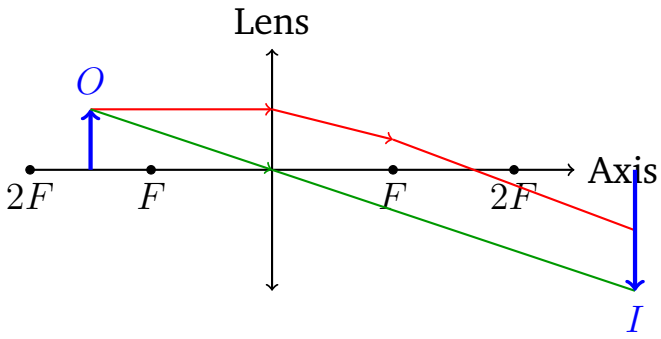
# JEECUP Group A Physics Sample Paper -19

**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.** An object is placed at a distance of $15$ cm in front of a convex lens of focal length $10$ cm. Which of the following diagrams correctly represents the ray path and position of the image formed?




(A) Real, inverted, and located at $20$ cm behind the lens.

(B) Real, inverted, and located at $30$ cm behind the lens.

(C) Virtual, erect, and located at $30$ cm in front of the lens.

(D) Real, inverted, and located at $15$ cm behind the lens.

**Q2.** A heavy stone is dropped from the top of a tower. If it covers $24.5$ m in its last second of fall, calculate the total height of the tower. (Take $g = 9.8$ m/s$^2$)

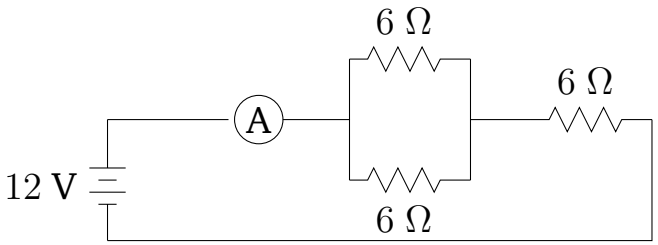
(A) $32.4$ m

(B) $44.1$ m

(C) $24.5$ m

(D) $19.6$ m

**Q3.** Consider the electrical circuit configuration shown below containing three identical resistors each of resistance $R = 6\ \Omega$ connected to a $12$ V battery. Determine the reading of an ideal ammeter placed in the main branch.




(A) $1.33$ A

(B) $2.00$ A

(C) $0.75$ A

(D) $1.50$ A

**Q4.** An engine pumps $600$ kg of water per minute from a well of depth $20$ m and hits it with a velocity of $10$ m/s. The minimum power required from the engine is (Take $g = 10$ m/s$^2$):

(A) $2.0$ kW

(B) $2.5$ kW

(C) $3.0$ kW

(D) $1.5$ kW

**Q5.** A tuning fork produces 4 beats per second when sounded with another tuning fork of frequency $256$ Hz. When the first fork is loaded with a little wax, the beat frequency decreases to 2 beats per second. The original frequency of the first tuning fork was:

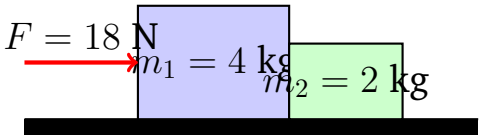
(A) $252$ Hz

(B) 262 Hz

(C) 260 Hz

(D) 250 Hz

**Q6.** Two blocks of masses $m_1 = 4$ kg and $m_2 = 2$ kg are in contact with each other on a smooth, horizontal surface. A horizontal force $F = 18$ N is applied to the mass $m_1$ as illustrated below. Find the contact force exerted between the two blocks.




(A) 12 N

(B) 9 N

(C) 6 N

(D) 3 N

**Q7.** A specific mass of radioactive material contains $8 \times 10^{10}$ active nuclei. If the half-life of this radioisotope is 6 hours, the number of active nuclei remaining intact at the end of 24 hours will be:

(A) $1 \times 10^{10}$

(B) $2 \times 10^{10}$

(C) $5 \times 10^{9}$

(D) $4 \times 10^{9}$

**Q8.** A block of wood of mass 2 kg floats in water such that exactly $\frac{3}{5}$th of its volume remains submerged beneath the surface. If the density of water is 1000 kg/m$^3$, the density of the wood block is:

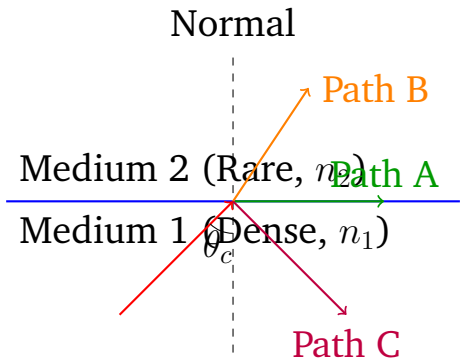
(A) 400 kg/m$^3$

(B) 600 kg/m$^3$

(C) 750 kg/m$^3$

(D) $800$ kg/m$^3$

**Q9.** A light ray travels from a dense medium (Medium 1, refractive index $n_1$) into a rare medium (Medium 2, refractive index $n_2$) as depicted below. If the angle of incidence is steadily increased until it matches the critical angle $\theta_c$, identify the correct path followed by the refracted ray.




(A) It travels along Path B inside Medium 2 making an angle less than $90^\circ$ with the normal.

(B) It reflects entirely into Medium 1 along Path C obeying regular laws of reflection.

(C) It skims along the boundary line separating the two media along Path A.

(D) It absorbs completely at the interface point without emerging along any path.

**Q10.** A block of mass $5$ kg is pulled along a rough horizontal plane by a constant force of $30$ N. If the frictional force resisting the motion is $10$ N, what is the total work done by the net force acting on the block over a displacement of $5$ m?

(A) $150$ J

(B) $200$ J

(C) $100$ J

(D) $50$ J

**Q11.** Equal masses of water at $20^\circ$C and water at $80^\circ$C are mixed thoroughly in an insulated container. Neglecting any heat capacity contribution from the vessel, the equilibrium final temperature of the liquid mixture will be:

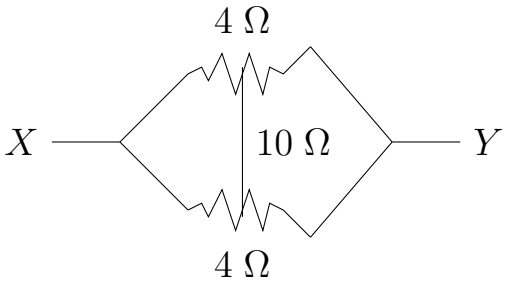
(A) $40^\circ$C

(B) $50^\circ$C

(C) $60^\circ$C

(D) $45^\circ$C

**Q12.** What is the equivalent resistance across the terminal points $X$ and $Y$ for the balanced electrical bridge circuit network displayed below?




(A) $18\ \Omega$

(B) $8\ \Omega$

(C) $4\ \Omega$

(D) $2\ \Omega$

**Q13.** An iron sphere and an aluminum sphere of equal volumes are completely immersed in water. If the density of iron is greater than that of aluminum, which of the following statements is true regarding the buoyant force experienced by them?

(A) The iron sphere experiences a greater buoyant force because of its higher mass.

(B) The aluminum sphere experiences a greater buoyant force because it is less dense.

(C) Both spheres experience exactly identical buoyant forces.

(D) The buoyant force depends on the depth at which they are suspended in water.

**Q14.** The temperature of a gas inside a closed container is raised from $27°$C to $327°$C. By what factor does the average kinetic energy of the gas molecules change?

(A) It becomes doubled.

(B) It increases by $\sqrt{2}$ times.

(C) It becomes four times its initial value.

(D) It remains unchanged.

**Q15.** A continuous sound wave has a wavelength of $0.85$ m in air. If the speed of sound waves in air under the given conditions is $340$ m/s, calculate the frequency of this acoustic wave?

(A) $250$ Hz

(B) $300$ Hz

(C) $400$ Hz

(D) $425$ Hz

**Q16.** During a radioactive decay process, a parent nucleus ${}^{A}_{Z}X$ emits one alpha ($\alpha$) particle followed closely by two beta ($\beta^-$) particles. The atomic number and mass number of the resulting stable daughter nucleus will be:

(A) $Z-2$, $A-4$

(B) $Z+1$, $A-4$

(C) $Z-1$, $A-2$

(D) $Z$, $A-4$

**Q17.** A concave mirror produces a sharp, real, inverted image of the same size as the actual object when it is placed at a certain point along the

principal axis. If the radius of curvature of this spherical mirror is $40$ cm, find the distance of the object from the pole of the mirror.

(A) $20$ cm

(B) $40$ cm

(C) $10$ cm

(D) $30$ cm

**Q18.** A body of mass $0.5$ kg is moving in a perfect circle of radius $2$ m with a constant linear speed of $4$ m/s. The work done by the inward centripetal force on the body during one complete revolution is:

(A) $8$ J

(B) $4$ J

(C) $16$ J

(D) $0$ J

**Q19.** Five electrical household appliances rated at $200$ W each are operated continuously for 6 hours everyday. Calculate the total electrical energy consumed by these appliances in a single day in terms of commercial units (kWh).

(A) $1.2$ units

(B) $5.0$ units

(C) $6.0$ units

(D) $3.6$ units

**Q20.** An object starts from rest and moves with a uniform linear acceleration along a straight path. If it travels a distance $S_1$ in the first 2 seconds and a further distance $S_2$ in the next 2 seconds, find the correct relationship establishing $S_1$ and $S_2$.

(A) $S_2 = 2S_1$

(B) $S_2 = 3S_1$

(C) $S_2 = 4S_1$

(D) $S_2 = S_1$

**Q21.** A liquid is heated in a vessel. It is observed that the level of the liquid initially falls slightly before it begins to steadily rise up. This initial drop in the liquid column level occurs because:

(A) The liquid contracts initially upon absorbing heat energy.

(B) Evaporation happens at an extremely rapid rate initially.

(C) The density of water is anomalous below $4^\circ$C.

(D) The vessel expands first before heat reaches the liquid inside.

**Q22.** An absolute object is placed $12$ cm away from a convex mirror. If a virtual image is successfully formed behind the mirror at a distance of $6$ cm from the pole, determine the absolute focal length of the convex mirror.

(A) $4$ cm

(B) $12$ cm

(C) $24$ cm

(D) $18$ cm

**Q23.** Two long copper wires have lengths in the ratio $1 : 2$ and cross-sectional radii in the ratio $2 : 1$. Find the ratio of their electrical resistances ($R_1 : R_2$).

(A) $1 : 4$

(B) $1 : 8$

(C) $1 : 2$

(D) $2 : 1$

**Q24.** A particle of mass $m$ possessing linear momentum $p$ enters a region. The kinetic energy $K$ of this moving particle can be precisely expressed mathematically as:

(A) $K = \frac{p^2}{2m}$

(B) $K = \frac{p}{2m}$

(C) $K = 2mp^2$

(D) $K = \frac{2m}{p^2}$

**Q25.** A passenger sitting inside a stationary bus leans forward with a sudden jerk when the bus starts moving forward abruptly. This classic real-world phenomenon is a direct consequence of:

(A) Inertia of motion of the upper body.

(B) Inertia of rest of the upper body.

(C) Newton's third law of motion.

(D) Conservation of linear momentum.

# Detailed Solutions

## Q1.

### Solution

**Concept:** The behavior of a convex lens is governed by the thin lens formula relating object distance ($u$), image distance ($v$), and focal length ($f$). Real images are formed behind the lens, whereas virtual images form on the same side as the object.

**Solution:**

(a) According to the given values and sign convention, $u = -15$ cm and $f = +10$ cm.

(b) Applying the thin lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we substitute the known values to find $\frac{1}{v} - \frac{1}{-15} = \frac{1}{10}$.

(c) Rearranging the equation yields $\frac{1}{v} = \frac{1}{10} - \frac{1}{15} = \frac{3-2}{30} = \frac{1}{30}$, which gives $v = +30$ cm.

(d) The positive sign of $v$ confirms that a real, inverted image is formed behind the lens at a distance of 30 cm.

**Final Answer:** Real, inverted, and located at 30 cm behind the lens.

**Answer: (B)**

Go Back to Question 1

## Q2.

### Solution

**Concept:** For an object moving with a uniform acceleration ($g$) from rest, the distance traveled in the $n$-th second is determined by the specific equation of motion for successive intervals.

**Solution:**

(a) Let the total time taken to hit the ground be $n$ seconds. The formula for distance in the $n$-th second is $S_n = u + \frac{g}{2}(2n - 1)$.

(b) Substituting $u = 0$, $g = 9.8$ m/s$^2$, and $S_n = 24.5$ m gives $24.5 = 0 + \frac{9.8}{2}(2n - 1)$.

(c) Simplifying the relation gives $24.5 = 4.9(2n - 1)$, which reduces to $5 = 2n - 1$, leading to $2n = 6$, or $n = 3$ seconds.

(d) The total height of the tower is calculated using $H = ut + \frac{1}{2}gt^2 = 0 + \frac{1}{2} \times 9.8 \times 3^2 = 4.9 \times 9 = 44.1$ m.

**Final Answer:** 44.1 m

**Answer: (B)**

Go Back to Question 2

## Q3.

### Solution

**Concept:** Circuit analysis involving combinations of resistors requires evaluating parallel and series groupings step-by-step to compute the equivalent circuit resistance, followed by using Ohm's law.

**Solution:**

(a) The schematic contains two identical resistors connected in a parallel configuration, which are in series with a third identical resistor.

(b) For the parallel branch, the equivalent resistance is $R_p = \frac{R \times R}{R+R} = \frac{6 \times 6}{6+6} = 3\ \Omega$.

(c) The total net resistance of the entire configuration becomes $R_{eq} = R_p + R = 3 + 6 = 9\ \Omega$.

(d) Using Ohm's law, the main branch ammeter reading is $I = \frac{V}{R_{eq}} = \frac{12}{9} = 1.33$ A.

**Final Answer:** 1.33 A

**Answer: (A)**

Go Back to Question 3

## Q4.

### Solution

**Concept:** The minimum power rating of a pump engine equals the total energy output per unit time, accounting for both the gravitational potential energy and the kinetic energy delivered to the water.

**Solution:**

(a) Given mass flow rate is $m = 600$ kg over a time period of $t = 60$ seconds, yielding a mass rate of 10 kg/s.

(b) Total work done per second comprises potential energy rate $mg\frac{h}{t}$ and kinetic energy rate $\frac{1}{2}\frac{m}{t}v^2$.

(c) Substituting the values gives $P = (10 \times 10 \times 20) + (\frac{1}{2} \times 10 \times 10^2) = 2000 + 500 = 2500$ W.

(d) Converting watts to kilowatts yields a total power value of 2.5 kW.

**Final Answer:** 2.5 kW

**Answer: (B)**

Go Back to Question 4

## Q5.

### Solution

**Concept:** The phenomenon of beats depends on the difference between two acoustic frequencies. Loading a tuning fork with wax increases its total inertia and consistently lowers its oscillation frequency.

**Solution:**

(a) Let the unknown frequency of the first fork be $f$. Given a known tuning fork of $256$ Hz producing $4$ beats/s, the initial choices are $f = 256 \pm 4$, meaning either $260$ Hz or $252$ Hz.

(b) When wax is added to the first fork, its frequency decreases from $f$ to a lower value $f'$.

(c) If the original value was $252$ Hz, adding wax lowers it further, increasing the gap with $256$ Hz, which raises the beat rate.

(d) If the original value was $260$ Hz, adding wax lowers it toward $256$ Hz, reducing the frequency difference to $2$ Hz. Thus, the initial value must be $260$ Hz.

**Final Answer:** $260$ Hz

**Answer: (C)**

Go Back to Question 5

## Q6.

### Solution

**Concept:** When contact masses move as a unified system, we first determine the mutual system acceleration using the net force, then compute individual internal contact dynamics with free-body isolation.

**Solution:**

(a) Treating both blocks together as a combined single entity, the net system acceleration is $a = \frac{F}{m_1+m_2} = \frac{18}{4+2} = 3$ m/s$^2$.

(b) Isolating the second mass block $m_2 = 2$ kg, the only horizontal force acting on it is the forward contact force $N$ from $m_1$.

(c) Applying Newton's second law directly to this block gives $N = m_2 \times a = 2 \times 3 = 6$ N.

**Final Answer:** $6$ N

**Answer: (C)**

Go Back to Question 6

## Q7.

### Solution

**Concept:** Radioactive decay processes track an exponential decrease where the remaining active core count drops by a factor of two during each full half-life interval.
**Solution:**

(a) Given a half-life of $T = 6$ hours and a total elapsed timeline of $t = 24$ hours.

(b) The total number of completed decay half-life cycles is $n = \frac{t}{T} = \frac{24}{6} = 4$.

(c) The remaining active nuclei formula is $N = N_0(\frac{1}{2})^n = (8 \times 10^{10}) \times (\frac{1}{2})^4$.

(d) Simplifying the numerical expression gives $N = \frac{8 \times 10^{10}}{16} = 0.5 \times 10^{10} = 5 \times 10^9$.

**Final Answer:** $5 \times 10^9$

**Answer: (C)**

Go Back to Question 7

## Q8.

### Solution

**Concept:** The principle of floatation states that a floating body displaces a volume of fluid whose total weight exactly matches the full weight of the object itself.
**Solution:**

(a) Let the total volume of the wooden block be $V$ and its mass density be $\rho_w$.

(b) At equilibrium, the buoyant force equals the total weight: $V_{sub} \times \rho_{water} \times g = V \times \rho_w \times g$.

(c) Substituting the submerged fraction gives $\frac{3}{5}V \times 1000 = V \times \rho_w$.

(d) Canceling volume $V$ from both sides results in $\rho_w = \frac{3}{5} \times 1000 = 600$ kg/m$^3$.

**Final Answer:** $600$ kg/m$^3$

**Answer: (B)**

Go Back to Question 8

## Q9.

### Solution

**Concept:** Critical angle refraction defines the boundary condition where light hitting a boundary at a specific incident angle produces a refraction angle of exactly ninety degrees.

**Solution:**

(a) When light travels from a high refractive index medium to a lower refractive index medium, it bends away from the normal line.

(b) As the incidence angle reaches the critical angle $\theta_c$, the angle of refraction becomes exactly $90^\circ$.

(c) Looking at the given options in the diagram, Path A represents a ray that skims straight along the interface between the two media.

(d) Therefore, the refracted ray follows Path A along the interface.

**Final Answer:** It skims along the boundary line separating the two media along Path A.

**Answer: (C)**

Go Back to Question 9

## Q10.

### Solution

**Concept:** The mechanical work done on a moving block by a net force is calculated as the product of the net force acting in the direction of motion and the total linear displacement.

**Solution:**

(a) The block experiences a forward pulling force of $30$ N and an opposing frictional resistance of $10$ N.

(b) The net force acting along the horizontal path is $F_{net} = F_{pull} - F_{friction} = 30 - 10 = 20$ N.

(c) Work done is computed using $W = F_{net} \times d$, where displacement $d = 5$ m.

(d) Substituting the values gives $W = 20 \times 5 = 100$ J.

**Final Answer:** $100$ J

**Answer: (C)**

Go Back to Question 10

## Q11.

### Solution

**Concept:** The principle of calorimetry states that in an insulated system, the total thermal heat lost by a hot substance equals the total heat gained by the cold substance.

**Solution:**

(a) Let the equal masses of water be $m$, the specific heat capacity be $c$, and the final equilibrium temperature be $T$.

(b) Heat gained by the cold water is $Q_{gain} = mc(T - 20)$, and heat lost by the hot water is $Q_{loss} = mc(80 - T)$.

(c) Setting them equal gives $mc(T-20) = mc(80-T)$. Canceling common parameters leaves $T - 20 = 80 - T$.

(d) Solving the linear equation results in $2T = 100$, which simplifies to $T = 50°$C.

**Final Answer:** $50°$C

**Answer: (B)**

Go Back to Question 11

## Q12.

### Solution

**Concept:** A balanced bridge circuit configuration satisfies a symmetry ratio condition that equates electric potentials across its central branch, rendering that central connection obsolete.

**Solution:**

(a) The network forms a bridge structure where the outer branch ratios are equivalent ($\frac{4}{4} = \frac{4}{4}$).

(b) Because the bridge is balanced, no current passes through the central resistor of $10\ \Omega$, and it can be removed.

(c) The upper path becomes a simple series combination: $R_{top} = 4 + 4 = 8\ \Omega$.

(d) The lower path becomes another series combination: $R_{bottom} = 4 + 4 = 8\ \Omega$.

(e) The final total equivalent resistance is the parallel combination of these paths: $R_{eq} = \frac{8\times8}{8+8} = 4\ \Omega$.

**Final Answer:** $4\ \Omega$

**Answer: (C)**

Go Back to Question 12

## Q13.

### Solution

**Concept:** According to Archimedes' principle, the buoyant force experienced by an object completely or partially immersed in a fluid is equal to the weight of the fluid displaced by it. This force depends on the volume of the submerged object and the density of the fluid, not the density or mass of the object itself.

**Solution:**

(a) Both the iron sphere and the aluminum sphere have exactly equal volumes, which means they displace the exact same volume of water when completely immersed.

(b) The buoyant force formula is given by $F_b = V \cdot \rho_{fluid} \cdot g$, where $V$ represents the volume of displaced liquid, $\rho_{fluid}$ is the fluid density, and $g$ is acceleration due to gravity.

(c) Since $V$, $\rho_{fluid}$, and $g$ are identical for both objects, the upward buoyant force acting on each sphere must be exactly the same.

**Final Answer:** Both spheres experience exactly identical buoyant forces.

**Answer: (C)**

Go Back to Question 13

## Q14.

### Solution

**Concept:** The average kinetic energy of the molecules in an ideal gas sample is directly proportional to its absolute temperature measured on the Kelvin scale, represented mathematically by the equation $K_E = \frac{3}{2}k_B T$.

**Solution:**

(a) First, we must convert the given temperatures from degrees Celsius to Kelvin.

(b) The initial absolute temperature is $T_1 = 27 + 273 = 300$ K.

(c) The final absolute temperature is $T_2 = 327 + 273 = 600$ K.

(d) Taking the ratio of the final temperature to the initial temperature, we find $\frac{T_2}{T_1} = \frac{600}{300} = 2$.

(e) Because kinetic energy scales linearly with absolute temperature, doubling the temperature means the average kinetic energy becomes doubled.

**Final Answer:** It becomes doubled.

**Answer: (A)**

Go Back to Question 14

## Q15.

### Solution

**Concept:** For any periodic wave propagation, the wave speed ($v$) is fundamentally related to its frequency ($f$) and its spatial wavelength ($\lambda$) through the definitive wave propagation equation $v = f \cdot \lambda$.

**Solution:**

(a) From the given text, the speed of the acoustic sound wave in air $v = 340$ m/s and the corresponding wavelength $\lambda = 0.85$ m.

(b) Rearranging the standard wave relation to solve directly for the frequency gives the mathematical expression $f = \frac{v}{\lambda}$.

(c) Substituting the numerical values into the equation yields $f = \frac{340}{0.85}$.

(d) Calculating the final fraction results in an absolute frequency of $400$ Hz.

**Final Answer:** $400$ Hz

**Answer: (C)**

Go Back to Question 15

## Q16.

### Solution

**Concept:** Radioactive transformations change nuclear identities. Emitting an alpha particle reduces mass number by four and atomic number by two, while a beta-minus decay converts a neutron to a proton, increasing atomic number by one.

**Solution:**

(a) The starting parent nucleus is given by the symbol ${}^{A}_{Z}X$.

(b) After the emission of a single alpha particle (${}^{4}_{2}\alpha$), the mass number drops to $A - 4$ and the atomic number drops to $Z - 2$.

(c) Next, the intermediate nucleus undergoes two successive beta-minus ($\beta^{-}$) emissions. Each individual beta emission raises the atomic number by $+1$ but leaves the mass number unchanged.

(d) Thus, the total change in the atomic number during the beta steps is $+2$, leading to a final atomic number of $(Z - 2) + 2 = Z$. The mass number remains $A - 4$.

**Final Answer:** $Z$, $A - 4$

**Answer: (D)**

Go Back to Question 16

## Q17.

### Solution

**Concept:** A spherical concave mirror forms a real, inverted image that matches the exact dimensions of the object if and only if the object is positioned precisely at the mirror's center of curvature ($C$).

**Solution:**

(a) For a concave mirror, the image size equals the object size when the object distance ($u$) equals the radius of curvature ($R$).

(b) The problem statement specifies that the radius of curvature of this spherical mirror is $40$ cm.

(c) Therefore, to satisfy the given criteria, the object must be located exactly at the center of curvature, which means its distance from the pole is equal to $R$.

(d) This matches the physical boundary distance value of $40$ cm.

**Final Answer:** $40$ cm

**Answer: (B)**

Go Back to Question 17

## Q18.

### Solution

**Concept:** Mechanical work is defined by the dot product of the force vector and the displacement vector. If the acting force is constantly perpendicular to the path of motion, the net work done remains zero.

**Solution:**

(a) A body undergoing uniform circular motion experiences an inward centripetal force directed radially toward the absolute center of the circular track.

(b) At any point along the path, the instantaneous displacement vector of the moving mass is directed tangentially to the circular boundary line.

(c) The angle between the radial centripetal force vector and the tangential displacement vector is always exactly $90^\circ$.

(d) Using the definition of work, $W = F \cdot d \cdot \cos(90^\circ) = 0$ J.

**Final Answer:** $0$ J

**Answer: (D)**

Go Back to Question 18

## Q19.

### Solution

**Concept:** The commercial unit of electrical energy consumption is the kilowatt-hour (kWh). Total energy is computed by multiplying the combined total power rating in kilowatts by the operating duration in hours.

**Solution:**

(a) The total power rating for all five appliances combined is $P = 5 \times 200$ W $= 1000$ W.

(b) Converting this total electrical wattage into kilowatts gives $P = \frac{1000}{1000} = 1$ kW.

(c) The daily usage time interval for these appliances is given as $t = 6$ hours.

(d) The total energy consumed per day is $E = P \cdot t = 1$ kW $\times$ 6 hours $= 6$ kWh, which corresponds to 6 units.

**Final Answer:** 6.0 units

**Answer: (C)**

Go Back to Question 19

## Q20.

### Solution

**Concept:** For linear motion starting from rest with a constant acceleration ($a$), displacements across consecutive equal intervals of time follow Galileo's law of odd integers.

**Solution:**

(a) The position after the first interval $t = 2$ s is given by the kinematic relation $S_1 = \frac{1}{2}a(2)^2 = 2a$.

(b) The total distance covered from the beginning over the entire combined time of 4 s is $S_{total} = \frac{1}{2}a(4)^2 = 8a$.

(c) The specific distance covered during the second separate 2-second window is $S_2 = S_{total} - S_1 = 8a - 2a = 6a$.

(d) Comparing the values of $S_1$ and $S_2$, we see that $S_2 = 3(2a) = 3S_1$.

**Final Answer:** $S_2 = 3S_1$

**Answer: (B)**

Go Back to Question 20

## Q21.

### Solution

**Concept:** When a liquid container is subjected to heat, thermal energy must pass through the solid walls of the vessel before reaching the fluid medium inside, leading to staggered expansion timelines.

**Solution:**

(a) Initially, the solid outer vessel absorbs the thermal heat energy directly from the source, causing it to expand first. This increases its internal volume capacity.

(b) Because the container expands while the liquid inside has not yet warmed up or expanded, the observed level of the liquid column drops slightly.

(c) Shortly after, heat conducts into the liquid, causing it to expand rapidly. Since liquids typically have higher thermal expansion coefficients than solids, the level then rises steadily.

**Final Answer:** The vessel expands first before heat reaches the liquid inside.

**Answer: (D)**

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## Q22.

### Solution

**Concept:** The focal properties of a spherical convex mirror are determined using the standard mirror formula relating object distance ($u$), virtual image distance ($v$), and mirror focal length ($f$).

**Solution:**

(a) Applying standard Cartesian sign conventions, the real object distance is $u = -12$ cm and the virtual image distance behind the mirror is $v = +6$ cm.

(b) The mirror formula is given by the relation $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$.

(c) Substituting our numerical values yields $\frac{1}{f} = \frac{1}{6} + \frac{1}{-12} = \frac{1}{6} - \frac{1}{12}$.

(d) Finding a common denominator shows $\frac{1}{f} = \frac{2-1}{12} = \frac{1}{12}$, which results in an absolute focal length of $f = +12$ cm.

**Final Answer:** 12 cm

**Answer: (B)**

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## Q23.

### Solution

**Concept:** The electrical resistance of a uniform conductor depends directly on its material resistivity ($\rho$), its total length ($l$), and inversely on its circular cross-sectional area ($A = \pi r^2$).

**Solution:**

(a) The resistance relation is written as $R = \rho\frac{l}{\pi r^2}$. Since both wires are made of copper, their material resistivity $\rho$ is identical.

(b) We are given the length ratio $\frac{l_1}{l_2} = \frac{1}{2}$ and the cross-sectional radius ratio $\frac{r_1}{r_2} = \frac{2}{1}$.

(c) Writing out the ratio of their resistances gives the equation $\frac{R_1}{R_2} = (\frac{l_1}{l_2}) \cdot (\frac{r_2}{r_1})^2$.

(d) Substituting the values yields $\frac{R_1}{R_2} = (\frac{1}{2}) \cdot (\frac{1}{2})^2 = \frac{1}{2} \cdot \frac{1}{4} = \frac{1}{8}$.

**Final Answer:** $1 : 8$

**Answer: (B)**

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## Q24.

### Solution

**Concept:** Linear momentum is defined as the product of mass and velocity ($p = mv$), whereas kinetic energy represents translational motion energy ($K = \frac{1}{2}mv^2$). These two variables can be related algebraically.

**Solution:**

(a) We begin with the standard mathematical equation for kinetic energy: $K = \frac{1}{2}mv^2$.

(b) Multiplying both the numerator and the denominator of this fraction by the mass parameter $m$ yields $K = \frac{m^2v^2}{2m}$.

(c) Recognizing that the numerator expression $m^2v^2$ is equal to $(mv)^2$, we can substitute linear momentum $p$ into the equation.

(d) This substitution produces the definitive relation $K = \frac{p^2}{2m}$.

**Final Answer:** $K = \frac{p^2}{2m}$

**Answer: (A)**

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## Q25.

### Solution

**Concept:** Newton's first law of motion establishes that an object will remain in its current state of rest or uniform motion unless acted upon by an external net force. This intrinsic property is called inertia.

**Solution:**

(a) While the bus remains stationary, both the vehicle and the passenger's entire body are completely at rest.

(b) When the bus abruptly accelerates forward, a forward force is applied directly to the lower body of the passenger through contact with the seat.

(c) However, due to the inertia of rest, the upper body tends to maintain its original stationary position in space.

(d) As a result, the upper body falls backward relative to the moving bus, which represents a response to the inertia of rest.

**Final Answer:** Inertia of rest of the upper body.

**Answer: (B)**

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# Answer Key

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