

JEECUP Group A Physics Sample Paper – 18

Duration: 45 Minutes

Maximum Marks: 100

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**. No marks will be deducted for incorrect answers. Unattempted questions carry **0** marks.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A particle moves along a circular path of radius R . If it completes two and a half revolutions, the ratio of the distance covered to the magnitude of its displacement is:

- (A) π
- (B) $\frac{5\pi}{2}$
- (C) 5π
- (D) $\frac{\pi}{5}$

Q2. An electrical appliance rated 220 V, 1000 W is operated at a voltage of 110 V. The power consumed by the appliance under this condition will be:

- (A) 1000 W
- (B) 500 W
- (C) 250 W
- (D) 125 W

Q3. A ray of light passes from water into a glass slab. If the refractive indices of water and glass with respect to air are $\frac{4}{3}$ and $\frac{3}{2}$ respectively, what is the refractive index of glass with respect to water?

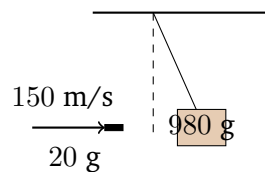


- (A) $\frac{8}{9}$
- (B) $\frac{9}{8}$
- (C) $\frac{1}{2}$
- (D) 2

Q4. A metallic ball weighing 80 g in air weighs 65 g when completely immersed in water. The relative density of the metal is:

- (A) 4.25
- (B) 5.33
- (C) 6.50
- (D) 1.23

Q5. A bullet of mass 20 g fired horizontally with a velocity of 150 m/s embeds itself into a stationary wooden block of mass 980 g suspended by a wire. The common velocity acquired by the system immediately after the impact is:



- (A) 3 m/s
- (B) 1.5 m/s
- (C) 30 m/s
- (D) 15 m/s

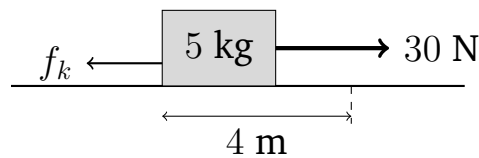
Q6. Two copper wires *A* and *B* have lengths in the ratio 1 : 2 and diameters in the ratio 2 : 1. The ratio of their electrical resistances ($R_A : R_B$) is:

- (A) 1 : 4
- (B) 1 : 8
- (C) 1 : 2

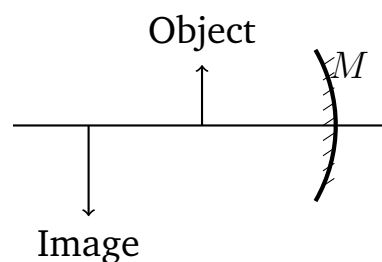


(D) 4 : 1

- Q7.** A block of mass 5 kg is pulled along a rough horizontal surface by a constant horizontal force of 30 N. If the coefficient of kinetic friction between the block and the surface is 0.4, the work done by the net force during a displacement of 4 m is (Take $g = 10 \text{ m/s}^2$):

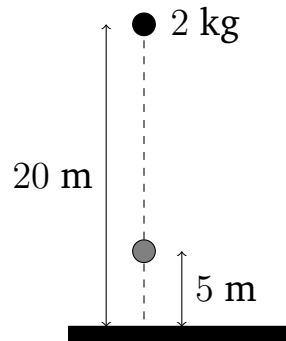


- (A) 120 J
(B) 80 J
(C) 40 J
(D) 160 J
- Q8.** A sound wave traveling through air has a frequency of 400 Hz and a wavelength of 85 cm. The time taken by this sound wave to travel a distance of 680 m is:
- (A) 1.5 s
(B) 2.0 s
(C) 2.5 s
(D) 4.0 s
- Q9.** A real object is placed at a distance of 15 cm in front of a concave mirror. If a real image is formed at a distance of 30 cm from the mirror, the focal length of the mirror is:



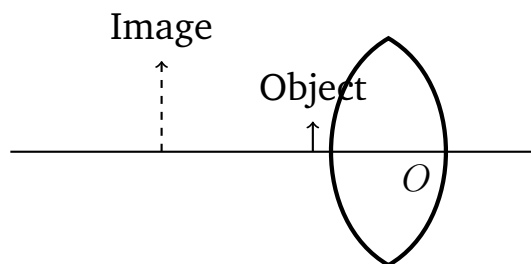
(D) 4 A

Q13. An object of mass 2 kg is dropped from a height of 20 m. Its kinetic energy at a height of 5 m above the ground is (Take $g = 10 \text{ m/s}^2$ and neglect air resistance):



- (A) 400 J
- (B) 300 J
- (C) 100 J
- (D) 200 J

Q14. An object is placed at a distance of 20 cm from a convex lens. If a virtual image is formed at a distance of 60 cm from the lens on the same side as the object, the power of the lens is:



- (A) +5.0 D
- (B) +3.33 D
- (C) -3.33 D
- (D) -5.0 D

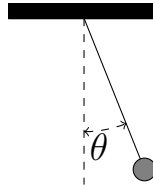


- Q15.** A body starts from rest and moves with a uniform acceleration. If it covers a distance s_1 in the first 3 seconds and a distance s_2 in the next 3 seconds, then the relation between s_1 and s_2 is:
- (A) $s_2 = s_1$
(B) $s_2 = 2s_1$
(C) $s_2 = 3s_1$
(D) $s_2 = 4s_1$
- Q16.** During a nuclear β^- (beta-minus) emission from a radioactive nucleus:
- (A) The mass number increases by 1 while the atomic number remains unchanged.
(B) The atomic number increases by 1 while the mass number remains unchanged.
(C) Both the atomic number and mass number decrease by 1.
(D) The atomic number decreases by 2 and the mass number decreases by 4.
- Q17.** A total of 3×10^{20} electrons pass through a given cross-section of a conductor in 2 minutes. The electric current flowing through the conductor is (Take charge of an electron = 1.6×10^{-19} C):
- (A) 0.4 A
(B) 2.4 A
(C) 4.0 A
(D) 0.24 A
- Q18.** A water heater raises the temperature of 5 kg of water from 25°C to 65°C in 7 minutes. If the specific heat capacity of water is $4200 \text{ J/kg} \cdot ^\circ\text{C}$, the average power delivered by the heater is:
- (A) 1000 W
(B) 2000 W



- (C) 3000 W
- (D) 4000 W

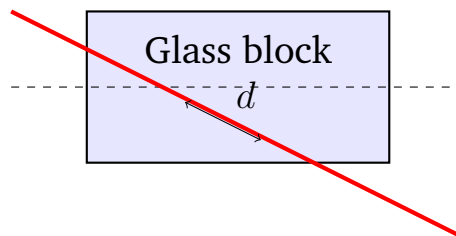
Q19. A simple pendulum completes 40 oscillations in 1 minute at a certain place. If the length of the pendulum is quadrupled, the time period of the new pendulum will be:



- (A) 0.75 s
 - (B) 1.5 s
 - (C) 3.0 s
 - (D) 6.0 s
- Q20.** A person cannot see objects clearly beyond a distance of 1.5 m. To correct this defect of vision, the person should use a lens of focal length and nature:
- (A) +1.5 m, Convex lens
 - (B) -1.5 m, Concave lens
 - (C) -0.67 m, Concave lens
 - (D) +0.67 m, Convex lens
- Q21.** How much heat energy is required to completely convert 20 g of ice at 0°C into water at 10°C ? (Latent heat of fusion of ice = 80 cal/g , specific heat capacity of water = $1\text{ cal/g}\cdot^{\circ}\text{C}$):
- (A) 1600 cal
 - (B) 200 cal
 - (C) 1800 cal
 - (D) 2000 cal



- Q22.** An electric circuit contains an ideal cell connected across a uniform wire of resistance R . If the length of this wire is stretched uniformly to double its original length while keeping the cell connected, the rate of heat dissipation in the wire will:
- (A) Become four times
 - (B) Double
 - (C) Reduce to one-half
 - (D) Reduce to one-fourth
- Q23.** A constant force acts on an object of mass 4 kg for a duration of 2 seconds, changing its velocity from 5 m/s to 11 m/s. The magnitude of the applied force is:
- (A) 6 N
 - (B) 12 N
 - (C) 24 N
 - (D) 3 N
- Q24.** A student tracks a light ray as it enters a rectangular glass block at an angle of incidence of 45° . If the lateral displacement of the emergent ray needs to be increased without changing the glass block, the student should:



- (A) Decrease the angle of incidence
- (B) Increase the angle of incidence
- (C) Submerge the entire setup in a liquid of higher refractive index than air
- (D) Use a light source with a longer wavelength



Q25. A block of mass M is placed on a smooth horizontal surface. A force F is applied at an angle θ with the horizontal. The work done by the vertical component of this force during a horizontal displacement d of the block is:

- (A) $Fd \sin \theta$
- (B) $Fd \cos \theta$
- (C) Mgd
- (D) Zero



Detailed Solutions

Q1.

Solution

Concept: The total distance covered by an object is the actual length of the path traveled during its motion, which is scalar. The magnitude of displacement is the shortest straight-line distance between the initial and final positions of the object, which is vector. For a body moving along a circular path of radius R , one full revolution covers a distance equal to the circumference $2\pi R$.

Solution: Step 1: Calculate the total distance traveled by the particle in two and a half revolutions.

One complete revolution equals the circumference of the circular track, which is given by $2\pi R$.

Therefore, for 2.5 revolutions, the total path length or distance is:

$$\text{Distance} = 2.5 \times 2\pi R = 5\pi R$$

Step 2: Determine the magnitude of the displacement after two and a half revolutions. After completing 2 full revolutions, the particle returns to its exact starting point, making its displacement zero at that instant.

The remaining half (0.5) revolution positions the particle at the diametrically opposite point on the circular path relative to the starting location.

The shortest straight-line path between two diametrically opposite points on a circle is equal to the diameter.

$$\text{Magnitude of Displacement} = 2R$$

Step 3: Compute the required ratio of the total distance covered to the magnitude of its displacement.

$$\text{Ratio} = \frac{\text{Distance}}{\text{Displacement}} = \frac{5\pi R}{2R} = \frac{5\pi}{2}$$

Final Answer:

$$\frac{5\pi}{2}$$

Answer: (B)

[Go Back to Question 1](#)



Q2.

Solution

Concept: The electrical resistance R of an appliance depends strictly on its design ratings and remains constant when operated under varying supply voltages, provided temperature fluctuations are neglected. The relation connecting power rating P , operating voltage V , and resistance R is expressed by the formula $P = \frac{V^2}{R}$.

Solution: Step 1: Calculate the internal electrical resistance R of the appliance using its nominal rated parameters.

The given rated voltage is $V_{\text{rated}} = 220$ V and the rated power is $P_{\text{rated}} = 1000$ W.

Using the power formula:

$$R = \frac{V_{\text{rated}}^2}{P_{\text{rated}}} = \frac{220 \times 220}{1000} = \frac{48400}{1000} = 48.4 \Omega$$

Step 2: Determine the actual power consumed by the appliance when it is connected to a modified supply voltage.

The new operating voltage is $V_{\text{actual}} = 110$ V.

The new power dissipation P_{actual} is given by substituting the constant resistance into the power relation:

$$P_{\text{actual}} = \frac{V_{\text{actual}}^2}{R} = \frac{110 \times 110}{48.4}$$

Step 3: Alternatively, simplify by expressing the actual voltage as a fraction of the rated voltage.

Notice that 110 V is exactly half of 220 V, meaning $V_{\text{actual}} = \frac{1}{2}V_{\text{rated}}$.

Since power is directly proportional to the square of the voltage, dropping the voltage by half scales the power down by a factor of four:

$$P_{\text{actual}} = \frac{P_{\text{rated}}}{4} = \frac{1000}{4} = 250 \text{ W}$$

Final Answer:

Answer: (C)

[Go Back to Question 2](#)



Q3.

Solution

Concept: The relative refractive index of a medium 2 with respect to a medium 1 is defined as the ratio of the absolute refractive index of medium 2 to the absolute refractive index of medium 1. Mathematically, this principle is stated as ${}_1\mu_2 = \frac{\mu_2}{\mu_1}$, where μ denotes the absolute refractive index relative to a vacuum or air.

Solution: Step 1: Identify the given values from the problem statement.

The absolute refractive index of water with respect to air is $\mu_w = \frac{4}{3}$.

The absolute refractive index of glass with respect to air is $\mu_g = \frac{3}{2}$.

Step 2: Apply the formula for the relative refractive index of glass with respect to water.

The light ray is traveling from water into glass, meaning we need to evaluate ${}_w\mu_g$:

$${}_w\mu_g = \frac{\mu_g}{\mu_w}$$

Step 3: Substitute the fractional values into the expression and simplify the resulting mathematical division.

$${}_w\mu_g = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{3}{2} \times \frac{3}{4} = \frac{9}{8}$$

Thus, the refractive index of glass relative to water is equal to nine-eighths, which means light travels slower in glass than in water.

Final Answer:

Answer: (B)

[Go Back to Question 3](#)



Q4.

Solution

Concept: According to Archimedes' principle, when a body is completely or partially immersed in a fluid, it experiences an upward buoyant force equal to the weight of the fluid displaced by the body. The relative density of a solid substance is defined as the ratio of its mass in air to the mass of an equal volume of pure water, which corresponds to the loss of weight in water.

Solution: Step 1: Record the measured weights of the metallic ball in air and when submerged in water.

Weight of the metallic ball in air (W_{air}) = 80 g

Weight of the metallic ball in water (W_{water}) = 65 g

Step 2: Calculate the apparent loss of weight of the metallic ball when completely immersed in water.

The buoyant force exerted by water equals this loss of weight:

$$\text{Loss of weight in water} = W_{\text{air}} - W_{\text{water}} = 80 \text{ g} - 65 \text{ g} = 15 \text{ g}$$

Step 3: Utilize the formal formulation for calculating relative density from weight measurements.

$$\text{Relative Density} = \frac{\text{Weight in air}}{\text{Loss of weight in water}} = \frac{W_{\text{air}}}{W_{\text{air}} - W_{\text{water}}}$$

$$\text{Relative Density} = \frac{80}{15} = \frac{16}{3} \approx 5.33$$

The relative density is a dimensionless quantity, and its value indicates that the metal is 5.33 times denser than water.

Final Answer:

Answer: (B) [Go Back to Question 4](#)



Q5.

Solution

Concept: In an inelastic collision where one body embeds itself into another, external forces along the horizontal direction are negligible during the brief impact interval. Consequently, the total linear momentum along the horizontal axis is perfectly conserved. The conservation of linear momentum states that the total initial momentum equals the total final momentum.

Solution: Step 1: Identify and convert all given mechanical properties into uniform units.

Mass of the bullet (m) = 20 g = $\frac{20}{1000}$ kg = 0.02 kg

Initial velocity of the bullet (u_1) = 150 m/s

Mass of the stationary wooden block (M) = 980 g = $\frac{980}{1000}$ kg = 0.98 kg

Initial velocity of the block (u_2) = 0 m/s

Step 2: Set up the equation representing the conservation of linear momentum.

Let V represent the common final velocity acquired by the combined system of the bullet and block immediately after collision.

$$mu_1 + Mu_2 = (m + M)V$$

Step 3: Substitute the values into the algebraic relation and solve for V .

$$(0.02 \times 150) + (0.98 \times 0) = (0.02 + 0.98) \times V$$

$$3 + 0 = 1.0 \times V$$

$$V = 3 \text{ m/s}$$

The combined mass moves forward with a velocity of 3 m/s immediately following the collision.

Final Answer:

Answer: (A)

[Go Back to Question 5](#)



Q6.

Solution

Concept: The electrical resistance R of a cylindrical conductor is directly proportional to its length l and inversely proportional to its cross-sectional area A . The area of a circle depends on its diameter d according to $A = \frac{\pi d^2}{4}$. Combining these dependencies gives the formula $R = \rho \frac{4l}{\pi d^2}$, where ρ is the material resistivity.

Solution: Step 1: Formulate the relationship between resistance, length, and diameter for two wires composed of identical material.

Since both wires are made of copper, their resistivity ρ is identical. Hence, we can write:

$$R \propto \frac{l}{d^2} \implies \frac{R_A}{R_B} = \left(\frac{l_A}{l_B}\right) \times \left(\frac{d_B}{d_A}\right)^2$$

Step 2: Substitute the known ratios given in the problem statement.

The ratio of their lengths is $\frac{l_A}{l_B} = \frac{1}{2}$.

The ratio of their diameters is $\frac{d_A}{d_B} = \frac{2}{1}$, which implies $\frac{d_B}{d_A} = \frac{1}{2}$.

Step 3: Perform the algebraic calculation to determine the final resistance ratio.

$$\frac{R_A}{R_B} = \left(\frac{1}{2}\right) \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$$

Thus, the electrical resistance of wire A to wire B stands in the ratio of 1 : 8.

Final Answer:

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



Q7.

Solution

Concept: The work done by a net force acting on a body is defined as the product of the net force component in the direction of motion and the magnitude of the displacement. Alternatively, according to the work-energy theorem, the work done by the net force is equivalent to the net change in kinetic energy. The friction force acting opposite to motion is $f_k = \mu_k N$.

Solution: Step 1: Determine the normal reaction force N acting on the block from the horizontal plane.

Since there is no vertical acceleration, the normal force balances the weight of the block:

$$N = mg = 5 \times 10 = 50 \text{ N}$$

Step 2: Calculate the magnitude of the kinetic friction force opposing the motion.

Using the given coefficient of friction $\mu_k = 0.4$:

$$f_k = \mu_k N = 0.4 \times 50 = 20 \text{ N}$$

Step 3: Evaluate the net horizontal force acting on the block along the direction of displacement.

The pulling force acts forward, while friction acts backward:

$$F_{\text{net}} = F_{\text{applied}} - f_k = 30 \text{ N} - 20 \text{ N} = 10 \text{ N}$$

Step 4: Compute the work done by this net force over the given displacement of 4 m.

$$\text{Work Done} = F_{\text{net}} \times d = 10 \text{ N} \times 4 \text{ m} = 40 \text{ J}$$

Final Answer:

Answer: (C)

[Go Back to Question 7](#)



Q8.

Solution

Concept: The propagation speed v of a wave through any homogeneous medium is fundamentally determined by the product of its frequency ν and its wavelength λ , expressed as $v = \nu\lambda$. Once the velocity is established, the time required to cover a specified linear distance at a constant speed is calculated using $\text{Time} = \frac{\text{Distance}}{\text{Velocity}}$.

Solution: Step 1: Convert the wavelength into standard SI units.

The given wavelength is $\lambda = 85 \text{ cm} = \frac{85}{100} \text{ m} = 0.85 \text{ m}$.

The given frequency is $\nu = 400 \text{ Hz}$.

Step 2: Compute the velocity of the sound wave in air.

$$v = \nu\lambda = 400 \times 0.85 = 340 \text{ m/s}$$

Step 3: Calculate the total time taken by the sound wave to traverse the specified distance of 680 m.

Using the constant speed formula:

$$\text{Time} = \frac{\text{Distance}}{v} = \frac{680}{340} = 2.0 \text{ s}$$

The wave will take exactly two seconds to travel a distance of 680 m.

Final Answer:

Answer: (B) [Go Back to Question 8](#)



Q9.

Solution

Concept: Spherical mirrors form images according to the mirror formula, which relates the object distance u , image distance v , and focal length f . The relation is expressed as $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$. According to the standard Cartesian sign convention, distances measured opposite to the direction of incident light are negative.

Solution: Step 1: Assign proper signs to the distances based on the Cartesian sign convention.

Since the object is real and located in front of the concave mirror, the object distance is $u = -15$ cm.

The problem states that a real image is formed. Real images are formed in front of the mirror, so the image distance is $v = -30$ cm.

Step 2: Set up the mirror formula to find the unknown focal length f .

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

Substitute the signed numerical values:

$$\frac{1}{f} = \frac{1}{-30} + \frac{1}{-15} = -\frac{1}{30} - \frac{1}{15}$$

Step 3: Compute the common denominator and find the value of f .

$$\frac{1}{f} = \frac{-1 - 2}{30} = \frac{-3}{30} = -\frac{1}{10}$$

Taking the reciprocal yields $f = -10$ cm. The negative sign confirms the concave nature of the mirror.

Final Answer:

Answer: (A) [Go Back to Question 9](#)



Q10.

Solution

Concept: Radioactive decay follows an exponential law where the quantity of remaining undecayed active nuclei decreases by half after every elapsed interval equal to its half-life $T_{1/2}$. The fraction of original nuclei remaining active after n half-lives is mathematically expressed by the function $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$.

Solution: Step 1: Determine the number of half-life periods n contained within the total elapsed time.

The total time given is $t = 12$ days, and the half-life of the sample is $T_{1/2} = 4$ days.

$$n = \frac{t}{T_{1/2}} = \frac{12}{4} = 3 \text{ half-lives}$$

Step 2: Compute the remaining undecayed fraction using the exponential reduction relation.

$$\text{Fraction remaining} = \frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^3$$

Step 3: Evaluate the power of the fraction.

$$\frac{N}{N_0} = \frac{1}{2 \times 2 \times 2} = \frac{1}{8}$$

Thus, after 12 days, exactly one-eighth of the initial active radioactive nuclei remain undecayed within the sample.

Final Answer:

Answer: (C)

[Go Back to Question 10](#)



Q11.

Solution

Concept: According to the principle of calorimetry, in an isolated system with no external heat exchange, the total heat energy lost by the hotter bodies must be exactly equal to the total heat energy gained by the colder bodies. The heat transferred is given by the formula $Q = mc\Delta T$, where m is mass, c is specific heat, and ΔT is the change in temperature.

Solution: Step 1: Identify the components and set up the heat exchange terms.

Let the mass of both liquids be m .

Liquid X is at a lower temperature (20°C), so it gains heat.

Liquid Y is at a higher temperature (40°C), so it loses heat.

The equilibrium temperature achieved by the mixture is $T = 32^\circ\text{C}$.

Step 2: Formulate the equation matching heat gained to heat lost.

$$\text{Heat Gained by } X = \text{Heat Lost by } Y$$

$$m \cdot c_X \cdot (T - T_X) = m \cdot c_Y \cdot (T_Y - T)$$

Step 3: Eliminate common factors and substitute the numerical temperatures.

$$c_X \cdot (32 - 20) = c_Y \cdot (40 - 32)$$

$$c_X \cdot 12 = c_Y \cdot 8$$

Step 4: Solve for the ratio of the specific heat capacities $\frac{c_X}{c_Y}$.

$$\frac{c_X}{c_Y} = \frac{8}{12} = \frac{2}{3}$$

Hence, the ratio $c_X : c_Y$ is equal to 2 : 3.

Final Answer:

[Go Back to Question 11](#)



Q12.

Solution

Concept: To find the total current drawn from an ideal source, the entire circuit configuration must be simplified to a single equivalent resistance R_{eq} . For resistors connected in parallel, $\frac{1}{R_p} = \sum \frac{1}{R_i}$, and for series configurations, values are added directly. Ohm's law states that $I = \frac{V}{R_{\text{eq}}}$.

Solution: Step 1: Calculate the equivalent resistance R_p of the three parallel resistors (4Ω , 6Ω , and 12Ω).

$$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12}$$

Find a common denominator, which is 12:

$$\frac{1}{R_p} = \frac{3 + 2 + 1}{12} = \frac{6}{12} = \frac{1}{2}$$

Taking the reciprocal gives $R_p = 2 \Omega$.

Step 2: Combine this parallel equivalent resistance with the remaining series resistor. The parallel combination is in series with a 5Ω resistor:

$$R_{\text{eq}} = R_p + R_{\text{series}} = 2 \Omega + 5 \Omega = 7 \Omega$$

Step 3: Use Ohm's law to determine the total electric current supplied by the 14 V battery.

$$I = \frac{V}{R_{\text{eq}}} = \frac{14 \text{ V}}{7 \Omega} = 2 \text{ A}$$

The circuit draws a steady total current of 2 A from the ideal battery source.

Final Answer:

Answer: (B) [Go Back to Question 12](#)



Q13.

Solution

Concept: According to the law of conservation of mechanical energy, the total mechanical energy (sum of potential energy and kinetic energy) of an isolated system remains constant throughout its motion if dissipative forces are absent. Thus, the loss in potential energy as an object falls is perfectly converted into a gain in kinetic energy.

Solution: Step 1: Determine the total mechanical energy of the object at its initial release height.

At the maximum height $H = 20$ m, the object is dropped from rest, meaning its initial kinetic energy is zero.

$$\text{Total Energy} = E = U_{\text{initial}} = mgH$$

$$E = 2 \text{ kg} \times 10 \text{ m/s}^2 \times 20 \text{ m} = 400 \text{ J}$$

Step 2: Calculate the potential energy of the object at the intermediate height.

At a height $h = 5$ m above the ground, the gravitational potential energy is:

$$U_{\text{intermediate}} = mgh = 2 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m} = 100 \text{ J}$$

Step 3: Apply the conservation of mechanical energy to extract the kinetic energy.

$$\text{Kinetic Energy} = \text{Total Energy} - U_{\text{intermediate}}$$

$$\text{Kinetic Energy} = 400 \text{ J} - 100 \text{ J} = 300 \text{ J}$$

Alternatively, the object fell through a distance of $\Delta h = 20 - 5 = 15$ m, so
K.E. = $mg\Delta h = 2 \times 10 \times 15 = 300$ J.

Final Answer:

Answer: (B)

[Go Back to Question 13](#)



Q14.

Solution

Concept: The relationship linking the object distance u , image distance v , and focal length f for a thin lens is given by the lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$. The optical power P of a lens represents its capacity to converge or diverge light and is defined as the reciprocal of its focal length measured in meters ($P = \frac{1}{f(\text{m})}$).

Solution: Step 1: Adopt the conventional Cartesian sign rules for the coordinates.

The real object is in front of the lens: $u = -20$ cm.

The virtual image forms on the same side as the object: $v = -60$ cm.

Step 2: Substitute these values into the standard lens formula to calculate the focal length.

$$\frac{1}{f} = \frac{1}{-60} - \frac{1}{-20} = -\frac{1}{60} + \frac{1}{20}$$

Find a common denominator:

$$\frac{1}{f} = \frac{-1 + 3}{60} = \frac{2}{60} = \frac{1}{30}$$

This gives a focal length of $f = +30$ cm = +0.3 m.

Step 3: Convert the focal length into optical power in Diopters (D).

$$P = \frac{1}{f(\text{m})} = \frac{1}{0.3} = \frac{10}{3} \approx +3.33 \text{ D}$$

The positive sign mathematically re-verifies that the lens is a converging or convex lens.

Final Answer:

Answer: (B)

[Go Back to Question 14](#)



Q15.

Solution

Concept: For an object moving with a uniform linear acceleration a starting from rest ($u = 0$), the displacement after any elapsed time interval t is modeled by Galileo's law of odd integers or via the kinematic equation $s = \frac{1}{2}at^2$. To find successive interval displacements, individual total positions are calculated and subtracted.

Solution: Step 1: Express the displacement s_1 covered during the first time interval of 3 seconds.

Using $s = ut + \frac{1}{2}at^2$ with $u = 0$:

$$s_1 = 0 + \frac{1}{2}a(3)^2 = \frac{9}{2}a = 4.5a$$

Step 2: Find the total displacement s_{total} covered from the beginning up to the end of 6 seconds.

The total time elapsed from rest is $3 + 3 = 6$ seconds:

$$s_{\text{total}} = \frac{1}{2}a(6)^2 = \frac{36}{2}a = 18a$$

Step 3: Calculate the distinct displacement s_2 covered specifically in the second 3 seconds block.

$$s_2 = s_{\text{total}} - s_1 = 18a - 4.5a = 13.5a$$

Step 4: Establish the mathematical proportion connecting s_1 and s_2 .

$$\frac{s_2}{s_1} = \frac{13.5a}{4.5a} = 3 \implies s_2 = 3s_1$$

This follows Galileo's rule, where consecutive equal-time intervals map to ratios of odd integers ($1 : 3 : 5 : \dots$).

Final Answer: $s_2 = 3s_1$

Answer: (C)

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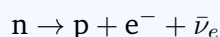
Q16.

Solution

Concept: A beta-minus (β^-) decay is a nuclear transformation process that occurs when a radioactive nucleus has an excess of neutrons. To achieve stability, a neutron within the parent nucleus transforms into a proton, emitting an electron (the β^- particle) and an electron antineutrino.

Solution: Step 1: Analyze the fundamental subatomic equation representing beta-minus decay.

The fundamental reaction occurring at the nucleon level is:



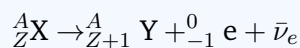
Step 2: Determine the effect of this transformation on the total number of nucleons (mass number, A).

Since a neutron turns into a proton, the total count of heavy nucleons ($A = \text{neutrons} + \text{protons}$) remains completely unchanged. Therefore, $\Delta A = 0$.

Step 3: Determine the effect of this transformation on the nuclear charge (atomic number, Z).

Because an additional proton is created inside the nucleus, the net positive charge increases by one unit. Therefore, $Z_{\text{new}} = Z + 1$.

The overarching transformation can be represented as:



Hence, the atomic number increases by 1 while the mass number stays the same.

Final Answer:

The atomic number increases by 1 while the mass number remains unchanged.

Answer: (B)

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Q17.

Solution

Concept: Electric current I is defined as the net rate of flow of electric charge through a specific cross-sectional area of a conductor over time, represented as $I = \frac{q}{t}$. According to the quantization of charge, the total charge q is the product of the number of passing electrons n and the elementary charge of a single electron e ($q = ne$).

Solution: Step 1: Collate the parameters and convert the time parameter into standard seconds.

Given number of electrons: $n = 3 \times 10^{20}$

Given time interval: $t = 2$ minutes $= 2 \times 60$ s $= 120$ seconds

Elementary electronic charge magnitude: $e = 1.6 \times 10^{-19}$ C

Step 2: Determine the total aggregate electrical charge q passing through the conductor.

$$q = n \cdot e = (3 \times 10^{20}) \times (1.6 \times 10^{-19} \text{ C}) = 48 \text{ C}$$

Step 3: Compute the electric current by dividing the net charge by the time duration.

$$I = \frac{q}{t} = \frac{48 \text{ C}}{120 \text{ s}} = 0.4 \text{ A}$$

The steady macroscopic current moving through the conductor wire is equal to 0.4 Ampere.

Final Answer:

Answer: (A)

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Q18.

Solution

Concept: The total thermal energy Q required to raise the temperature of a substantive fluid mass without inducing a phase change is given by $Q = mc\Delta T$. The average operational electrical power P delivered by an energy source is the total thermal energy transferred divided by the corresponding time interval t ($P = \frac{Q}{t}$).

Solution: Step 1: Identify the thermal traits of the system and compute the temperature variation ΔT .

Mass of water (m) = 5 kg

Specific heat capacity (c) = 4200 J/kg \cdot $^{\circ}$ C

Temperature change (ΔT) = 65 $^{\circ}$ C – 25 $^{\circ}$ C = 40 $^{\circ}$ C

Step 2: Calculate the total quantity of thermal energy absorbed by the mass of water.

$$Q = m \cdot c \cdot \Delta T = 5 \times 4200 \times 40$$

$$Q = 21000 \times 40 = 840000 \text{ J}$$

Step 3: Convert the operational duration from minutes into standard metric seconds.

$$t = 7 \text{ minutes} = 7 \times 60 \text{ s} = 420 \text{ seconds}$$

Step 4: Compute the average power delivered by evaluating the rate of energy transfer.

$$P = \frac{Q}{t} = \frac{840000 \text{ J}}{420 \text{ s}} = 2000 \text{ W}$$

The average power delivered by the heating appliance is equal to 2000 Watts.

Final Answer:

Answer: (B) [Go Back to Question 18](#)



Q19.

Solution

Concept: The time period T of a simple pendulum executing small-angle simple harmonic motion depends directly on the square root of its effective suspended length l and is inversely proportional to the square root of local gravitational acceleration g , given by $T = 2\pi\sqrt{\frac{l}{g}}$. Thus, $T \propto \sqrt{l}$.

Solution: Step 1: Determine the original time period T_1 of the simple pendulum from the initial data.

The pendulum performs 40 complete cycles in 1 minute (60 seconds).

The time period is defined as the time taken for one single oscillation:

$$T_1 = \frac{\text{Total Time}}{\text{Number of Oscillations}} = \frac{60 \text{ s}}{40} = 1.5 \text{ s}$$

Step 2: Analyze the mathematical effect of quadrupling the physical length of the pendulum.

Let the initial length be l_1 and the new length be $l_2 = 4l_1$.

Using the proportionality relation:

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} = \sqrt{\frac{4l_1}{l_1}} = \sqrt{4} = 2$$

Step 3: Compute the numerical value of the new operational time period T_2 .

$$T_2 = 2 \times T_1 = 2 \times 1.5 \text{ s} = 3.0 \text{ s}$$

Quadrupling the physical length doubles the time period, raising it to exactly three seconds.

Final Answer:

Answer: (C) [Go Back to Question 19](#)



Q20.

Solution

Concept: A person who cannot see distant objects clearly suffers from shortsightedness or myopia. In a myopic eye, parallel rays coming from infinity focus in front of the retina. To correct this, a diverging (concave) lens is placed in front of the eye so that an object at infinity forms a virtual image at the person's far point d . Thus, $f = -d$.

Solution: Step 1: Diagnose the specific refractive defect of vision based on the optical limitation.

The individual can see nearby objects but faces a strict visual cutoff beyond a distance of 1.5 m.

This inability to view far objects clearly is the hallmark of myopia.

Step 2: Determine the required focal length of the corrective lens.

For a myopic eye to clearly view a distant object at infinity ($u = -\infty$), the lens must create its image at the individual's actual physical far point ($v = -1.5$ m).

Applying the standard lens formula:

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \implies \frac{1}{f} = \frac{1}{-1.5} - \frac{1}{-\infty} = -\frac{1}{1.5} + 0$$
$$f = -1.5 \text{ m}$$

Step 3: Interpret the mathematical sign to determine the structural nature of the lens.

A negative focal length indicates a diverging lens, which is a concave lens. Thus, a concave lens of focal length -1.5 m is required.

Final Answer:

Answer: (B)

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Q21.

Solution

Concept: The total heat required to change a solid at its melting point into a liquid at a higher temperature involves two consecutive steps: first, a phase transformation at constant temperature ($Q_1 = mL_f$), and second, a temperature elevation of the resulting liquid phase ($Q_2 = mc\Delta T$). The total energy is $Q_{\text{total}} = Q_1 + Q_2$.

Solution: Step 1: Calculate the heat energy Q_1 needed to melt the ice into liquid water at a stable temperature of 0°C .

Mass of ice (m) = 20 g, Latent heat of fusion (L_f) = 80 cal/g.

$$Q_1 = m \cdot L_f = 20 \text{ g} \times 80 \text{ cal/g} = 1600 \text{ cal}$$

Step 2: Calculate the heat energy Q_2 required to raise the temperature of the melted water from 0°C to 10°C .

The specific heat capacity of water is $c = 1 \text{ cal/g} \cdot ^\circ\text{C}$, and $\Delta T = 10^\circ\text{C} - 0^\circ\text{C} = 10^\circ\text{C}$.

$$Q_2 = m \cdot c \cdot \Delta T = 20 \text{ g} \times 1 \text{ cal/g} \cdot ^\circ\text{C} \times 10^\circ\text{C} = 200 \text{ cal}$$

Step 3: Compute the total thermal energy required by summing both values.

$$Q_{\text{total}} = Q_1 + Q_2 = 1600 \text{ cal} + 200 \text{ cal} = 1800 \text{ cal}$$

A total of 1800 calories must be supplied to complete the physical transformation.

Final Answer:

Answer: (C) [Go Back to Question 21](#)



Q22.

Solution

Concept: The resistance of a uniform wire of resistivity ρ , length l , and cross-sectional area A is given by $R = \rho \frac{l}{A}$. When a wire is stretched uniformly, its total material volume $V_{\text{vol}} = A \cdot l$ remains perfectly constant. The thermal power or rate of heat dissipation under a constant voltage V is given by $P = \frac{V^2}{R}$.

Solution: Step 1: Analyze the geometric modification of resistance when the wire is stretched to double its original length.

Let the initial parameters be l_1 and A_1 , so $R_1 = R$.

The new length is $l_2 = 2l_1$. Since volume remains constant ($A_1 l_1 = A_2 l_2$), doubling the length cuts the cross-sectional area in half: $A_2 = \frac{A_1}{2}$.

The modified electrical resistance R_2 becomes:

$$R_2 = \rho \frac{l_2}{A_2} = \rho \frac{2l_1}{\left(\frac{A_1}{2}\right)} = 4 \left(\rho \frac{l_1}{A_1} \right) = 4R$$

Step 2: Examine the relationship for the rate of heat dissipation under constant voltage.

The wire remains connected across the same ideal cell, keeping the voltage V constant.

Initial power dissipation: $P_1 = \frac{V^2}{R}$

New power dissipation: $P_2 = \frac{V^2}{R_2} = \frac{V^2}{4R} = \frac{1}{4}P_1$

Step 3: Determine the final operational state of heat generation.

The rate of heat dissipation decreases to exactly one-fourth of its initial value due to the quadrupled resistance.

Final Answer:

Answer: (D)

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Q23.

Solution

Concept: According to Newton's second law of motion, the net force acting on an object is directly proportional to the rate of change of its linear momentum. For a constant mass system, this principle reduces to the formula $F = ma$, where the linear acceleration a can be determined from the kinematic definition $a = \frac{v-u}{t}$.

Solution: Step 1: Identify the given dynamic inputs from the problem statement.

Mass of the object (m) = 4 kg

Initial velocity (u) = 5 m/s

Final velocity (v) = 11 m/s

Time duration (t) = 2 seconds

Step 2: Calculate the uniform linear acceleration experienced by the object.

$$a = \frac{v - u}{t} = \frac{11 - 5}{2} = \frac{6}{2} = 3 \text{ m/s}^2$$

Step 3: Apply Newton's second law to calculate the magnitude of the applied force.

$$F = m \cdot a = 4 \text{ kg} \times 3 \text{ m/s}^2 = 12 \text{ N}$$

The constant force acting on the object has a magnitude of twelve Newtons.

Final Answer:

Answer: (B) [Go Back to Question 23](#)



Q24.

Solution

Concept: When a light ray passes through a parallel-sided rectangular glass slab, it shifts sideways relative to its original path. This shift is called lateral displacement (d). The formula for lateral displacement is $d = \frac{t \cdot \sin(i-r)}{\cos r}$, where t is slab thickness, i is the angle of incidence, and r is the angle of refraction.

Solution: Step 1: Analyze the structural parameters influencing the magnitude of lateral displacement.

From the expression $d = \frac{t \cdot \sin(i-r)}{\cos r}$, lateral displacement is directly proportional to the thickness of the slab t and increases with a larger angle of incidence i .

Step 2: Evaluate the options to maximize lateral displacement without altering the slab itself.

Since the physical block properties (thickness t and refractive index) are fixed, we can only vary the external launch properties of the light ray.

Increasing the angle of incidence i causes a corresponding increase in the term $(i - r)$, which leads to a larger value for $\sin(i - r)$ and increases the lateral displacement.

Changing to a longer wavelength would decrease the refractive index, causing less bending and reducing displacement, which is counterproductive.

Final Answer:

Answer: (B)

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Q25.

Solution

Concept: Work done by a force is defined by the dot product of the force vector and the displacement vector, given by $W = \vec{F} \cdot \vec{d} = Fd \cos \phi$, where ϕ is the angle between the specific force component and the displacement direction. If a force component is perpendicular to the direction of motion, it does no work.

Solution: Step 1: Resolve the applied force F into its orthogonal components. The force is applied at an angle θ relative to the horizontal surface:

$$\text{Horizontal component of force} = F_x = F \cos \theta$$

$$\text{Vertical component of force} = F_y = F \sin \theta$$

Step 2: Identify the direction of the displacement vector.

The block moves exclusively along the smooth horizontal surface. Thus, the displacement vector \vec{d} is horizontal.

Step 3: Evaluate the work done specifically by the vertical component F_y .

The vertical force component $F \sin \theta$ points perpendicular (90°) to the horizontal displacement.

$$\text{Work Done by } F_y = F_y \cdot d \cdot \cos(90^\circ)$$

Since $\cos(90^\circ) = 0$:

$$\text{Work Done by vertical component} = 0$$

The vertical component does no work because it does not cause any displacement along its line of action.

Final Answer:

Answer: (D)

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Answer Key

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

