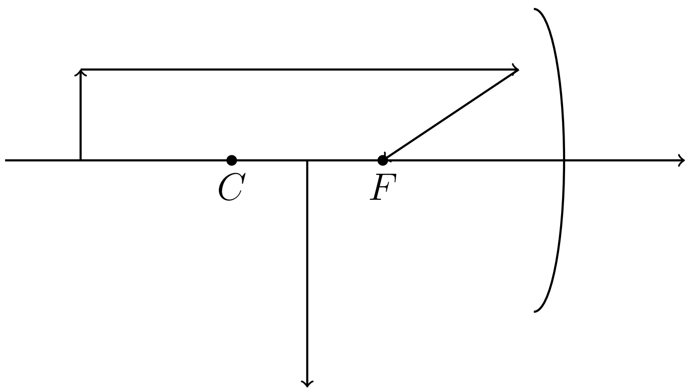
JEECUP Group A Physics Sample Paper – 15

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 concave mirror forms a real image three times the size of an object placed on the principal axis. If the distance between the object and image is 40 cm, then the focal length of the mirror is:



(A) 5 cm

(B) 10 cm

(C) 15 cm

(D) 20 cm

Q2. A ray of light travelling in glass of refractive index $\frac{3}{2}$ strikes the glass-air interface. The angle of incidence is gradually increased. The angle at which the refracted ray just grazes the surface is:

(A) 30°

(B) 42°

(C) 48°

(D) 60°

Q3. An object is placed at a distance of 30 cm from a convex lens of focal length 20 cm. The image formed by the lens is shifted by 10 cm when another convex lens of focal length 60 cm is placed in contact with it. The equivalent focal length of the combination is:

(A) 12 cm

(B) 15 cm

(C) 18 cm

(D) 24 cm

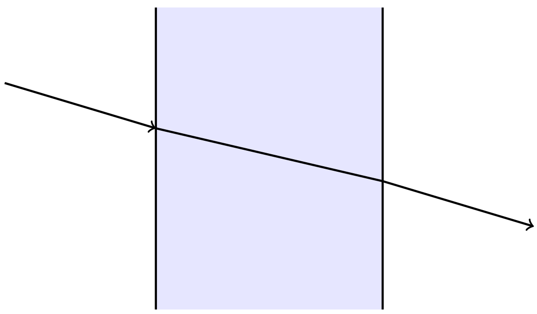
Q4. A light ray enters a glass slab obliquely and emerges parallel to its original direction. If the thickness of the slab is doubled while keeping angle of incidence unchanged, then the lateral displacement will:

(A) Become half

(B) Remain same

(C) Double

(D) Become zero



Q5. An object of height 4 cm is placed in front of a concave mirror. The image formed is virtual, erect and twice the size of the object. The object distance from the mirror is:

(A) Equal to focal length

(B) Less than focal length

(C) Greater than radius of curvature

(D) Equal to radius of curvature

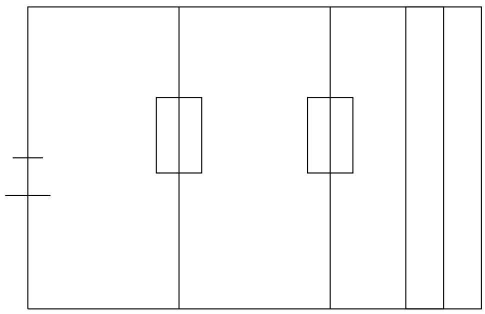
Q6. Three resistors of resistances 2Ω, 3Ω and 6Ω are connected in parallel across a battery. The equivalent resistance of the combination is:

(A) 1Ω

(B) 2Ω

(C) 3Ω

(D) 6Ω



Q7. A heater coil connected to a 220 V source produces 4840 J heat energy in 10 seconds. The resistance of the coil is:

(A) 10Ω

(B) 50Ω

(C) 100Ω

(D) 220Ω

Q8. Two bulbs rated 100 W, 220 V and 60 W, 220 V are connected in series across a 220 V source. Which bulb will glow brighter?

(A) 100 W bulb

(B) 60 W bulb

(C) Both equally bright

(D) Neither glows

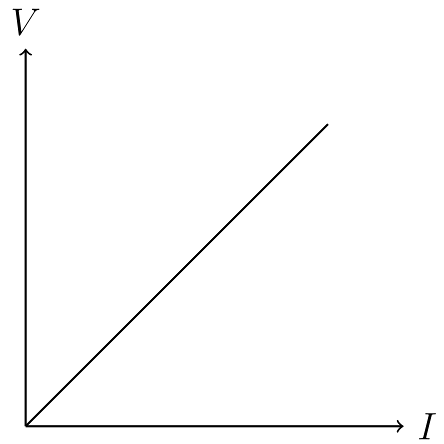
Q9. The graph between potential difference and current for a metallic conductor at constant temperature is shown below. The slope of the graph represents:

(A) Resistance

(B) Current

(C) Power

(D) Charge



Q10. A fuse wire should have low melting point and high resistivity because during excess current it should:

(A) Conduct more current

(B) Melt quickly and break circuit

(C) Reduce resistance of circuit

(D) Increase voltage

Q11. A body starting from rest moves with uniform acceleration and covers distances x, $3x$, and $5x$ in successive equal intervals of time. The ratio of distances confirms:

(A) Uniform velocity

(B) Uniform acceleration

(C) Retardation

(D) Circular motion

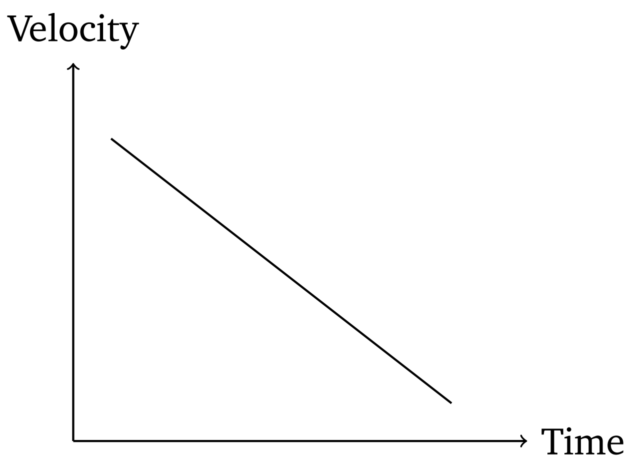
Q12. A car moving at 20 m/s is brought to rest uniformly in 5 seconds. The retardation produced in the car is:

(A) 2 m/s^2

(B) 4 m/s^2

(C) 5 m/s^2

(D) 10 m/s^2



Q13. Two bodies of masses 2 kg and 4 kg moving with velocities 6 m/s and 3 m/s respectively collide and stick together. The common velocity after collision is:

(A) 2 m/s

(B) 3 m/s

(C) 4 m/s

(D) 5 m/s

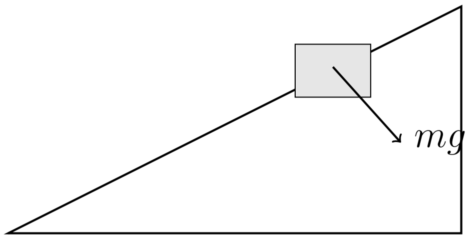
Q14. A block slides down an inclined rough surface with constant velocity. Which of the following forces balances the component of gravitational force along the incline?

(A) Normal reaction

(B) Frictional force

(C) Weight

(D) Tension



Q15. A force acts on a body but no displacement occurs. In this situation the work done by the force is:

(A) Positive

(B) Negative

(C) Maximum

(D) Zero

Q16. A body projected vertically upward returns to the point of projection after some time. Neglecting air resistance, which quantity remains conserved throughout the motion?

(A) Kinetic energy only

(B) Potential energy only

(C) Mechanical energy

(D) Momentum only

Q17. A machine lifts a load of 500 N through a height of 2 m in 5 seconds. The power developed by the machine is:

(A) 50 W

(B) 100 W

(C) 200 W

(D) 500 W

Q18. Equal masses of water at $90°C$ and $30°C$ are mixed in a perfectly insulated vessel. The final temperature of the mixture will be:

(A) $45°C$

(B) $50°C$

(C) $60°C$

(D) $75°C$

Q19. The handle of cooking utensils is generally made of wood or bakelite because these materials are:

(A) Good conductors of heat

(B) Good conductors of electricity

(C) Poor conductors of heat

(D) Highly elastic

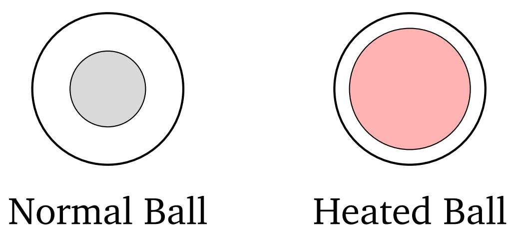
Q20. A metal ball passes through a metal ring at room temperature. On heating the ball strongly, the ball no longer passes through the ring because of:

(A) Increase in density

(B) Thermal expansion

(C) Increase in mass

(D) Change in shape only



Q21. A sound wave has wavelength 0.5 m and frequency 660 Hz. The speed of sound corresponding to the wave is:

(A) 165 m/s

(B) 220 m/s

(C) 330 m/s

(D) 660 m/s

Q22. A person hears an echo after 2 seconds. If the speed of sound in air is 340 m/s, then the distance between the person and the reflecting surface is:

(A) 170 m

(B) 340 m

(C) 680 m

(D) 1360 m

Q23. During radioactive decay, a nucleus emits a β-particle. Which change occurs in the nucleus?

(A) Mass number decreases by 4

(B) Atomic number increases by 1

(C) Atomic number decreases by 2

(D) Mass number increases by 1

Q24. Among α, β, and γ radiations, the radiation possessing maximum penetrating power and minimum ionising power is:

(A) α-rays

(B) β-rays

(C) γ-rays

(D) Cathode rays

Q25. Three holes are made at different depths in the side of a water tank. The water coming out from the lowest hole goes farthest because:

(A) Pressure is maximum at greater depth

(B) Density of water increases downward

(C) Temperature is highest at bottom

(D) Atmospheric pressure decreases

Detailed Solutions

Q1.

Solution

Concept: For a spherical mirror:

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

and

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

For a concave mirror forming a real image:

$$m < 0, \quad u < 0, \quad v < 0$$

Solution: Step 1: Using magnification:

$$-3 = -\frac{v}{u} \Rightarrow v = 3u$$

Let:

$$u = -x, \quad v = -3x$$

Step 2: Distance between object and image:

$$|v - u| = |-3x - (-x)| = 2x$$

$$2x = 40 \Rightarrow x = 20$$

Thus,

$$u = -20 \text{ cm}, \quad v = -60 \text{ cm}$$

Step 3: Using mirror formula:

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

$$\frac{1}{f} = -\frac{1}{15} \Rightarrow f = -15 \text{ cm}$$

Final Answer: $\boxed{15 \text{ cm}}$

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: When light travels from an optically denser medium (glass) to an optically rarer medium (air), the angle of refraction (r) is larger than the angle of incidence (i).

- The critical angle (C) is the specific angle of incidence in the denser medium for which the corresponding angle of refraction is exactly $90°$. At this angle, the refracted ray just grazes the boundary of separation.
- Using Snell's Law:

$$\mu_{\text{glass}} \cdot \sin C = \mu_{\text{air}} \cdot \sin 90° \implies \sin C = \frac{1}{\mu_{\text{glass}}}$$

Solution: Step 1: Identify the given parameters:

$$\text{Refractive index of glass, } \mu_{\text{glass}} = \frac{3}{2} = 1.5$$

$$\text{Refractive index of air, } \mu_{\text{air}} = 1.0$$

Step 2: Substitute into the critical angle formula:

$$\sin C = \frac{1}{3/2} = \frac{2}{3} \approx 0.6667$$

Step 3: Determine the angle C:

$$C = \sin^{-1}\left(\frac{2}{3}\right) \approx 41.81°$$

Step 4: Compare this result with the given choices. The angle is closest to $42°$.

Final Answer: $\boxed{42°}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: When two thin lenses of focal lengths f_1 and f_2 are placed coaxially in contact, the equivalent focal length (F) of the lens combination is given by:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

Since both lenses are convex (converging), their focal lengths are positive.

Solution: Step 1: Identify the focal lengths of the individual lenses:

$$\text{Focal length of the first lens, } f_1 = +20 \text{ cm}$$
$$\text{Focal length of the second lens, } f_2 = +60 \text{ cm}$$

Step 2: Substitute these values into the combination formula:

$$\frac{1}{F} = \frac{1}{20} + \frac{1}{60}$$

Step 3: Find a common denominator to simplify the fractions:

$$\frac{1}{F} = \frac{3+1}{60} = \frac{4}{60} = \frac{1}{15}$$

Step 4: Solve for F:

$$F = 15 \text{ cm}$$

The equivalent focal length of the combined system is 15 cm. This reduction in focal length increases the converging power of the system, shifting the image position.

Final Answer: $\boxed{15 \text{ cm}}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: When a light ray passes through a rectangular glass slab, the lateral displacement (d) of the emergent ray is given by the formula:

$$d = \frac{t \cdot \sin(i - r)}{\cos r}$$

where:

- t is the thickness of the glass slab.
- i is the angle of incidence.
- r is the angle of refraction.

Solution: Step 1: Analyze the dependencies in the lateral displacement formula.

Step 2: Since the angle of incidence i and the refractive index of the glass remain unchanged, the angle of refraction r also remains constant according to Snell's Law.

Step 3: Consequently, the entire angular term $\frac{\sin(i-r)}{\cos r}$ remains completely constant.

Step 4: Under these conditions, the lateral displacement is directly proportional to the thickness of the glass slab:

$$d \propto t$$

Step 5: If the thickness of the glass slab is doubled ($t' = 2t$), the lateral displacement will also double ($d' = 2d$).

Final Answer: Double

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept: For a concave mirror, the nature and size of the image formed depend heavily on the position of the object relative to the principal focus (F) and the pole (P):

- If the object is placed at any position beyond the focus (F), the image formed is real and inverted.
- If the object is placed exactly at the focus (F), the image is formed at infinity.
- A virtual, erect, and magnified image is formed if and only if the object is placed between the pole (P) and the focus (F) of the mirror.

Solution: Step 1: Analyze the given characteristics of the image. The image is virtual, erect, and twice the size of the object (magnified, $m = +2$).

Step 2: A concave mirror can produce a virtual and magnified image only under a single placement condition.

Step 3: This condition is when the object distance (u) is less than the focal length (f) of the concave mirror.

Step 4: Therefore, the object distance from the mirror must be less than the focal length.

Final Answer: Less than focal length

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: For a parallel combination of n resistors, the equivalent resistance (R_p) of the combination is calculated using the reciprocal sum formula:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

Solution: Step 1: Identify the individual resistances of the parallel arrangement:

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

Step 2: Substitute these values into the parallel equivalent formula:

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

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

$$\frac{1}{R_p} = \frac{3 \cdot 1 + 2 \cdot 1 + 1 \cdot 1}{6} = \frac{3 + 2 + 1}{6} = \frac{6}{6} = 1\ \Omega^{-1}$$

Step 4: Solve for R_p by taking the reciprocal:

$$R_p = 1\ \Omega$$

The equivalent resistance of this parallel combination is $1\ \Omega$, which is smaller than the smallest individual resistance in the combination.

Final Answer: $\boxed{1\ \Omega}$

Answer: (A) Go Back to Question 6

Q7.

Solution

Concept: The electrical heat energy (H) generated in a resistor of resistance R connected across a constant potential difference V for a time interval t is given by Joule's Law:

$$H = \frac{V^2}{R} \cdot t$$

By rearranging this formula, we can express the resistance as:

$$R = \frac{V^2 \cdot t}{H}$$

Solution: Step 1: Identify the given physical parameters:

$$\text{Voltage, } V = 220 \text{ V}$$
$$\text{Heat energy produced, } H = 4840 \text{ J}$$
$$\text{Time interval, } t = 10 \text{ seconds}$$

Step 2: Substitute these parameters into the rearranged resistance formula:

$$R = \frac{(220 \text{ V})^2 \cdot 10 \text{ s}}{4840 \text{ J}}$$

Step 3: Calculate the square of the potential difference:

$$V^2 = 220 \cdot 220 = 48400 \text{ V}^2$$

Step 4: Substitute and compute:

$$R = \frac{48400 \cdot 10}{4840} = 10 \cdot 10 = 100 \ \Omega$$

The resistance of the heater coil is $100 \ \Omega$.

Final Answer: $\boxed{100 \ \Omega}$

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: The brightness of an electric bulb depends directly on the actual power (P_{actual}) it dissipates during operation.

- The resistance (R) of a bulb rated for power P_{rated} at voltage V_{rated} is:

$$R = \frac{V_{\text{rated}}^2}{P_{\text{rated}}}$$

- For a series connection, the same current (I) flows through both bulbs. The actual power dissipated in each is:

$$P_{\text{actual}} = I^2 \cdot R$$

Solution: Step 1: Compare the resistances of the two bulbs based on their ratings ($V_{\text{rated}} = 220$ V):

$$R \propto \frac{1}{P_{\text{rated}}}$$

Since the 60 W bulb has a lower power rating than the 100 W bulb, its resistance is higher:

$$R_{60\text{W}} > R_{100\text{W}}$$

Step 2: Analyze the series connection. Because the bulbs are in series across the source, both carry the identical current I.

Step 3: Compare actual power dissipation ($P_{\text{actual}} = I^2 R$):

$$P_{\text{actual, 60W}} > P_{\text{actual, 100W}}$$

Step 4: Since power dissipation determines brightness, the 60 W bulb will dissipate more energy and thus glow brighter.

Final Answer: 60 W bulb

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: According to Ohm's Law, the potential difference (V) across a metallic conductor at a constant temperature is directly proportional to the current (I) flowing through it:

$$V = I \cdot R$$

where R is the constant resistance of the conductor.

Solution: Step 1: Identify the coordinates of the graph. The potential difference V is plotted on the vertical y-axis, and the current I is plotted on the horizontal x-axis.

Step 2: Express the mathematical definition of the slope of a line on this graph:

$$\text{Slope} = \frac{\text{Change in } V}{\text{Change in } I} = \frac{\Delta V}{\Delta I}$$

Step 3: Relate this ratio to Ohm's Law:

$$\frac{V}{I} = R \quad \text{(Resistance)}$$

Therefore, the slope of the V-vs-I graph represents the electrical resistance of the conductor.

Final Answer: Resistance

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: An electrical fuse is a critical safety device connected in series with the live wire of a circuit. It operates based on Joule's heating effect:

$$H = I^2 \cdot R \cdot t$$

To protect domestic appliances from excessive current spikes:

- The fuse wire must have high resistivity to produce sufficient localized heat quickly when current exceeds the safe limit.
- It must have a low melting point so that once heated, it melts rapidly, opening the circuit and stopping current flow.

Solution: Step 1: Analyze the purpose of a fuse during excess current (overloading or short circuits).

Step 2: The excessive current must be stopped immediately to protect valuable appliances and prevent electrical fires.

Step 3: High resistivity ensures rapid heat generation (I^2Rt), and the low melting point ensures the wire melts and breaks the circuit quickly.

Step 4: This physical mechanism safely cuts off the power supply.

Final Answer: Melt quickly and break circuit

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: According to Galileo's Law of Odd Numbers:

- For a body starting from rest ($u = 0$) and moving with a constant (uniform) acceleration (a), the distances covered in successive equal intervals of time (t) are in the ratio of consecutive odd integers:

$$1 : 3 : 5 : 7 : \ldots$$

Solution: Step 1: Let the equal time intervals be t. Step 2: The total distance covered from rest in time T is given by $S = \frac{1}{2}aT^2$.

- Distance in first interval (t): $s_1 = \frac{1}{2}at^2 = x$
- Total distance in $2t$: $S_2 = \frac{1}{2}a(2t)^2 = 4 \cdot \left(\frac{1}{2}at^2\right) = 4x$
- Distance in second interval: $s_2 = S_2 - s_1 = 4x - x = 3x$
- Total distance in $3t$: $S_3 = \frac{1}{2}a(3t)^2 = 9 \cdot \left(\frac{1}{2}at^2\right) = 9x$
- Distance in third interval: $s_3 = S_3 - S_2 = 9x - 4x = 5x$

Step 3: The ratio of distances in successive equal intervals is:

$$s_1 : s_2 : s_3 = x : 3x : 5x = 1 : 3 : 5$$

Step 4: Since this mathematical progression holds true for any constant acceleration from rest, the given ratio of distances confirms uniform acceleration.

Final Answer: Uniform acceleration

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Retardation (or deceleration) is defined as the negative of acceleration. It represents the rate at which the velocity of a body decreases with time:

$$\text{Acceleration, } a = \frac{v-u}{t}$$

$$\text{Retardation} = -a = \frac{u-v}{t}$$

where u is the initial velocity, v is the final velocity, and t is the time interval.

Solution: Step 1: Identify the given kinematic values:

$$\text{Initial velocity, } u = 20 \text{ m/s}$$
$$\text{Final velocity, } v = 0 \text{ m/s} \quad \text{(brought to rest)}$$
$$\text{Time interval, } t = 5 \text{ seconds}$$

Step 2: Calculate the acceleration (a):

$$a = \frac{0 \text{ m/s} - 20 \text{ m/s}}{5 \text{ s}} = -4 \text{ m/s}^2$$

Step 3: Find the magnitude of retardation (negative of acceleration):

$$\text{Retardation} = -(-4 \text{ m/s}^2) = 4 \text{ m/s}^2$$

The retardation produced in the car is 4 m/s^2.

Final Answer: $\boxed{4 \text{ m/s}^2}$

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: For any isolated system of colliding bodies, the total linear momentum is conserved. When the two bodies collide and stick together, they undergo a perfectly inelastic collision, moving with a common final velocity (v):

$$\text{Total Initial Momentum} = \text{Total Final Momentum}$$

$$m_1 \cdot v_1 + m_2 \cdot v_2 = (m_1 + m_2) \cdot v$$

Solution: Step 1: Identify the masses and initial velocities of the two bodies:

$$\text{First body: } m_1 = 2 \text{ kg}, \quad v_1 = 6 \text{ m/s}$$
$$\text{Second body: } m_2 = 4 \text{ kg}, \quad v_2 = 3 \text{ m/s}$$

(Since they are moving in the same direction, both initial velocities are positive).

Step 2: Substitute these values into the momentum conservation equation:

$$(2 \text{ kg} \cdot 6 \text{ m/s}) + (4 \text{ kg} \cdot 3 \text{ m/s}) = (2 \text{ kg} + 4 \text{ kg}) \cdot v$$

Step 3: Simplify the expression:

$$12 + 12 = 6 \cdot v$$

$$24 = 6 \cdot v$$

Step 4: Solve for the common velocity v:

$$v = \frac{24}{6} = 4 \text{ m/s}$$

The common velocity after the collision is 4 m/s.

Final Answer: $\boxed{4 \text{ m/s}}$

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: For an object sliding down an inclined plane of inclination angle θ:

- The force of gravity (mg) acting on the block is resolved into two perpendicular components:
  (a) $mg\sin\theta$, parallel to the inclined surface and acting downwards.
  (b) $mg\cos\theta$, perpendicular to the inclined surface and acting downwards.
- The normal reaction force (N) exerted by the surface acts perpendicular to the incline and balances the component $mg\cos\theta$.
- If the block moves with constant velocity, the acceleration of the block is zero, which means the net force acting on it is zero. Therefore, the forces parallel to the incline must be balanced.

Solution: Step 1: Set up the force equations parallel to the incline.

Step 2: The gravitational component acting downwards along the slope is $mg\sin\theta$.

Step 3: To keep the block moving at a constant velocity (without accelerating), an equal and opposite force must act upwards along the incline.

Step 4: This upward resistive force is the frictional force (f) acting between the rough surface and the block $(f = mg\sin\theta)$.

Step 5: Thus, the frictional force balances the component of gravitational force along the incline.

Final Answer: Frictional force

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The work done (W) by a constant force (F) displacing an object through a displacement (d) is mathematically defined by the scalar product:

$$W = F \cdot d \cdot \cos\theta$$

where θ is the angle between the force and the displacement vectors. For work to be done, two conditions must be simultaneously satisfied:

(a) A non-zero force must act on the body ($F \neq 0$).

(b) The body must undergo a non-zero displacement ($d \neq 0$).

Solution: Step 1: Identify the given physical conditions. A force acts on the body ($F \neq 0$), but no displacement occurs ($d = 0$).

Step 2: Substitute $d = 0$ into the work formula:

$$W = F \cdot 0 \cdot \cos\theta$$

$$W = 0 \text{ J}$$

Step 3: Since there is no displacement, the work done by the force is zero.

Final Answer: $\boxed{\text{Zero}}$

Answer: (D)

Go Back to Question 15

Q16.

Solution

Concept: Under the influence of conservative forces (such as gravitational force):

- The total mechanical energy (E) of a system is the sum of its kinetic energy ($K.E.$) and potential energy ($P.E.$):

$$E = K.E. + P.E.$$

- In the absence of non-conservative forces like air resistance or friction, the total mechanical energy remains constant (conserved) at all points during the motion:

$$\Delta E = 0$$

Solution: Step 1: When a body is projected vertically upwards, its kinetic energy is gradually converted into gravitational potential energy. At the highest point, kinetic energy becomes zero, and potential energy reaches its maximum.

Step 2: As the body falls back down, potential energy is converted back into kinetic energy.

Step 3: Since kinetic energy and potential energy are constantly transforming into one another, neither remains conserved on its own throughout the entire flight.

Step 4: Linear momentum is also not conserved because gravity constantly accelerates the body, changing both the magnitude and direction of its velocity.

Step 5: Therefore, only the total mechanical energy remains conserved throughout the motion.

Final Answer: Mechanical energy

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept: Power (P) is defined as the rate of doing work, or the work done (W) per unit time (t):

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

When a machine lifts a load of weight F vertically through a height h, the work done by the machine against gravity is:

$$W = F \cdot h$$

Solution: Step 1: Identify the given physical parameters:

$$\text{Force (Load)}, F = 500 \text{ N}$$
$$\text{Height}, h = 2 \text{ m}$$
$$\text{Time}, t = 5 \text{ seconds}$$

Step 2: Calculate the work done (W) by the machine:

$$W = 500 \text{ N} \cdot 2 \text{ m} = 1000 \text{ J}$$

Step 3: Calculate the power developed by dividing the work by the time taken:

$$P = \frac{1000 \text{ J}}{5 \text{ s}}$$

$$P = 200 \text{ W}$$

The power developed by the machine is 200 Watts.

Final Answer: $\boxed{200 \text{ W}}$

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: In a perfectly insulated vessel, there is no heat exchange with the surroundings. According to the principle of calorimetry (or conservation of energy):

$$\text{Heat lost by hot water} = \text{Heat gained by cold water}$$

The heat exchanged (Q) is given by:

$$Q = m \cdot c \cdot \Delta T$$

where m is the mass, c is the specific heat capacity of the substance, and ΔT is the change in temperature.

Solution: Step 1: Identify the given quantities. Let the mass of both portions of water be m, and the specific heat capacity of water be c.

$$\text{Initial temperature of hot water, } T_1 = 90°C$$
$$\text{Initial temperature of cold water, } T_2 = 30°C$$

Let the final equilibrium temperature of the mixture be T.
Step 2: Set up the calorimetry equation:

$$m \cdot c \cdot (T_1 - T) = m \cdot c \cdot (T - T_2)$$

Step 3: Since the masses and the substances (water) are identical on both sides, divide both sides of the equation by $m \cdot c$:

$$T_1 - T = T - T_2$$

Step 4: Substitute the given temperatures and solve for T:

$$90 - T = T - 30$$

$$2T = 120$$

$$T = 60°C$$

The final temperature of the mixture is $60°C$.

Final Answer: $\boxed{60°C}$

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: Thermal conduction is the process of heat transfer through a material medium. Materials are categorized based on their ability to conduct heat:

- Good thermal conductors: Materials (such as metals like copper, aluminum, and iron) that transfer heat quickly.
- Poor thermal conductors (Insulators): Materials (such as wood, plastic, bakelite, and cork) that resist the transfer of heat.

Solution: Step 1: The body of cooking utensils is made of metal to ensure rapid and uniform heat transfer from the stove to the food.

Step 2: However, to safely handle these utensils during cooking, their handles must remain cool.

Step 3: Wood and bakelite are used to make handles because they are poor conductors of heat (thermal insulators). This prevents heat from conducting from the hot metal body to the user's hand.

Step 4: Therefore, these materials are chosen because they are poor conductors of heat.

Final Answer: Poor conductors of heat

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: Thermal expansion is the increase in the size (length, area, or volume) of a substance when its temperature is raised.

- When a solid (like a metal ball) is heated, the average distance between its atoms increases due to increased thermal vibrations. This results in an increase in the ball's volume.

Solution: Step 1: At room temperature, the metal ball's diameter is slightly smaller than the inner diameter of the metal ring, allowing it to pass through easily.

Step 2: When the ball is heated strongly, it absorbs thermal energy, causing its atoms to vibrate more violently.

Step 3: This leads to thermal expansion, increasing the overall volume and diameter of the ball.

Step 4: Because its expanded diameter exceeds the inner diameter of the ring, the heated ball can no longer pass through the ring.

Step 5: Thus, the physical phenomenon responsible for this behavior is thermal expansion.

Final Answer: Thermal expansion

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: For any periodic wave, the wave speed (v) is related to its frequency (f) and wavelength (λ) by the fundamental wave equation:

$$v = f \cdot \lambda$$

This relationship holds true for all mechanical and electromagnetic waves, including sound waves.

Solution: Step 1: Identify the given wave parameters:

$$\text{Wavelength, } \lambda = 0.5 \text{ m}$$
$$\text{Frequency, } f = 660 \text{ Hz}$$

Step 2: Substitute these values into the wave speed formula:

$$v = 660 \text{ Hz} \cdot 0.5 \text{ m}$$

Step 3: Perform the multiplication:

$$v = 330 \text{ m/s}$$

The speed of the sound wave is 330 m/s.

Final Answer: $\boxed{330 \text{ m/s}}$

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept: An echo is the reflection of a sound wave back to its source from a distant reflecting obstacle. The total distance covered by the sound wave to the obstacle and back to the listener is $2d$, where d is the distance to the reflecting surface.

$$\text{Total Distance} = 2d = v \cdot t$$

where v is the speed of sound and t is the total time elapsed between emitting the sound and hearing the echo.

Solution: Step 1: Identify the given values:

$$\text{Total round trip time, } t = 2 \text{ seconds}$$
$$\text{Speed of sound in air, } v = 340 \text{ m/s}$$

Step 2: Use the echo formula to solve for the distance (d):

$$2d = v \cdot t \implies d = \frac{v \cdot t}{2}$$

Step 3: Substitute the given values:

$$d = \frac{340 \text{ m/s} \cdot 2 \text{ s}}{2}$$
$$d = 340 \text{ m}$$

The distance between the person and the reflecting surface is 340 meters.

Final Answer: $\boxed{340 \text{ m}}$

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: During beta-minus (β^-) decay (the most common form of beta decay), a neutron inside a radioactive parent nucleus is converted into a proton, emitting a high-energy electron (the β-particle) and an electron antineutrino ($\bar{\nu}_e$):

$$\text{neutron} \longrightarrow \text{proton} + e^- + \bar{\nu}_e$$

The general nuclear equation representing this decay is:

$${}_{Z}^{A}X \longrightarrow {}_{Z+1}^{A}Y + {}_{-1}^{0}e + \bar{\nu}_e$$

where Z is the atomic number and A is the mass number of the nucleus.

Solution: Step 1: Analyze the transformation. A neutron transforms into a proton inside the nucleus.

Step 2: Since a new proton is added to the nucleus, the atomic number (Z, which is the number of protons) increases by 1.

Step 3: The mass number (A, total protons + neutrons) remains unchanged because the total number of nucleons remains constant (one neutron is lost, but one proton is gained).

Step 4: Looking at the options, the correct change is that the atomic number increases by 1.

Final Answer: Atomic number increases by 1

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The properties of alpha (α), beta (β), and gamma (γ) radiations differ based on their mass, charge, and velocity:

- Alpha (α) rays: Heavy helium nuclei ($^4_2\text{He}^{2+}$) with high mass and charge ($+2e$). They collide frequently with atoms, causing maximum ionising power and minimum penetrating power.
- Beta (β) rays: Fast-moving electrons/positrons with low mass and charge. They have moderate ionizing and penetrating powers.
- Gamma (γ) rays: Massless, neutral high-energy photons. Because they have no charge and interact very weakly with matter, they possess maximum penetrating power and minimum ionising power.

Solution: Step 1: Analyze the physical properties of the radiations.

Step 2: Due to the absence of charge and mass, gamma (γ) rays have the least interaction with the atoms of the medium they pass through, resulting in the lowest ionization rate.

Step 3: This allows them to penetrate deeply into substances (requiring thick lead or concrete to be stopped).

Step 4: Therefore, gamma (γ) rays possess the maximum penetrating power and minimum ionizing power.

Final Answer: $\boxed{\gamma\text{-rays}}$

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: The hydrostatic pressure (P) at any point inside a liquid of uniform density (ρ) is given by the formula:

$$P = P_0 + \rho \cdot g \cdot h$$

where:

- P_0 is the atmospheric pressure at the liquid surface.
- g is the acceleration due to gravity.
- h is the depth of the point below the free surface of the liquid.

The pressure increases linearly with depth (h). A higher pressure at a hole causes the water to eject with a greater horizontal velocity ($v = \sqrt{2gh}$ according to Torricelli's Law).

Solution: Step 1: Identify that the three holes are made at different depths along the tank's side wall.

Step 2: The lowest hole is at the greatest depth (h) below the water surface.

Step 3: Since hydrostatic pressure is directly proportional to depth ($P \propto h$), the pressure is maximum at this greatest depth.

Step 4: This maximum pressure pushes the water out of the lowest hole with the highest horizontal velocity, making it travel the farthest distance horizontally.

Step 5: Thus, the water goes farthest because pressure is maximum at greater depth.

Final Answer: Pressure is maximum at greater depth

Answer: (A)

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Answer Key

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