JEECUP Group A Physics Sample Paper – 7

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 car accelerating uniformly from rest acquires a velocity of 54 km/h in 10 seconds. The distance covered by the car during this time interval is:

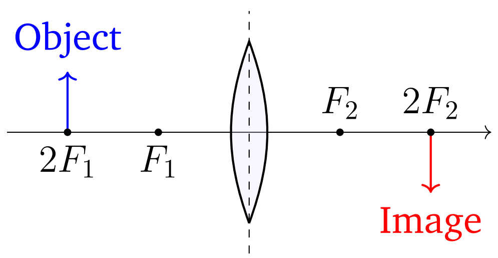
(A) 75 m

(B) 150 m

(C) 270 m

(D) 540 m

Q2. A convex lens of focal length 20 cm forms a real and inverted image of an object. If the size of the image is exactly equal to the size of the object, the distance of the object from the optical center of the lens is:



(A) 10 cm

(B) 20 cm

(C) 40 cm

(D) 80 cm

Q3. A wire of resistance R is stretched uniformly to double its original length. The new resistance of the wire will be:

(A) $R/2$

(B) $2R$

(C) $R/4$

(D) $4R$

Q4. An object of mass 5 kg is dropped from a height of 20 m above the ground. Taking $g = 10\ \text{m/s}^2$ and neglecting air resistance, its kinetic energy just before hitting the ground is:

(A) 100 J

(B) 500 J

(C) 1000 J

(D) 2000 J

Q5. A sound wave travels from a rarer medium to a denser medium. During this transition, which of the following characteristics of the wave remains completely unchanged?

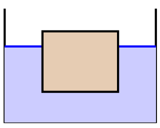
(A) Velocity

(B) Wavelength

(C) Frequency

(D) Amplitude

Q6. A block of wood floats in water with exactly two-thirds of its volume submerged. When placed in an oil, it floats with three-fourths of its volume submerged. The density of the oil is:



(A) $667\ \text{kg/m}^3$

(B) $750\ \text{kg/m}^3$

(C) $889\ \text{kg/m}^3$

(D) $1125\ \text{kg/m}^3$

Q7. How much heat energy is required to completely convert 10 g of ice at $0°$C into liquid water at $20°$C? (Take latent heat of fusion of ice $= 80$ cal/g and specific heat capacity of water $= 1$ cal/g°C)

(A) 200 cal

(B) 800 cal

(C) 1000 cal

(D) 1800 cal

Q8. A radioactive nucleus emits one α-particle followed by two β^--particles. The mass number (A) and atomic number (Z) of the resulting daughter nucleus compared to the original parent nucleus will have:

(A) Same A, decreased Z

(B) Decreased A, same Z

(C) Decreased A, decreased Z

(D) Increased A, same Z

Q9. Three resistors of values $2\ \Omega$, $3\ \Omega$, and $6\ \Omega$ are connected together in a parallel configuration. This combination is then connected across an ideal battery of 6 V. The total current drawn from the battery is:

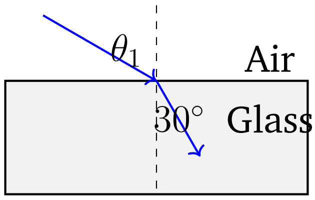
(A) 1 A

(B) 2 A

(C) 6 A

(D) 11 A

Q10. A ray of light enters a rectangular glass slab of refractive index $\sqrt{3}$ from air. If the refracted ray makes an angle of 30° with the normal inside the glass, the angle of incidence in air is:



(A) 30°

(B) 45°

(C) 60°

(D) 90°

Q11. A constant force of 20 N acts on a body of mass 4 kg initially at rest. The kinetic energy acquired by the body at the end of 5 seconds is:

(A) 250 J

(B) 500 J

(C) 1250 J

(D) 2500 J

Q12. Two separate iron spheres, one with a mass of 1 kg and the other with a mass of 4 kg, are dropped simultaneously from the top of a tall tower. Neglecting air resistance, when they are 10 m above the ground, both spheres will have the same:

(A) Momentum

(B) Kinetic energy

(C) Acceleration

(D) Potential energy

Q13. An electric heater rated 2000 W, 220 V is operated daily for 4 hours. What is the total cost of energy consumed in a 30-day month if the commercial rate of electricity is Rs. 5 per unit (kWh)?

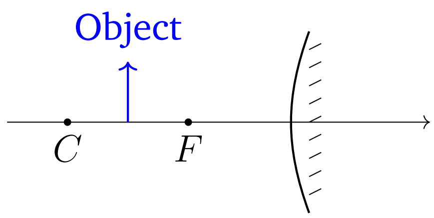
(A) Rs. 240

(B) Rs. 400

(C) Rs. 1200

(D) Rs. 2400

Q14. An object is placed at a distance of 15 cm in front of a concave mirror of focal length 10 cm. The nature and magnification (m) of the image formed are:



(A) Real, $m = -2$

(B) Virtual, $m = +2$

(C) Real, $m = -0.5$

(D) Virtual, $m = +0.5$

Q15. At what temperature do the Celsius and Fahrenheit scales show exactly the same numerical reading?

(A) $-273°$

(B) $-40°$

(C) $0°$

(D) $40°$

Q16. A clinical sonar device emits a sound wave with a frequency of 40 kHz into a biological tissue sample. If the speed of sound in this tissue is 1600 m/s, the wavelength of the wave in the sample is:

(A) 4 cm

(B) 4 mm

(C) 40 mm

(D) 0.4 mm

Q17. In a domestic electrical circuit, all household appliances are connected in a parallel arrangement. This specific layout ensures that:

(A) The current passing through every appliance remains identical.

(B) The total resistance of the household circuit increases.

(C) Every appliance operates at the same rated voltage.

(D) If one appliance fuses, all other appliances stop working immediately.

Q18. The half-life of a specific radioactive isotope is exactly 10 days. If an initial sample contains 80 g of this isotope, the mass of the remaining active isotope left after 30 days will be:

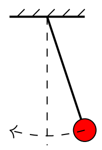
(A) 5 g

(B) 10 g

(C) 20 g

(D) 26.6 g

Q19. A simple pendulum completes 60 full oscillations in a time interval of 2 minutes. The frequency and the time period of this pendulum are respectively:



(A) 0.5 Hz, 2.0 s

(B) 2.0 Hz, 0.5 s

(C) 30 Hz, 0.033 s

(D) 0.5 Hz, 0.5 s

Q20. An engine pumps 600 kg of clean water from a deep well of depth 20 m in exactly one minute. The average power output delivered by the engine is: (Take $g = 10$ m/s^2)

(A) 200 W

(B) 1200 W

(C) 2000 W

(D) 120000 W

Q21. A liquid is filled in a large open container. The pressure exerted by the liquid at a point deep inside the fluid depends directly on:

(A) The total surface area of the container

(B) The shape of the container

(C) The mass of the liquid filled

(D) The depth of the point below the free liquid surface

Q22. A bullet of mass 20 g traveling horizontally at a speed of 150 m/s strikes a stationary wooden block and comes to rest inside it in 0.03 seconds. The magnitude of the average resistive force exerted by the block on the bullet is:

(A) 10 N

(B) 20 N

(C) 100 N

(D) 200 N

Q23. A person standing in front of a large vertical mirror finds that their face appears highly magnified and upright, while their legs appear to be of normal size. This indicates that the mirror is a composite made of:

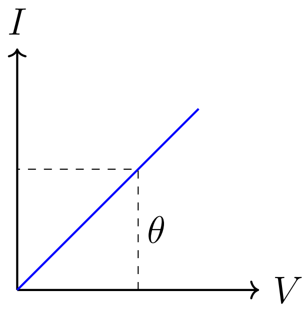
(A) Convex mirror at the top, concave mirror at the bottom

(B) Concave mirror at the top, plane mirror at the bottom

(C) Plane mirror at the top, convex mirror at the bottom

(D) Concave mirror at the top, convex mirror at the bottom

Q24. A student sets up an experiment to verify Ohm's law and plots a graph between potential difference (V) on the x-axis and current (I) on the y-axis for a metallic wire. The slope of this $I - V$ graph represents:



(A) Resistance

(B) Resistivity

(C) Conductance

(D) Conductivity

Q25. Equal masses of two different liquids, X and Y, are heated using identical heaters supplying heat at a constant rate. If the temperature of liquid X rises much faster than that of liquid Y, it can be concluded that:

(A) Specific heat capacity of X is greater than that of Y

(B) Specific heat capacity of X is less than that of Y

(C) Latent heat of X is greater than that of Y

(D) Both liquids have exactly the same specific heat capacity

Detailed Solutions

Q1.

Solution

Concept:
The motion of the car occurs with uniform acceleration starting from rest. We can determine the distance covered by converting the final velocity into standard metric units (m/s) and then utilizing the fundamental equations of rectilinear motion for constant acceleration.

Solution:
Step 1: Write down the given initial parameters.
Initial velocity, $u = 0$ m/s (since it starts from rest)
Time interval, $t = 10$ seconds
Final velocity, $v = 54$ km/h Step 2: Convert the final velocity from kilometers per hour (km/h) to meters per second (m/s) by multiplying with the conversion factor $\frac{5}{18}$:

$$v = 54 \times \frac{5}{18} = 3 \times 5 = 15 \text{ m/s}$$

Step 3: Calculate the uniform acceleration (a) using the first equation of motion, $v = u + at$:

$$15 = 0 + a \times 10$$
$$a = \frac{15}{10} = 1.5 \text{ m/s}^2$$

Step 4: Calculate the total distance covered (s) during this time interval using the second equation of motion, $s = ut + \frac{1}{2}at^2$:

$$s = (0 \times 10) + \frac{1}{2} \times 1.5 \times (10)^2$$
$$s = 0 + \frac{1}{2} \times 1.5 \times 100$$
$$s = 1.5 \times 50 = 75 \text{ m}$$

Step 5: Alternatively, use the average velocity formula for uniform acceleration, where $s = \left(\frac{u+v}{2}\right) \times t$:

$$s = \left(\frac{0 + 15}{2}\right) \times 10 = 7.5 \times 10 = 75 \text{ m}$$

Final Answer: 75 m

Answer: (A) Go Back to Question 1

Q2.

Solution

Concept:
For a thin spherical convex lens, the nature, size, and position of the image formed depend entirely on the relative placement of the object along the principal axis. When a real and inverted image is formed with a magnification magnitude of exactly 1, the object must be positioned at the center of curvature ($2F$) on one side of the lens.

Solution:
Step 1: Identify the properties given for the convex lens.
Focal length, $f = +20$ cm (positive for a converging convex lens)
The image formed is real and inverted, which implies that the image distance (v) is positive.
The size of the image is exactly equal to the size of the object, meaning the magnification (m) is exactly -1.
Step 2: Apply the magnification formula for lenses, $m = \frac{v}{u}$:

$$-1 = \frac{v}{u} \implies v = -u$$

Step 3: Substitute this relation into the standard thin lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$:

$$\frac{1}{20} = \frac{1}{-u} - \frac{1}{u}$$

$$\frac{1}{20} = -\frac{2}{u}$$

$$u = -40 \text{ cm}$$

Step 4: The negative sign confirms that the object is placed in front of the lens on the incident side. The question asks for the absolute distance from the optical center of the lens.

$$\text{Distance} = |u| = 40 \text{ cm}$$

This matches the theoretical position $2f = 2 \times 20 = 40$ cm.
Final Answer: 40 cm

Answer: (C) Go Back to Question 2

Q3.

Solution

Concept:
The electrical resistance of a uniform conductor is directly proportional to its length and inversely proportional to its cross-sectional area. When a wire is stretched mechanically without losing any mass, its total volume remains completely constant. Consequently, an increase in length causes a simultaneous, proportional decrease in its cross-sectional area.

Solution:
Step 1: Express the initial resistance (R) of the wire in terms of its initial length (l), initial cross-sectional area (A), and material resistivity (ρ):

$$R = \rho \frac{l}{A}$$

Step 2: Let the new length of the wire after stretching be l'. According to the problem statement, the wire is stretched to double its length:

$$l' = 2l$$

Step 3: Since the mass and density of the wire do not change, the total volume (V) must remain constant. Write the conservation of volume equation:

$$V = A \times l = A' \times l'$$

Substitute $l' = 2l$ into the volume equivalence:

$$A \times l = A' \times (2l) \implies A' = \frac{A}{2}$$

Step 4: Set up the expression for the new resistance (R') using the modified parameters:

$$R' = \rho \frac{l'}{A'} = \rho \frac{2l}{\left(\frac{A}{2}\right)}$$

$$R' = \rho \frac{4l}{A} = 4 \left(\rho \frac{l}{A}\right)$$

Step 5: Substitute the original resistance value R into the expression:

$$R' = 4R$$

Final Answer: $4R$

Answer: (D) Go Back to Question 3

Q4.

Solution

Concept:
By the law of conservation of mechanical energy, when an object falls freely under the sole influence of gravity without any dissipative forces like air resistance, its total mechanical energy remains constant. The gravitational potential energy lost during the descent is completely converted into kinetic energy just before impact.

Solution:
Step 1: Identify the given mechanical parameters from the text.
Mass of the object, $m = 5$ kg
Initial height, $h = 20$ m
Acceleration due to gravity, $g = 10$ m/s^2
Initial velocity, $u = 0$ m/s (since it is dropped from rest)
Step 2: Calculate the initial gravitational potential energy (U) at the maximum height relative to the ground baseline:

$$U = mgh$$

$$U = 5 \times 10 \times 20 = 1000 \text{ J}$$

Step 3: Since the object starts from rest, its initial kinetic energy (K_{initial}) is equal to zero. Therefore, the total initial mechanical energy is 1000 J.
Step 4: At the moment just before hitting the ground, the final height becomes 0 m, meaning the final potential energy becomes zero. All initial potential energy transforms entirely into final kinetic energy (K_{final}):

$$K_{\text{final}} = U = 1000 \text{ J}$$

Step 5: Alternatively, verify using equations of motion to find the final velocity (v):

$$v^2 = u^2 + 2gh \implies v^2 = 0 + 2 \times 10 \times 20 = 400 \text{ m}^2/\text{s}^2$$

$$K_{\text{final}} = \frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times 400 = 5 \times 200 = 1000 \text{ J}$$

Final Answer: 1000 J

Answer: (C) Go Back to Question 4

Q5.

Solution

Concept:
A sound wave is a mechanical longitudinal wave that requires a material medium to propagate. When any wave transitions from one medium into another with different physical properties, its velocity changes due to differences in elasticity and density. However, the frequency of a wave is determined solely by the vibrating source that creates it.

Solution:
Step 1: Analyze the nature of wave propagation across boundaries. The frequency (ν) of a sound wave represents the number of pressure oscillations produced per second by the source. Once the wave is emitted, its frequency becomes an intrinsic characteristic of that wave packet.

Step 2: Understand the relationship between wave speed (v), wavelength (λ), and frequency (ν), given by the wave equation:

$$v = \nu\lambda$$

Step 3: When sound transitions from a rarer medium (like air) to a denser medium (like water or iron), the mechanical rigidity and bulk modulus change significantly, which causes the propagation velocity (v) to increase.

Step 4: To maintain the consistency of the wave equation because frequency (ν) remains strictly constant, the wavelength (λ) must change proportionally with the velocity. Therefore, as velocity increases, the wavelength also increases.

Step 5: The amplitude of the wave decreases or changes due to partial reflection and energy absorption at the boundary interface. Thus, frequency is the only parameter that remains completely unchanged.

Final Answer: Frequency

Answer: (C) Go Back to Question 5

Q6.

Solution

Concept:
According to Archimedes' principle and the law of floatation, for any floating body, the weight of the floating object is exactly equal to the buoyant force exerted on it by the displaced liquid. The buoyant force depends directly on the volume of the submerged part of the body and the density of the fluid.

Solution:
Step 1: State the variables for the system. Let the total volume of the wooden block be V. Let the density of the wooden block be ρ_w. The density of water is $\rho_{\text{water}} = 1000\ \text{kg/m}^3$. Let the density of the unknown oil be ρ_{oil}. Step 2: Set up the equilibrium equation for the block floating in water. The submerged volume is given as $\frac{2}{3}V$:

$$\text{Weight of block} = \text{Buoyant force in water}$$

$$V\rho_w g = \left(\frac{2}{3}V\right)\rho_{\text{water}} g$$

$$\rho_w = \frac{2}{3}\rho_{\text{water}}$$

Step 3: Set up the equilibrium equation for the same block floating in the oil. Here, the submerged volume is given as $\frac{3}{4}V$:

$$\text{Weight of block} = \text{Buoyant force in oil}$$

$$V\rho_w g = \left(\frac{3}{4}V\right)\rho_{\text{oil}} g$$

$$\rho_w = \frac{3}{4}\rho_{\text{oil}}$$

Step 4: Equate the two expressions obtained for the density of wood (ρ_w):

$$\frac{2}{3}\rho_{\text{water}} = \frac{3}{4}\rho_{\text{oil}}$$

Step 5: Solve explicitly for the density of the oil (ρ_{oil}) by substituting the known density of water:

$$\rho_{\text{oil}} = \frac{8}{9}\rho_{\text{water}}$$

$$\rho_{\text{oil}} = \frac{8}{9} \times 1000 = \frac{8000}{9} \approx 888.89\ \text{kg/m}^3$$

Rounding to the nearest integer gives $889\ \text{kg/m}^3$.

Final Answer: $\boxed{889\ \text{kg/m}^3}$

Answer: (C) **Go Back to Question 6**

Q7.

Solution

Concept:
The total thermal energy required to change the state and temperature of a substance is computed in distinct steps. First, heat is absorbed at a constant temperature during a phase transformation (latent heat). Second, heat is absorbed to raise the temperature of the resulting single-phase substance (specific heat).

Solution:
Step 1: Divide the process into two consecutive thermal stages.
Stage 1: Phase change converting ice at $0°$C to liquid water at $0°$C.
Stage 2: Temperature rise converting liquid water at $0°$C to liquid water at $20°$C.
Step 2: Calculate the heat energy required for Stage 1 (Q_1) using the latent heat equation, $Q = mL_f$:
Mass of ice, $m = 10$ g
Latent heat of fusion, $L_f = 80$ cal/g

$$Q_1 = 10 \times 80 = 800 \text{ cal}$$

Step 3: Calculate the heat energy required for Stage 2 (Q_2) using the specific heat formula, $Q = mc\Delta\theta$:
Specific heat capacity of water, $c = 1$ cal/g°C
Temperature change, $\Delta\theta = 20°\text{C} - 0°\text{C} = 20°\text{C}$

$$Q_2 = 10 \times 1 \times 20 = 200 \text{ cal}$$

Step 4: Sum the heat values from both stages to find the total heat energy required (Q_{total}):

$$Q_{\text{total}} = Q_1 + Q_2$$

$$Q_{\text{total}} = 800 + 200 = 1000 \text{ cal}$$

Final Answer: 1000 cal

Answer: (C) Go Back to Question 7

Q8.

Solution

Concept:

Radioactive decay changes the composition of a nucleus. An alpha (α) decay reduces the mass number by 4 and the atomic number by 2 due to the emission of a helium nucleus ($^4_2$He). A beta-minus (β^-) decay converts a neutron into a proton, emitting an electron ($^{0}_{-1}$e), which leaves the mass number unchanged while increasing the atomic number by 1.

Solution:

Step 1: Let the original parent nucleus be represented as ^A_ZX, where A is the initial mass number and Z is the initial atomic number.

Step 2: Write the nuclear reaction for the emission of one α-particle. This produces an intermediate nucleus $^{A'}_{Z'}$Y:

$$^A_Z\text{X} \longrightarrow \, ^{A-4}_{Z-2}\text{Y} + \, ^4_2\text{He}$$

Thus, after alpha decay:

New mass number, $A' = A - 4$

New atomic number, $Z' = Z - 2$

Step 3: Write the nuclear reaction for the consecutive emission of two β^--particles from the intermediate nucleus $^{A-4}_{Z-2}$Y. Each beta particle increases the atomic number by 1 and leaves the mass number unchanged:

$$^{A-4}_{Z-2}\text{Y} \longrightarrow \, ^{A-4}_{(Z-2)+2}\text{D} + 2\, ^{0}_{-1}\text{e}$$

Simplifying the atomic number of the final daughter nucleus D:

$$Z_{\text{final}} = (Z - 2) + 2 = Z$$

$$A_{\text{final}} = A - 4$$

Step 4: Compare the final parameters with the original parent nucleus. The mass number has decreased by 4 (decreased A), and the atomic number remains exactly the same (same Z).

Final Answer: Decreased A, same Z

Answer: (B) Go Back to Question 8

Q9.

Solution

Concept:

For a parallel combination of resistors, the reciprocal of the total equivalent resistance is equal to the sum of the reciprocals of the individual resistances. Once the total equivalent resistance is determined, the total current drawn from an ideal source can be calculated directly using Ohm's law.

Solution:

Step 1: List the values of the parallel resistors.

$R_1 = 2\ \Omega$, $R_2 = 3\ \Omega$, $R_3 = 6\ \Omega$

Applied Voltage, $V = 6$ V

Step 2: Calculate the equivalent resistance (R_{eq}) using the parallel combination formula:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$$

Step 3: Find a common denominator to add the fractions, which is 6:

$$\frac{1}{R_{eq}} = \frac{3+2+1}{6} = \frac{6}{6} = 1\ \Omega^{-1}$$

Taking the reciprocal gives:

$$R_{eq} = 1\ \Omega$$

Step 4: Apply Ohm's law to determine the total electric current (I) drawn from the battery source:

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

$$I = \frac{6\ \text{V}}{1\ \Omega} = 6\ \text{A}$$

Final Answer: 6 A

Answer: (C) Go Back to Question 9

Q10.

Solution

Concept:
When a ray of light crosses a boundary between two media with different refractive indices, it undergoes refraction. The angle of incidence and the angle of refraction are mathematically linked by Snell's law, which states that the product of the refractive index and the sine of the angle with the normal is constant across the interface.

Solution:
Step 1: Identify the given values from the problem statement.
Refractive index of the first medium (air), $n_1 = 1$
Refractive index of the second medium (glass slab), $n_2 = \sqrt{3}$
Angle of refraction inside the glass, $r = 30^\circ$
Let the angle of incidence in air be i.
Step 2: State and set up Snell's law for the air-glass interface:

$$n_1 \sin(i) = n_2 \sin(r)$$

Step 3: Substitute the known values into the mathematical relation:

$$1 \times \sin(i) = \sqrt{3} \times \sin(30^\circ)$$

Step 4: Use the standard trigonometric value $\sin(30^\circ) = \frac{1}{2}$:

$$\sin(i) = \sqrt{3} \times \frac{1}{2} = \frac{\sqrt{3}}{2}$$

Step 5: Determine the angle i whose sine evaluates to $\frac{\sqrt{3}}{2}$ within the standard domain:

$$i = \arcsin\left(\frac{\sqrt{3}}{2}\right) = 60^\circ$$

Final Answer: 60°

Answer: (C) Go Back to Question 10

Q11.

Solution

Concept:
According to Newton's second law of motion, a net constant force acting on a mass produces a uniform acceleration. We can find the final velocity acquired by the body over a given time interval using kinematics, and then calculate the final kinetic energy using the standard kinetic energy formula.

Solution:
Step 1: Identify the given parameters.
Constant force, $F = 20$ N
Mass of the body, $m = 4$ kg
Initial velocity, $u = 0$ m/s (since it is initially at rest)
Time interval, $t = 5$ seconds
Step 2: Calculate the uniform acceleration (a) using Newton's second law:

$$a = \frac{F}{m} = \frac{20}{4} = 5 \text{ m/s}^2$$

Step 3: Determine the final velocity (v) at the end of 5 seconds using the first equation of motion:

$$v = u + at$$

$$v = 0 + 5 \times 5 = 25 \text{ m/s}$$

Step 4: Calculate the kinetic energy (K) acquired by the body using the formula:

$$K = \frac{1}{2}mv^2$$

$$K = \frac{1}{2} \times 4 \times (25)^2$$

$$K = 2 \times 625 = 1250 \text{ J}$$

Step 5: Alternatively, apply the impulse-momentum theorem. Impulse $= F \times t = 20 \times 5 = 100$ N $\cdot$ s
Final momentum, $p =$ Impulse $= 100$ kg $\cdot$ m/s

$$K = \frac{p^2}{2m} = \frac{100^2}{2 \times 4} = \frac{10000}{8} = 1250 \text{ J}$$

Final Answer: 1250 J

Answer: (C) Go Back to Question 11

Q12.

Solution

Concept:
In the absence of air resistance, all objects falling freely near the surface of the Earth experience the same acceleration due to gravity (g), regardless of their mass. This principle of equivalence ensures that their kinematic parameters develop identically over time if they are dropped from rest simultaneously.

Solution:
Step 1: Analyze the motion of the two spheres.
Sphere 1 mass, $m_1 = 1$ kg
Sphere 2 mass, $m_2 = 4$ kg
Both are dropped from the same height with an initial velocity $u = 0$ m/s.
Step 2: According to the equations of motion, the velocity (v) of a freely falling body at any given distance or position depends only on the gravitational acceleration and the vertical distance fallen (s):

$$v^2 = u^2 + 2gs \implies v = \sqrt{2gs}$$

Since u, g, and s are identical for both spheres when they reach a height of 10 m above the ground, both spheres will have exactly the same velocity.
Step 3: Evaluate the options systematically based on mass dependence:
Momentum $= mv$ (depends on mass, so it will differ)
Kinetic Energy $= \frac{1}{2}mv^2$ (depends on mass, so it will differ)
Potential Energy $= mgh$ (depends on mass, so it will differ)
Acceleration $= g$ (completely independent of the mass of the object)
Step 4: Since the acceleration for any freely falling object is equal to $g \approx 9.8$ m/s^2 or 10 m/s^2, both objects share this identical value at all points during their descent.

Final Answer: Acceleration

Answer: (C) Go Back to Question 12

Q13.

Solution

Concept:
The commercial unit of electrical energy consumption is the kilowatt-hour (kWh), which is commonly referred to as a single electrical 'unit'. The total energy consumed depends on the power rating of the appliance in kilowatts and the total operating time in hours. The financial cost is found by multiplying the total units by the unit price.

Solution:
Step 1: Write down the given operational parameters.
Power rating of the heater, $P = 2000$ W
Daily usage duration, $t = 4$ hours
Total billing period, $N = 30$ days
Rate per unit of energy = Rs. 5
Step 2: Convert the power rating from watts (W) to kilowatts (kW):

$$P = \frac{2000}{1000} = 2 \text{ kW}$$

Step 3: Calculate the total operating time (T) over the entire 30-day month:

$$T = 4 \text{ hours/day} \times 30 \text{ days} = 120 \text{ hours}$$

Step 4: Compute the total electrical energy consumed (E) in kilowatt-hours (kWh):

$$E = P \times T = 2 \text{ kW} \times 120 \text{ hours} = 240 \text{ kWh}$$

This is equal to exactly 240 electrical units.
Step 5: Calculate the total financial cost by multiplying the units consumed by the billing rate:

$$\text{Total Cost} = 240 \times \text{Rs. } 5 = \text{Rs. } 1200$$

Final Answer: Rs. 1200

Answer: (C) **Go Back to Question 13**

Q14.

Solution

Concept:
For a spherical concave mirror, the position and characteristics of the image are governed by the mirror formula and the magnification relation. Comparing the object distance to the focal length and radius of curvature provides a direct conceptual check on the nature and size of the image.

Solution:
Step 1: Write down the given values using the standard Cartesian sign convention.
Focal length of the concave mirror, $f = -10$ cm
Object distance, $u = -15$ cm
Step 2: Apply the standard mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, to locate the image distance (v):

$$\frac{1}{-10} = \frac{1}{v} + \frac{1}{-15}$$

$$\frac{1}{v} = \frac{1}{15} - \frac{1}{10}$$

Step 3: Find a common denominator to subtract the fractions, which is 30:

$$\frac{1}{v} = \frac{2-3}{30} = -\frac{1}{30}$$

$$v = -30 \text{ cm}$$

Step 4: Determine the magnification (m) of the image using the mirror magnification formula:

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

$$m = -\frac{-30}{-15} = -2$$

Step 5: Interpret the negative sign and magnitude of the magnification value:
The negative sign indicates that the image is real and inverted.
The absolute value $|m| = 2$ means the image is twice the size of the object (magnified).
This matches the conceptual rule that an object placed between F and C (10 cm and 20 cm) produces a real, inverted, and magnified image beyond C.
Final Answer: Real, $m = -2$

Answer: (A) Go Back to Question 14

Q15.

Solution

Concept:
The Celsius (°C) and Fahrenheit (°F) temperature scales are linear scales calibrated differently based on the freezing and boiling points of water. We can determine the specific temperature where both scales share the same numerical value by solving the standard linear conversion equation.

Solution:
Step 1: State the mathematical conversion formula that links the Celsius scale (C) and the Fahrenheit scale (F):

$$\frac{C}{5} = \frac{F - 32}{9}$$

Step 2: Let x be the common numerical temperature value where both scales show the exact same reading:

$$C = F = x$$

Step 3: Substitute x into the conversion relationship:

$$\frac{x}{5} = \frac{x - 32}{9}$$

Step 4: Perform cross-multiplication to solve the linear algebraic equation:

$$9x = 5(x - 32)$$

$$9x = 5x - 160$$

Step 5: Isolate the variable x by subtracting $5x$ from both sides:

$$4x = -160$$

$$x = -\frac{160}{4} = -40$$

Therefore, -40°C is exactly equal to -40°F.

Final Answer: $\boxed{-40^\circ}$

Answer: (B) Go Back to Question 15

Q16.

Solution

Concept:
The basic wave equation relates the speed of a wave to its frequency and wavelength. When working with ultra-high frequency acoustic waves like sonar or ultrasound, it is important to convert the given parameters into standard SI metric units to avoid errors before performing calculations.
Solution:
Step 1: Write down the given parameters.
Frequency, $\nu = 40$ kHz
Speed of sound in tissue, $v = 1600$ m/s
Step 2: Convert the wave frequency from kilohertz (kHz) into standard hertz (Hz):

$$\nu = 40 \times 1000 = 40000 \text{ Hz} = 4 \times 10^4 \text{ Hz}$$

Step 3: State the standard wave equation that isolates the wavelength (λ):

$$v = \nu\lambda \implies \lambda = \frac{v}{\nu}$$

Step 4: Substitute the values into the equation to calculate the wavelength in meters:

$$\lambda = \frac{1600}{40000} = \frac{16}{400} = \frac{4}{100} = 0.04 \text{ m}$$

Step 5: Convert the calculated value from meters into millimeters (mm) to match the given options:

$$\lambda = 0.04 \times 1000 \text{ mm} = 40 \text{ mm}$$

Final Answer: 40 mm

Answer: (C) Go Back to Question 16

Q17.

Solution

Concept:
In electrical circuit design, a parallel connection connects each component across the same two common nodes. This ensures that every branch experiences the exact same electric potential difference (voltage), allowing individual appliances to operate independently at their rated specifications.

Solution:
Step 1: Analyze the fundamental properties of a parallel circuit configuration. In a parallel arrangement, the positive terminals of all appliances are effectively connected to one common live wire node, and their negative terminals connect to the neutral wire node.

Step 2: Because they are connected across the same common nodes, the potential difference across every single appliance is equal to the main supply voltage (typically 220 V in domestic lines). This allows each appliance to draw current based on its own power rating.

Step 3: Evaluate option (A): The current in a parallel circuit splits among the branches based on their individual resistances, so it does not remain identical. Thus, option (A) is incorrect.

Step 4: Evaluate option (B): The total equivalent resistance of a parallel circuit decreases as more branches are added ($\frac{1}{R_{eq}} = \sum \frac{1}{R_i}$). Thus, option (B) is incorrect.

Step 5: Evaluate option (D): If one appliance fails or is turned off, the remaining parallel branches stay connected to the voltage source and continue to operate normally. This independent operation is the main reason household circuits use parallel wiring rather than series wiring. Therefore, option (C) is the correct statement.

Final Answer: Every appliance operates at the same rated voltage.

Answer: (C) Go Back to Question 17

Q18.

Solution

Concept:

Radioactive decay follows a statistical first-order kinetic process where the amount of a remaining active isotope decreases by half during each consecutive half-life period. The final remaining mass can be calculated using the number of half-lives that elapse over the total time interval.

Solution:

Step 1: Identify the given radioactive parameters.
Initial mass of the isotope, $M_0 = 80$ g
Half-life period, $T_{1/2} = 10$ days
Total time elapsed, $t = 30$ days

Step 2: Determine the total number of half-lives (n) that occur during the given time interval:

$$n = \frac{t}{T_{1/2}} = \frac{30}{10} = 3 \text{ half-lives}$$

Step 3: State the standard exponential decay formula for mass retention:

$$M = M_0 \left(\frac{1}{2}\right)^n$$

Step 4: Substitute the parameters into the equation to calculate the remaining mass (M):

$$M = 80 \left(\frac{1}{2}\right)^3$$

$$M = 80 \times \frac{1}{8} = 10 \text{ g}$$

Step 5: Alternatively, trace the decay step-by-step:
Initial amount $= 80$ g
After 1st half-life (10 days) $= 40$ g
After 2nd half-life (20 days) $= 20$ g
After 3rd half-life (30 days) $= 10$ g

Final Answer: $\boxed{10 \text{ g}}$

Answer: (B) Go Back to Question 18

Q19.

Solution

Concept:
The frequency of an oscillating system is defined as the total number of complete cycles or oscillations performed per unit of time (specifically per second). The time period is the duration required to complete one single oscillation, and it is the reciprocal of the frequency.

Solution:
Step 1: Write down the operational parameters of the pendulum.
Total number of complete oscillations, $N = 60$
Total time taken, $t = 2$ minutes
Step 2: Convert the total time from minutes into standard SI seconds:

$$t = 2 \times 60 = 120 \text{ seconds}$$

Step 3: Calculate the oscillation frequency (f) in hertz (Hz), which represents cycles per second:

$$f = \frac{\text{Total Oscillations}}{\text{Total Time}}$$

$$f = \frac{60}{120} = 0.5 \text{ Hz}$$

Step 4: Calculate the time period (T) of the pendulum, which is the reciprocal of the frequency:

$$T = \frac{1}{f}$$

$$T = \frac{1}{0.5} = 2.0 \text{ seconds}$$

Step 5: Alternatively, calculate the time period directly by dividing the total time by the total number of oscillations:

$$T = \frac{120 \text{ seconds}}{60} = 2.0 \text{ seconds}$$

This gives a frequency of 0.5 Hz and a time period of 2.0 s.

Final Answer: $\boxed{0.5 \text{ Hz, } 2.0 \text{ s}}$

Answer: (A) Go Back to Question 19

Q20.

Solution

Concept:
Power is defined as the rate at which work is performed or energy is transferred over time. For an engine lifting a mass against gravity, the work done equals the change in the gravitational potential energy of the lifted mass.

Solution:
Step 1: Write down the given parameters.
Mass of water lifted, $m = 600$ kg
Vertical height (depth), $h = 20$ m
Time taken, $t = 1$ minute
Acceleration due to gravity, $g = 10$ m/s^2
Step 2: Convert the time interval from minutes into standard SI seconds:

$$t = 1 \times 60 = 60 \text{ seconds}$$

Step 3: Calculate the total work done (W) by the engine to lift the water, which equals the change in gravitational potential energy (mgh):

$$W = mgh$$

$$W = 600 \times 10 \times 20 = 120000 \text{ J}$$

Step 4: Compute the average power output (P) by dividing the total work done by the time taken:

$$P = \frac{W}{t}$$

$$P = \frac{120000 \text{ J}}{60 \text{ seconds}} = 2000 \text{ W}$$

Step 5: Double-check the unit cancellation. Joules per second is equivalent to Watts (W). The final calculated power output is 2000 W (or 2 kW).

Final Answer: 2000 W

Answer: (C) Go Back to Question 20

Q21.

Solution

Concept:
The hydrostatic pressure exerted by a static fluid column at any point inside a liquid depends on the weight of the fluid column directly above that point. This pressure can be calculated using the hydrostatic formula, which accounts for the liquid density, gravitational acceleration, and the vertical depth below the free surface.

Solution:
Step 1: State the formula for the gauge pressure (P) exerted by a liquid column at a vertical depth h below its free surface:

$$P = h\rho g$$

Where:
h = vertical depth below the free surface
ρ = mass density of the liquid
g = acceleration due to gravity
Step 2: Analyze the mathematical variables in the formula. The formula shows that for a given liquid (ρ constant) at a fixed location (g constant), the pressure depends only on the depth (h).
Step 3: Notice that the surface area of the container, the total mass of the liquid filled, and the overall shape of the vessel do not appear in this expression. This lack of dependence on container shape is known as the hydrostatic paradox.
Step 4: Therefore, the pressure at any deep point within a fluid depends directly on the vertical depth of that point below the free liquid surface.

Final Answer: The depth of the point below the free liquid surface

Answer: (D) Go Back to Question 21

Q22.

Solution

Concept:
According to the impulse-momentum theorem, which is derived from Newton's second law of motion, the average net force acting on an object is equal to its change in linear momentum divided by the time interval during which that change occurs.

Solution:
Step 1: Write down the given parameters.
Mass of the bullet, $m = 20$ g
Initial horizontal velocity, $u = 150$ m/s
Final horizontal velocity, $v = 0$ m/s (since it comes to rest)
Time interval, $\Delta t = 0.03$ seconds
Step 2: Convert the mass of the bullet from grams (g) to standard kilograms (kg):

$$m = \frac{20}{1000} = 0.02 \text{ kg}$$

Step 3: Calculate the initial momentum (p_{initial}) and final momentum (p_{final}) of the bullet:

$$p_{\text{initial}} = m \times u = 0.02 \times 150 = 3 \text{ kg} \cdot \text{m/s}$$

$$p_{\text{final}} = m \times v = 0.02 \times 0 = 0 \text{ kg} \cdot \text{m/s}$$

Step 4: Calculate the magnitude of the change in momentum (Δp):

$$|\Delta p| = |p_{\text{final}} - p_{\text{initial}}| = |0 - 3| = 3 \text{ kg} \cdot \text{m/s}$$

Step 5: Calculate the average resistive force (F) using the momentum equation:

$$F = \frac{|\Delta p|}{\Delta t} = \frac{3}{0.03} = \frac{300}{3} = 100 \text{ N}$$

Final Answer: 100 N

Answer: (C) Go Back to Question 22

Q23.

Solution

Concept:
Different types of spherical and plane mirrors produce different image characteristics based on the object distance. A plane mirror always forms a virtual image of the same size ($m = +1$). A concave mirror can produce an upright, highly magnified virtual image when an object is placed close to it, within its focal length.

Solution:
Step 1: Break down the observer's description of their reflection into two separate parts:
Part 1: The face appears upright and highly magnified.
Part 2: The legs appear to be of normal size.
Step 2: Analyze the optical properties required for Part 1. A mirror that produces an upright, magnified image of an object placed close to it must be a concave mirror. Neither plane mirrors (which form same-size images) nor convex mirrors (which form diminished images) can produce a magnified upright image. Thus, the top portion of the mirror must be concave.
Step 3: Analyze the optical properties required for Part 2. A mirror that produces an upright image of normal, identical size must be a plane mirror. Thus, the bottom portion of the composite mirror must be a plane mirror.
Step 4: Combine these findings. The mirror is a composite structure consisting of a concave mirror at the top section and a plane mirror at the bottom section.

Final Answer: Concave mirror at the top, plane mirror at the bottom

Answer: (B) Go Back to Question 23

Q24.

Solution

Concept:

Ohm's law defines the linear relationship between voltage (V) and current (I) for an ohmic conductor, written as $V = IR$. When graphing this relationship, the property represented by the slope depends on which variable is plotted on each axis.

Solution:

Step 1: Identify the variables assigned to each axis on the student's graph.

Horizontal axis (x-axis) = Potential difference (V)

Vertical axis (y-axis) = Current (I)

Step 2: State the definition of the slope for a straight-line graph plotted on Cartesian coordinates:

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta I}{\Delta V}$$

Step 3: Rearrange the standard Ohm's law equation ($V = IR$) to express the ratio of current to voltage:

$$\frac{I}{V} = \frac{1}{R}$$

Step 4: Identify the physical term for the reciprocal of electrical resistance ($\frac{1}{R}$). The reciprocal of resistance is defined as electrical conductance (G):

$$G = \frac{1}{R} = \frac{I}{V}$$

Step 5: Conclude that the slope of this specific $I - V$ graph represents conductance. Note that if V were plotted on the y-axis and I on the x-axis, the slope would represent resistance (R). For this current-versus-voltage configuration, it represents conductance.

Final Answer: Conductance

Answer: (C) Go Back to Question 24

Q25.

Solution

Concept:
The specific heat capacity of a substance determines how much thermal energy is needed to change the temperature of a unit mass by one degree. When heat is supplied at a constant rate, the rate of temperature rise is inversely proportional to the substance's specific heat capacity.

Solution:
Step 1: Write down the specific heat equation that relates heat transfer (Q) to temperature change ($\Delta\theta$):

$$Q = mc\Delta\theta$$

Step 2: Express this relationship as a rate by dividing both sides by time (t):

$$\frac{Q}{t} = mc\left(\frac{\Delta\theta}{t}\right)$$

Where $\frac{Q}{t}$ is the heat supply rate, and $\frac{\Delta\theta}{t}$ is the rate of temperature rise.
Step 3: Account for the constants given in the problem statement. Both liquids have equal masses ($m_X = m_Y = m$), and they are heated by identical heaters supplying heat at the same rate ($\frac{Q}{t} = \text{constant}$).
Step 4: Rearrange the equation to isolate the rate of temperature rise:

$$\frac{\Delta\theta}{t} = \frac{\left(\frac{Q}{t}\right)}{m \cdot c} \implies \frac{\Delta\theta}{t} \propto \frac{1}{c}$$

This shows that the rate of temperature rise is inversely proportional to the specific heat capacity (c).
Step 5: The problem states that the temperature of liquid X rises much faster than that of liquid Y:

$$\left(\frac{\Delta\theta}{t}\right)_X > \left(\frac{\Delta\theta}{t}\right)_Y \implies c_X < c_Y$$

Therefore, the specific heat capacity of liquid X is less than that of liquid Y.
Final Answer: Specific heat capacity of X is less than that of Y

Answer: (B) Go Back to Question 25

Answer Key

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