal electric field lines must cancel out.

Step 3: Analyze the external field cancellation: When placed in an external field, charges migrate to the outer boundaries, generating an internal field that is equal in magnitude and opposite in direction to the external field, resulting in a net field of zero inside.

Options A (Infinite), B (Constant but non-zero), and D (Depends on charge) are incorrect.



Final Answer:

Answer: (C)

[Go Back to Question 18](#)



Q19.

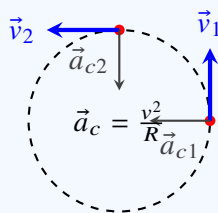
Solution

Concept: Uniform circular motion is defined as motion along a circular path with constant speed. However, because the velocity is a vector quantity (\vec{v}) representing both speed and direction, a change in the direction of motion implies a continuously changing velocity:

$$\vec{v} \neq \text{constant}$$

Solution: Step 1: Check velocity properties: In circular motion, the velocity vector is always directed tangent to the circular path. Since the direction is constantly changing, the velocity vector is variable, meaning Option A (Constant velocity) is incorrect, and Option C is correct.

Step 2: Check acceleration properties: An object in circular motion undergoes centripetal acceleration (\vec{a}_c) directed toward the center of the circle. The magnitude ($a_c = v^2/R$) is constant, but the direction changes as the object revolves. Thus, the acceleration vector is variable, making Option B (Constant acceleration vector) and Option D (Zero acceleration) incorrect.



Final Answer: Variable velocity

Answer: (C)

[Go Back to Question 19](#)



Q20.

Solution

Concept: The fraction of a radioactive sample remaining after a period of time t is given by the expression:

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

where $n = \frac{t}{T_{1/2}}$ represents the number of half-lives that have elapsed, and $T_{1/2}$ is the half-life.

Solution: Step 1: Identify the given values: - Half-life, $T_{1/2} = 10$ days - Elapsed time, $t = 30$ days

Step 2: Calculate the number of half-lives (n):

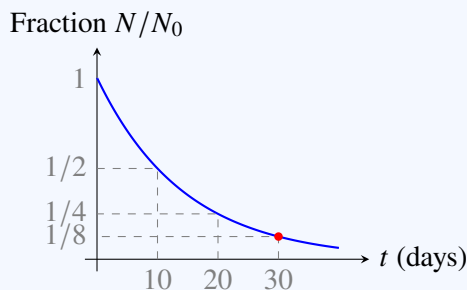
$$n = \frac{30}{10} = 3$$

Step 3: Calculate the fraction remaining:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

Step 4: Verify step-by-step: - Start ($t = 0$): fraction remaining = 1 - After 10 days (1 half-life): fraction remaining = $\frac{1}{2}$ - After 20 days (2 half-lives): fraction remaining = $\frac{1}{4}$ - After 30 days (3 half-lives): fraction remaining = $\frac{1}{8}$

Options A, B, and D correspond to incorrect numbers of half-lives.



Final Answer: $\frac{1}{8}$

Answer: (C)

[Go Back to Question 20](#)



Q21.

Solution

Concept: A potentiometer is an instrument used to measure an unknown EMF or potential difference. It consists of a long, uniform wire through which a constant current I is maintained by a driver cell. Since the wire has a uniform cross-section, its resistance per unit length r is constant. The potential drop V across any segment of length l of the wire is:

$$V = IR = I(rl) = (Ir)l$$

Since current I and resistance per unit length r are constant, the potential drop is directly proportional to the length of that segment:

$$V \propto l \implies V = kl$$

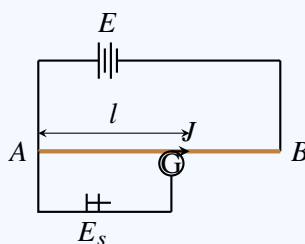
where k is the potential gradient.

Solution: Step 1: Write down the governing equation for a uniform wire carrying constant current:

$$V = kl$$

Step 2: Understand the physical meaning: The potential drop across any length of the wire is directly proportional to the length of that portion. This is the fundamental working principle of a potentiometer.

Step 3: Analyze the options: - Option A (Current remains constant) and Option B (Resistance remains constant) are necessary pre-conditions for the potentiometer to function, but they are not the underlying principle of measurement itself. - Option D (EMF decreases uniformly) is incorrect. Thus, Option C is correct.



Final Answer: Potential drop is proportional to length

Answer: (C)

[Go Back to Question 21](#)



Q22.

Solution

Concept: Self-inductance (L) is the property of a coil by virtue of which it opposes any change in the strength of current flowing through it. The induced EMF (e) is given by:

$$e = -L \frac{dI}{dt}$$

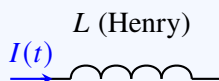
Rearranging to solve for the unit of L :

$$\text{Unit of } L = \frac{\text{Unit of } e}{\text{Unit of } dI/dt} = \frac{\text{Volt}}{\text{Ampere / Second}} = \text{V} \cdot \text{s} \cdot \text{A}^{-1}$$

This combined unit is named the Henry (symbol: H).

Solution: Step 1: Match the SI unit of self-inductance with the options: - Weber (Option A): The SI unit of magnetic flux (Φ_B). - Henry (Option B): The SI unit of self-inductance (and mutual inductance). - Tesla (Option C): The SI unit of magnetic field strength (B). - Farad (Option D): The SI unit of electrical capacitance (C).

Step 2: Conclude that the correct SI unit of self-inductance is the Henry.



Final Answer:

Answer: (B)

[Go Back to Question 22](#)



Q23.

Solution

Concept: For a particle executing simple harmonic motion (SHM) with amplitude A and angular frequency ω , its displacement x at any time t is represented by:

$$x = A \sin(\omega t + \phi)$$

The velocity v of the particle is the time derivative of displacement:

$$v = \frac{dx}{dt} = \omega A \cos(\omega t + \phi)$$

Solution: Step 1: Identify the expression for velocity:

$$v(t) = \omega A \cos(\omega t + \phi)$$

Step 2: Determine the maximum value of $v(t)$: The cosine function oscillates between -1 and $+1$. Thus, the maximum value of velocity occurs when $\cos(\omega t + \phi) = \pm 1$:

$$v_{\max} = \omega A$$

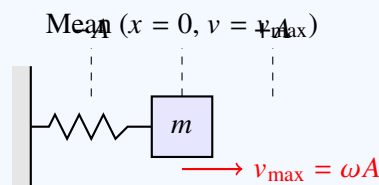
Step 3: Alternatively, express velocity as a function of displacement x :

$$v = \omega \sqrt{A^2 - x^2}$$

The velocity is maximum at the mean position where $x = 0$:

$$v_{\max} = \omega \sqrt{A^2 - 0} = \omega A$$

- Option A (ω/A) and Option C (A/ω) are incorrect. - Option D ($\omega^2 A$) represents the magnitude of the maximum acceleration ($a_{\max} = \omega^2 A$) of the particle in SHM.



Final Answer: ωA

Answer: (B)

[Go Back to Question 23](#)



Q24.

Solution

Concept: The sensitivity of a thermometer refers to its ability to detect and visibly display small variations in temperature. For a thermometer based on thermal expansion, the sensitivity depends directly on the volume expansion coefficient (γ) of the thermometric substance:

$$\Delta V = V_0 \gamma \Delta T$$

A larger expansion coefficient γ means a much larger and more measurable change in volume (ΔV) for the same temperature change (ΔT).

Solution: Step 1: Compare the thermal expansion properties of gases and liquids: Gases have a significantly larger coefficient of volume expansion (γ) compared to liquids (such as mercury). - For an ideal gas at room temperature, $\gamma \approx 3.4 \times 10^{-3} \text{ K}^{-1}$. - For liquid mercury, $\gamma \approx 1.8 \times 10^{-4} \text{ K}^{-1}$.

Step 2: Relate expansion to sensitivity: Because the expansion coefficient of gas is nearly 20 times larger than that of mercury, a small temperature change produces a much more pronounced expansion in a gas than in mercury, making gas thermometers far more sensitive.

Step 3: Analyze other options: - Option A (Lower density) and Option D (Lower boiling point) are characteristic properties of gases but do not directly dictate the volumetric temperature sensitivity. - Option B (Higher specific heat) actually makes a substance slower to change temperature, which would decrease thermal responsiveness rather than increase sensitivity.

Thus, Option C is correct.

Final Answer: Greater expansion coefficient

Answer: (C)

[Go Back to Question 24](#)



Q25.

Solution

Concept: For a body rolling down an inclined plane without slipping, static friction acts at the point of contact. Since the instantaneous velocity of the contact point is zero, static friction does no work, and the total mechanical energy (E) of the body is conserved:

$$E = K_{\text{trans}} + K_{\text{rot}} + U = \text{constant}$$

As the body descends, its height h decreases, meaning gravitational potential energy ($U = mgh$) is converted into kinetic energy.

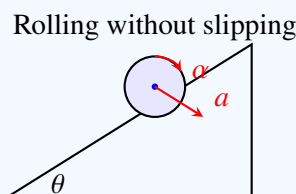
Solution: Step 1: Analyze Potential Energy (Option A): As the body rolls down, its height h decreases. Consequently, its potential energy ($U = mgh$) continuously *decreases*.

Step 2: Analyze Total Mechanical Energy (Option C): Because there is no work done by non-conservative forces, the total mechanical energy is conserved and remains *constant*.

Step 3: Analyze Rest Energy (Option D): The rest mass of the body does not change, so its rest energy ($E_0 = mc^2$) remains *constant*.

Step 4: Analyze Rotational Kinetic Energy (Option B): As potential energy is lost, the body accelerates. Its linear velocity v and angular velocity ω continuously increase. Consequently, both translational kinetic energy ($K_{\text{trans}} = \frac{1}{2}mv^2$) and rotational kinetic energy ($K_{\text{rot}} = \frac{1}{2}I\omega^2$) continuously *increase*.

Thus, Option B is correct.



Final Answer: Rotational kinetic energy

Answer: (B)

[Go Back to Question 25](#)



Q26.



Solution

Concept: In simple harmonic motion (SHM), the displacement x as a function of time t is expressed as:

$$x = A \sin(\omega t)$$

The acceleration a is related to the displacement by the defining equation of SHM:

$$a = -\omega^2 x$$

Solution: Step 1: Write down the equation for displacement:

$$x = A \sin(\omega t)$$

Step 2: Express acceleration in terms of time by substituting x :

$$a = -\omega^2 A \sin(\omega t)$$

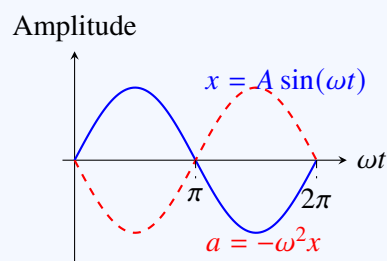
Step 3: Convert the negative sine function into a positive sine function with a phase shift using the trigonometric identity $-\sin \theta = \sin(\theta + \pi)$:

$$a = \omega^2 A \sin(\omega t + \pi)$$

Step 4: Determine the phase difference: Comparing the phases of displacement (ωt) and acceleration ($\omega t + \pi$), the phase difference is:

$$\Delta\phi = (\omega t + \pi) - \omega t = \pi \text{ radians} = 180^\circ$$

The negative sign in $a = -\omega^2 x$ indicates that acceleration is always directed opposite to displacement, confirming a 180° out-of-phase relationship. Option C (90°) is the phase difference between velocity and displacement (or velocity and acceleration).



Final Answer:

Answer: (D)

[Go Back to Question 26](#)



Q27.

Solution

Concept: A transformer is an electrical device that transfers electrical energy between two or more circuits. It operates on the principle of mutual induction between two coils wound around a common magnetic core. This process is governed by Faraday's Law of Electromagnetic Induction, which states that a time-varying magnetic flux induces an electromotive force (EMF) in a conductor:

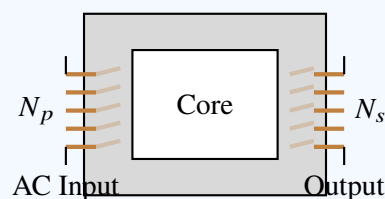
$$e = -N \frac{d\Phi_B}{dt}$$

Solution: Step 1: Analyze how a transformer works: An alternating current (AC) in the primary winding creates a changing magnetic field in the iron core. This changing magnetic flux passes through the secondary winding, inducing an alternating EMF in it.

Step 2: Identify the governing law: The generation of an induced EMF by a changing magnetic field is the definition of electromagnetic induction, formulated by Faraday's Law.

Step 3: Analyze the other options: - Coulomb's Law (Option A): Relates to electrostatic forces between static charges. - Ohm's Law (Option C): Relates voltage, current, and resistance in a DC circuit ($V = IR$). - Ampere's Law (Option D): Relates magnetic fields to the electric currents that produce them, but does not describe the induction of EMF.

Thus, Option B is correct.



Final Answer: Faraday's law

Answer: (B)

[Go Back to Question 27](#)



Q28.

Solution

Concept: The de Broglie wavelength λ of a particle is given by:

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

where p is the momentum of the particle. The momentum is related to its kinetic energy K and mass m by:

$$p = \sqrt{2mK}$$

Substituting this expression into the wavelength formula gives:

$$\lambda = \frac{h}{\sqrt{2mK}}$$

Solution: Step 1: Establish the proportionality relation: Since Planck's constant h is a constant, and both the proton and the electron have the same kinetic energy (K is constant):

$$\lambda \propto \frac{1}{\sqrt{m}}$$

Step 2: Compare the masses of the two particles: The mass of a proton (m_p) is much larger than the mass of an electron (m_e):

$$m_p \approx 1836 m_e \implies m_p > m_e$$

Step 3: Determine which wavelength is smaller: Since λ is inversely proportional to the square root of the mass, the heavier particle will have a smaller de Broglie wavelength:

$$\lambda_p < \lambda_e$$

Thus, the proton has the smaller de Broglie wavelength. Option B is correct.

Final Answer:

Answer: (B)

[Go Back to Question 28](#)



Q29.

Solution

Concept: Drift velocity (v_d) is the average velocity that free electrons in a conductor acquire under the influence of an applied electric field. It is related to the electric current I by:

$$I = neAv_d \implies v_d = \frac{I}{neA}$$

where:

- n is the free electron density (typically $\approx 10^{28} \text{ m}^{-3}$ for copper),
- e is the elementary charge ($1.6 \times 10^{-19} \text{ C}$),
- A is the cross-sectional area of the wire.

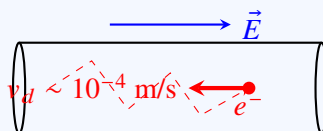
Solution: Step 1: Estimate a typical value for a wire: For a copper wire of cross-sectional area $1 \text{ mm}^2 = 10^{-6} \text{ m}^2$ carrying a current of 1 A:

$$v_d = \frac{1}{(10^{28})(1.6 \times 10^{-19})(10^{-6})} \approx 6 \times 10^{-4} \text{ m/s}$$

Step 2: Determine the order of magnitude: The calculated value is of the order of 10^{-4} m/s (or fractions of a millimeter per second).

Step 3: Clarify a common misconception: Even though the drift velocity is extremely slow, an electrical appliance turns on almost instantly because the electromagnetic field propagates through the wire at nearly the speed of light ($\sim 10^8 \text{ m/s}$), causing all free electrons in the circuit to start drifting almost simultaneously.

Thus, Option D is correct.



Final Answer: 10^{-4} m/s

Answer: (D)

[Go Back to Question 29](#)



Q30.

Solution

Concept: The average value of a time-varying current $I(t)$ over a time period T is defined mathematically as:

$$I_{\text{avg}} = \frac{1}{T} \int_0^T I(t) dt$$

For a standard sinusoidal alternating current:

$$I(t) = I_0 \sin(\omega t)$$

where the duration of one complete cycle is $T = \frac{2\pi}{\omega}$.

Solution: Step 1: Set up the integral for one complete cycle:

$$I_{\text{avg}} = \frac{1}{T} \int_0^T I_0 \sin(\omega t) dt$$

Step 2: Evaluate the integral:

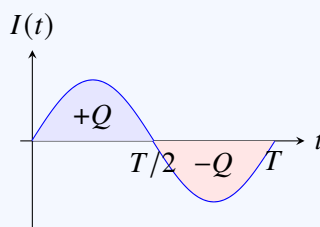
$$I_{\text{avg}} = \frac{I_0}{T} \left[-\frac{\cos(\omega t)}{\omega} \right]_0^T = -\frac{I_0}{\omega T} [\cos(\omega T) - \cos(0)]$$

Step 3: Substitute $\omega T = 2\pi$:

$$I_{\text{avg}} = -\frac{I_0}{2\pi} [\cos(2\pi) - \cos(0)] = -\frac{I_0}{2\pi} [1 - 1] = 0$$

Step 4: Provide physical interpretation: During the first half-cycle, current flows in one direction (transferring charge $+Q$), and during the second half-cycle, it flows in the exact opposite direction (transferring charge $-Q$). Over one complete cycle, the net charge transferred is zero, making the average current zero.

Thus, Option C is correct. (Note: The average value of AC is usually specified over a *half-cycle* to avoid obtaining zero: $I_{\text{avg, half}} = \frac{2I_0}{\pi} \approx 0.637I_0$).



Final Answer:

Answer: (C)

[Go Back to Question 30](#)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	C	4	B	5	D
6	B	7	B	8	A	9	A	10	A
11	B	12	C	13	D	14	B	15	C
16	B	17	B	18	C	19	C	20	C
21	C	22	B	23	B	24	C	25	B
26	D	27	B	28	B	29	D	30	C

