ICSE Class 10 Physics (Science Paper - 1) 2026 Question Paper

Time Allowed :2 Hours	Maximum Marks :80	Total Questions :10

General Instructions

1. *Answers to this Paper must be written on the paper provided separately.*
2. *You will not be allowed to write during the first 15 minutes.*
3. *This time is to be spent in reading the question paper.*
4. ***The time given at the head of this Paper is the time allowed for writing the answers.***
5. *Attempt all questions from* ***Section A*** *and any four questions from* ***Section B****.*
6. *The intended marks for questions or parts of questions are given in brackets[ ].*

1(i). For a body to be in dynamic equilibrium, its:

(a) momentum should be zero
(b) acceleration should be zero
(c) kinetic energy should be zero
(d) velocity should be zero

Correct Answer: (b) acceleration should be zero

Solution:

Step 1: Understanding the Concept:
Equilibrium refers to a state where the net external force acting on a body is zero.
Dynamic equilibrium occurs when a body remains in a state of uniform motion (constant velocity) in a straight line.

Step 2: Detailed Explanation:
According to Newton's Second Law of Motion, $F_{net} = m \cdot a$.
For a body to be in equilibrium (static or dynamic), the net force F_{net} must be zero.
If $F_{net} = 0$, then the acceleration a must also be zero.
In dynamic equilibrium, the body has a non-zero constant velocity v, which implies its change in velocity over time is zero, hence $a = 0$.

Step 3: Final Answer:
Therefore, for dynamic equilibrium, the acceleration of the body must be zero.

Quick Tip

Remember: Static Equilibrium means Velocity = 0 and Acceleration = 0. Dynamic Equilibrium means Velocity = Constant ($\neq 0$) and Acceleration = 0.

1(ii). The energy transformation taking place during photosynthesis in plants is:

(a) heat to chemical
(b) chemical to light
(c) light to chemical
(d) chemical to heat

Correct Answer: (c) light to chemical

Solution:

Step 1: Understanding the Concept:
Photosynthesis is the biological process by which green plants convert raw materials like carbon dioxide and water into glucose.

Step 2: Detailed Explanation:
During photosynthesis, chlorophyll in the leaves captures solar energy (light energy) from the sun.
This light energy is used to trigger chemical reactions that store energy in the chemical bonds of glucose (chemical energy).
The process is summarized as:

$$6CO_2 + 6H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Step 3: Final Answer:
The transformation is light energy to chemical energy.

Quick Tip

Think of plants as solar panels that store the sun's energy in "food batteries" (chemical bonds).

1(iii). The Velocity Ratio (VR) of a block and tackle system of 3 pulleys with the effort in the upward direction is:

(a) 1
(b) 2
(c) 3
(d) 4

Correct Answer: (d) 4

Solution:

Step 1: Understanding the Concept:
In a block and tackle system, the Velocity Ratio (VR) is determined by the number of strands of the string supporting the movable block.

Step 2: Key Formula or Approach:
If the effort is applied in the downward direction, $VR = n$ (where n is the number of pulleys).
If the effort is applied in the upward direction, the effort strand itself contributes to lifting the load, so $VR = n + 1$.

Step 3: Detailed Explanation:
The system has $n = 3$ pulleys.
The effort is applied in the **upward** direction.
Therefore, $VR = 3 + 1 = 4$.

Step 4: Final Answer:
The Velocity Ratio is 4.

> Quick Tip
>
> If the free end of the string comes out of the lower (movable) block, the VR is always $n + 1$.

1(iv). From the figure given below, the refractive index of medium B with respect to medium A ($_A\mu_B$) is:

(a) $\frac{\sin 45^\circ}{\sin 30^\circ}$
(b) $\frac{\sin 30^\circ}{\sin 45^\circ}$
(c) $\frac{\sin 45^\circ}{\sin 60^\circ}$
(d) $\frac{\sin 60^\circ}{\sin 45^\circ}$

Correct Answer: (c) $\frac{\sin 45^\circ}{\sin 60^\circ}$

Solution:

Step 1: Understanding the Concept:
According to Snell's Law, the refractive index of the second medium with respect to the first medium is the ratio of the sine of the angle of incidence to the sine of the angle of refraction.
Critical Note: The angles must be measured between the ray and the **normal**.

Step 2: Key Formula or Approach:

$$_A\mu_B = \frac{\sin i}{\sin r}$$

Step 3: Detailed Explanation:
From the diagram, the angle between the incident ray and the interface in Medium A is 45°.
The normal NN' is perpendicular to the interface.
Angle of incidence $i = 90^\circ - 45^\circ = 45^\circ$.
In Medium B, the angle between the refracted ray and the interface is 30°.
Angle of refraction $r = 90^\circ - 30^\circ = 60^\circ$.
Substituting into the formula:

$$ {}_A\mu_B = \frac{\sin 45^\circ}{\sin 60^\circ} $$

Step 4: Final Answer:
The correct expression is $\frac{\sin 45^\circ}{\sin 60^\circ}$.

Quick Tip

Don't be tricked by the diagram! Always check if the angle is given with the surface or the normal. $Angle_{Normal} = 90^\circ - Angle_{Surface}$.

1(v). When a blackened bulb thermometer is moved beyond the red region of the visible spectrum, there is a rapid rise in the temperature. This is due to the presence of:

(a) Infrared radiations
(b) Ultraviolet radiations
(c) X-rays
(d) Radio waves

Correct Answer: (a) Infrared radiations

Solution:

Step 1: Understanding the Concept:
The solar spectrum consists of visible light and invisible radiations. The region just beyond the red end of visible light is the infrared region.

Step 2: Detailed Explanation:
Infrared radiations are thermal radiations. They have high heating power because their frequencies match the vibrational frequencies of many molecules.
A blackened bulb absorbs these radiations efficiently, leading to a significant increase in temperature.

This property was used by William Herschel to discover infrared rays.

Step 3: Final Answer:
The heating effect beyond the red region is caused by infrared radiations.

> Quick Tip
>
> Infrared = Heat rays. Ultraviolet = Chemical/Fluorescence rays.

1(vi). A fast-moving cyclist stops pedalling on reaching a hilly track. If he continues to move with the acquired energy, then assuming no loss of energy:

(a) his kinetic energy remains constant at all times.
(b) his potential energy remains constant at all times.
(c) his total mechanical energy continuously increases.
(d) his total mechanical energy remains constant.

Correct Answer: (d) his total mechanical energy remains constant.

Solution:

Step 1: Understanding the Concept:
Mechanical energy is the sum of kinetic energy (K) and potential energy (U).

Step 2: Key Formula or Approach:
Total Mechanical Energy $E = K + U$.

Step 3: Detailed Explanation:
The problem states "assuming no loss of energy," which means there is no friction or air resistance (conservative system).
As the cyclist moves up the hill, his velocity decreases (kinetic energy decreases) and his height increases (gravitational potential energy increases).
According to the Law of Conservation of Energy, the energy is merely transformed from kinetic to potential, but the total sum E stays the same.

Step 4: Final Answer:
The total mechanical energy remains constant.

> Quick Tip
>
> In the absence of dissipative forces like friction, mechanical energy is always conserved.

1(vii). The distance (v) of a virtual image formed by a lens of focal length 15 cm exceeds a certain finite value, then this value will be:

(a) less than 15 cm
(b) between 15 cm to 30 cm
(c) less than or equal to 30 cm
(d) less than or equal to 15 cm

Correct Answer: (d) less than or equal to 15 cm

Solution:

Step 1: Understanding the Concept:
This question pertains to the characteristics of images formed by a concave lens.

Step 2: Detailed Explanation:
A concave lens always produces a virtual, erect, and diminished image for any position of the real object.
The image is always formed between the optical center (O) and the focus (F) on the same side as the object.
Therefore, the magnitude of the image distance v is always less than or equal to the focal length f.
Given $f = 15$ cm, the image distance $v \leq 15$ cm.

Step 3: Final Answer:
The value is less than or equal to 15 cm.

Quick Tip

For a concave lens, the virtual image is restricted to the region between the lens and the focus.

1(viii). Assertion (A): Tiny air molecules scatter blue light more than red light. Reason (R): The refractive index of a medium is greater for blue light than red light.

(a) (A) is true but (R) is false.
(b) (A) is false but (R) is true.
(c) Both (A) and (R) are true and (R) is the correct explanation of (A).
(d) Both (A) and (R) are true but (R) is not the correct explanation of (A).

Correct Answer: (d) Both (A) and (R) are true but (R) is not the correct explanation of (A).

Solution:

Step 1: Understanding the Concept:
Rayleigh scattering explains why the sky is blue, while the refractive index explains how light bends in a medium.

Step 2: Detailed Explanation:
Assertion (A): Rayleigh's Law of Scattering states that the intensity of scattered light is inversely proportional to the fourth power of the wavelength ($I \propto 1/\lambda^4$). Since blue light has a shorter wavelength than red light, it is scattered more. (A is true).
Reason (R): Cauchy's formula states that refractive index μ increases as wavelength decreases. Thus, $\mu_{blue} > \mu_{red}$. (R is true).
However, scattering is caused by the interaction of light with particles much smaller than its wavelength, whereas refractive index describes the phase velocity of light in a bulk medium. The reason for scattering is the small wavelength, not the high refractive index.

Step 3: Final Answer:
Both statements are correct, but R does not explain why A happens.

Quick Tip

Scattering is a diffraction-like phenomenon at the particle level. Refraction is a bulk property of the medium.

1(ix). In the circuit given below, identify the lamp (L_1, L_2, L_3 or L_4) whose failure would not interrupt the power supply to the other lamps.

(a) L_1
(b) L_2
(c) L_3
(d) L_4

Correct Answer: (d) L_4

Solution:

Step 1: Understanding the Concept:
In a circuit, components in series share the same current path. If one fails, the circuit breaks. Components in parallel have independent current paths.

Step 2: Detailed Explanation:
Looking at the diagram:
L_1 is in series with the entire combination. If it fails, the whole circuit opens.
L_2, L_3, and L_4 are in parallel branches.
If L_4 fails, the branch containing L_4 becomes an open circuit. However, current can still flow from the battery through L_1 and then through the other parallel branches (L_2 and L_3).

Thus, L_4 (as a parallel component) does not stop the flow to others.

Step 3: Final Answer:
The correct lamp is L_4.

> Quick Tip
>
> Parallel = Independent paths. Series = Dependent path.

1(x). Equal volumes of water are added to three cylindrical jars A, B and C of same height and radii r_A, r_B and r_C respectively with $r_A < r_B < r_C$. If you blow across the mouth of these jars, which tube will produce the shrillest note?

(a) A
(b) B
(c) C
(d) All will produce the notes of same shrillness

Correct Answer: (a) A

Solution:

Step 1: Understanding the Concept:
Shrillness is another term for high pitch or high frequency. For an air column in a pipe, the frequency is inversely proportional to the length of the air column ($f \propto 1/L$).

Step 2: Detailed Explanation:
Volume of water V is constant. $V = \pi r^2 h$, where h is the height of water.
Since r_A is the smallest, the height of water h_A will be the greatest ($h = V/\pi r^2$).
Length of the air column L = Height of Jar − Height of Water.
Jar A, having the most water, will have the **shortest** air column.
Since Jar A has the shortest air column, it produces the highest frequency (shrillest note).

Step 3: Final Answer:
Jar A produces the shrillest note.

> Quick Tip
>
> Shortest air column = Highest frequency = Shriller sound. Think of a flute or test tubes with different water levels.

1(xi). A metallic wire is stretched in such a way that its new length becomes double its original length. How does its specific heat capacity change?

(a) becomes double
(b) becomes 4 times
(c) becomes 1/4
(d) remains the same

Correct Answer: (d) remains the same

Solution:

Step 1: Understanding the Concept:
Specific heat capacity is the amount of heat required to raise the temperature of unit mass of a substance by 1 degree Celsius.

Step 2: Detailed Explanation:
Specific heat capacity is a **characteristic property** of a material. It depends only on the nature of the substance and its state of matter.
Stretching a wire changes its physical dimensions (length and area) but does not change the material it is made of.
Because the material is the same, the specific heat capacity remains unchanged.

Step 3: Final Answer:
The specific heat capacity remains the same.

Quick Tip

Be careful! Resistance would change (becomes 4 times), but characteristic properties like resistivity and specific heat capacity do not change with dimensions.

1(xii). The correct formula to calculate the equivalent resistance of two resistors R_1 and R_2 when connected in parallel, is:

(a) $\frac{R_1+R_2}{R_1R_2}$
(b) $\frac{R_1R_2}{R_1+R_2}$
(c) $\frac{R_1-R_2}{R_1R_2}$
(d) $\frac{R_1R_2}{R_1-R_2}$

Correct Answer: (b) $\frac{R_1R_2}{R_1+R_2}$

Solution:

Step 1: Understanding the Concept:
The reciprocal of the equivalent resistance of a parallel combination is the sum of the reciprocals

of the individual resistances.

Step 2: Key Formula or Approach:

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

Step 3: Detailed Explanation:
Taking the LCM on the right side:

$$\frac{1}{R_p} = \frac{R_2 + R_1}{R_1 \cdot R_2}$$

To find R_p, take the reciprocal of the whole expression:

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

Step 4: Final Answer:
The equivalent resistance is the product of the two resistances divided by their sum.

> Quick Tip
>
> Mnemonic for 2 resistors in parallel: "Product over Sum".

1(xiii). The diagram below shows the top view of the Wire A shown by a cross (X) carrying current into the plane of the paper. Which of the compasses is correctly aligned with the magnetic field, produced by the current carrying wire?

(a) Only 1 is aligned
(b) Only 2 is aligned
(c) Both 1 and 2 are aligned
(d) Both 1 and 2 are not aligned

Correct Answer: (a) Only 1 is aligned

Solution:

Step 1: Understanding the Concept:
The Right-Hand Thumb Rule determines the direction of the magnetic field around a straight conductor.

Step 2: Key Formula or Approach:
Thumb = Direction of current. Fingers = Direction of magnetic field lines.

Step 3: Detailed Explanation:
The cross (X) indicates that the current is flowing **into** the paper.
Using the Right-Hand Thumb Rule, point your thumb into the page. Your fingers curl in a **clockwise** direction.
The magnetic field lines are circles centered on the wire.
At position 1 (Top), the clockwise tangent points to the **right**. Compass 1 shows this direction. (Aligned).
At position 2 (Right), the clockwise tangent points **downwards**. Compass 2 shows an upward direction. (Not aligned).

Step 4: Final Answer:
Only compass 1 is correctly aligned.

> Quick Tip
>
> X = Into page = Clockwise. Dot (.) = Out of page = Anti-clockwise.

1(xiv). Three substances A, B and C of same mass are present at their respective melting points. On heating, if they melt completely in 5 minutes, 7 minutes and 3 minutes respectively, then which substance has the highest specific latent heat? (Assume heat is absorbed at the same rate)

(a) Substance A
(b) Substance B
(c) Substance C
(d) All the substances have same specific latent heat

Correct Answer: (b) Substance B

Solution:

Step 1: Understanding the Concept:
Latent heat of fusion (L) is the heat required to change a substance from solid to liquid without changing its temperature.

Step 2: Key Formula or Approach:

$$Q = m \cdot L$$

Since heat is absorbed at a constant rate (P), total heat $Q = P \cdot t$.

Step 3: Detailed Explanation:
Combining the formulas: $m \cdot L = P \cdot t$.

Since mass (m) and power (P) are the same for all three:

$$L \propto t$$

The substance that takes more time to melt completely requires more total heat, implying it has a higher specific latent heat.
Substance B takes the longest time (7 minutes).

Step 4: Final Answer:
Substance B has the highest specific latent heat.

> Quick Tip
>
> More time taken to melt (at the same heating rate) = More heat energy required = Higher Latent Heat.

1(xv). An atom of lithium contains 3 electrons, 3 protons and 4 neutrons. Its mass number is:

(a) 3
(b) 4
(c) 7
(d) 10

Correct Answer: (c) 7

Solution:

Step 1: Understanding the Concept:
The mass number of an atom is defined as the total number of nucleons (protons + neutrons) in the nucleus.

Step 2: Key Formula or Approach:

$$\text{Mass Number (A)} = \text{Number of Protons (Z)} + \text{Number of Neutrons (N)}$$

Step 3: Detailed Explanation:
Given:
Protons = 3
Neutrons = 4
Electrons = 3 (Electrons are not counted in the mass number because their mass is negligible).

$$A = 3 + 4 = 7$$

Step 4: Final Answer:
The mass number is 7.

> Quick Tip
>
> Atomic number = Protons. Mass number = Sum of heavy particles in the nucleus.

2(i)(a). A car is moving in uniform circular motion. The direction of friction between the tyres and the path is _____ [towards the centre / tangential to the path].

Correct Answer: towards the centre

Solution:

Step 1: Understanding the Concept:
For any object to move in a circular path, a net force must act on it directed toward the center of the circle. This is known as the centripetal force.

Step 2: Detailed Explanation:
When a car turns on a flat road, the only force that can provide this centripetal acceleration is the static friction between the tyres and the road surface.
If friction did not act toward the center, the car would skid outward due to its inertia. Therefore, to maintain uniform circular motion, the frictional force must be directed radially inward, i.e., towards the centre of the path.

Step 3: Final Answer:
The direction of friction is towards the centre.

> Quick Tip
>
> In circular motion, velocity is always tangential, but the net force (and thus friction here) is always centripetal (radially inward).

2(i)(b). When a ray of light passes from a denser to a rarer medium, its wavelength _____ [decreases / increases].

Correct Answer: increases

Solution:

Step 1: Understanding the Concept:
Refraction occurs because light travels at different speeds in different media. The frequency of light remains constant when it changes media.

Step 2: Key Formula or Approach:
The relationship between speed (v), frequency (f), and wavelength (λ) is given by:

$$v = f \cdot \lambda$$

Step 3: Detailed Explanation:
When light travels from a denser medium (like glass) to a rarer medium (like air), its speed increases ($v_{rarer} > v_{denser}$).
Since frequency (f) is a characteristic of the source and remains unchanged during refraction:

$$\lambda \propto v$$

An increase in speed directly leads to an increase in the wavelength of the light ray.

Step 4: Final Answer:
Its wavelength increases.

Quick Tip

Remember: Frequency stays constant. Speed and Wavelength both change in the same direction when moving between media.

2(i)(c). The lid of a calorimeter minimises heat loss by _____ [convection / radiation].

Correct Answer: convection

Solution:

Step 1: Understanding the Concept:
Heat loss from a container can occur via conduction, convection, and radiation. A calorimeter is designed to isolate the system thermally.

Step 2: Detailed Explanation:
Convection involves the physical movement of fluid (like air). When a calorimeter is open, hot air above the substance rises and is replaced by cooler air, carrying heat away.

By placing a lid, we trap the air and prevent this continuous circulation of air currents. Radiation loss is minimized by polishing or silvering the inner and outer surfaces of the calorimeter, not primarily by the lid.

Step 3: Final Answer:
The lid minimises heat loss by convection.

> Quick Tip
>
> Insulating jackets stop conduction; lids stop convection; polished surfaces stop radiation.

2(i)(d). Quality of sound depends on its _____ [amplitude / waveform].

Correct Answer: waveform

Solution:

Step 1: Understanding the Concept:
Sound has three main characteristics: Loudness, Pitch, and Quality (or Timbre).

Step 2: Detailed Explanation:
1. Loudness depends on the amplitude of the vibration.
2. Pitch depends on the frequency of the vibration.
3. Quality (Timbre) is the characteristic that allows us to distinguish between two sounds of the same pitch and loudness produced by different instruments. This depends on the number and intensity of subsidiary notes (overtones) present, which determines the overall shape of the vibration, known as the waveform.

Step 3: Final Answer:
Quality of sound depends on its waveform.

> Quick Tip
>
> A violin and a piano sound different even if playing the same note because their waveforms are distinct.

2(i)(e). A substance whose resistance becomes almost negligible at a temperature near absolute zero is called a _____ [semiconductor / superconductor].

Correct Answer: superconductor

Solution:

Step 1: Understanding the Concept:
The resistance of most conductors decreases as temperature decreases. For certain materials, resistance drops abruptly to zero at a specific critical temperature.

Step 2: Detailed Explanation:
A superconductor is a material that can conduct electricity with zero resistance when cooled below its critical temperature (usually very close to absolute zero, 0 K).
In contrast, a semiconductor's resistance increases as temperature decreases toward absolute zero, eventually behaving like an insulator.

Step 3: Final Answer:
The substance is called a superconductor.

> Quick Tip
>
> Mercury becomes a superconductor at approximately 4.2 K.

2(i)(f). _____ radiation deviates minimum in a magnetic field. [Alpha / Beta].

Correct Answer: Alpha

Solution:

Step 1: Understanding the Concept: The deflection of charged particles in a magnetic field is governed by the Lorentz force and the particle's inertia (mass).

Step 2: Key Formula or Approach: The radius of curvature r for a particle of mass m, charge q, and velocity v in a magnetic field B is:

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

Smaller deflection (deviation) corresponds to a larger radius of curvature.

Step 3: Detailed Explanation: - Alpha (α) particles are helium nuclei with a mass of approximately 4 u and a charge of +2e.
- Beta (β) particles are fast-moving electrons with a mass of approximately $\frac{1}{1840}$ u and a charge of -1e.
For similar velocities, the mass-to-charge ratio (m/q) for an alpha particle ($4/2 = 2$) is much larger than that for a beta particle (≈ 0.0005).

Because alpha particles have much greater mass (inertia), they are harder to deflect, resulting in minimum deviation compared to beta particles.

Step 4: Final Answer: Alpha radiation deviates minimum.

Quick Tip

Gamma radiation (γ) is neutral and has zero deviation, but among charged particles, the heavier one (Alpha) deviates less.

2(ii). State two factors on which the position of Center of Gravity of a body depends.

Correct Answer: 1. Geometric shape of the body, 2. Distribution of mass.

Solution:

Step 1: Understanding the Concept:
The Center of Gravity (C.G.) is the point through which the entire weight of a body acts, regardless of its orientation.

Step 2: Detailed Explanation:
The position of C.G. depends on the following factors:
1. **The geometric shape of the body:** For bodies with uniform density, the C.G. is usually at its geometric center (e.g., center of a sphere, intersection of diagonals for a rectangle).
2. **The distribution of mass:** If mass is added to one part of the body or if the density is non-uniform, the C.G. shifts towards the heavier part.

Step 3: Final Answer:
Factors: (i) Geometric shape of the body and (ii) Distribution of mass within the body.

Quick Tip

The center of gravity can even lie outside the material of the body, such as in the case of a ring or a hollow sphere.

2(iii)(a). Case 1: Lata cuts a potato into two halves, using a cutter which belongs to a Class II lever. She needed effort E_1.
Case 2: Then she cuts one half of this potato again, but this time she needed effort E_2. If $E_1 > E_2$ then:

In which case (1^{st} or 2^{nd}) was the potato closer to her hand applying the effort? (Assume normal reaction of the surface of the potato is same in both cases)

Correct Answer: 1^{st} case

Solution:

Step 1: Understanding the Concept:
A Class II lever has the Load situated between the Fulcrum and the Effort. Common examples include a paper cutter or a nutcracker.

Step 2: Key Formula or Approach:
The Principle of Levers states:

$$\text{Effort} \times \text{Effort Arm} = \text{Load} \times \text{Load Arm}$$

$$\text{Effort}(E) = \text{Load}(L) \times \frac{\text{Load Arm}}{\text{Effort Arm}}$$

Step 3: Detailed Explanation:
- The effort arm is the fixed length of the cutter (distance from fulcrum to hand).
- The load arm is the distance from the fulcrum to the potato.
- We are given $E_1 > E_2$. Since the Load L is assumed constant (normal reaction), a higher effort E_1 implies a larger load arm ($L.A._1$).
- In Case 1, the load arm was larger, meaning the potato was further from the fulcrum.
- Since the potato is between the fulcrum and the hand, being further from the fulcrum automatically means it is closer to the hand applying the effort.

Step 4: Final Answer:
The potato was closer to her hand in the 1^{st} case.

Quick Tip

To minimize effort in a Class II lever, move the load as close to the fulcrum as possible (away from the hand).

2(iii)(b). Give a reason for your answer in (a) above.

Correct Answer: Effort is directly proportional to the Load Arm.

Solution:

Step 1: Detailed Explanation:
In a Class II lever, the effort arm (length of handle) is constant. The required effort decreases as the load arm (distance of the load from the fulcrum) decreases.
Since $E_2 < E_1$, the load arm in Case 2 must be smaller than in Case 1.
A smaller load arm means the potato is closer to the fulcrum in Case 2.
Consequently, in Case 1, where the load arm was larger, the potato must have been positioned closer to the effort point (the hand).

Step 2: Final Answer:
Because a larger effort corresponds to a larger load arm for a fixed effort arm, placing the load closer to the hand increases the effort required.

Quick Tip

Mechanical Advantage ($MA = \frac{EffortArm}{LoadArm}$) increases as the Load Arm decreases.

3(i)(a). The graph below shows the variation of image distance (v) with the object distance (u) when an object is kept in front of a lens. Identify the type of lens used.

Correct Answer: Convex lens

Solution:

Step 1: Understanding the Concept:
A lens formula relates object distance (u), image distance (v), and focal length (f):

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

Step 2: Detailed Explanation:
The provided graph is a rectangular hyperbola located in a region where u is negative and v is positive (indicating real images formed on the opposite side).
For a convex lens, as an object moves from infinity toward the focus, the real image moves from the focus toward infinity. This characteristic curve (where v decreases as $|u|$ increases) is unique to a convex lens forming real images.

Step 3: Final Answer:
The lens used is a Convex (converging) lens.

Quick Tip

The point on the graph where $|u| = |v|$ corresponds to the object being placed at $2F$.

3(i)(b). What would be the magnification (more than 1 / less than 1 / equal to 1) if the object is placed between F and 2F of the above lens?

Correct Answer: more than 1

Solution:

Step 1: Understanding the Concept:
Magnification (m) for a lens is the ratio of image distance to object distance: $m = \frac{v}{|u|}$.

Step 2: Detailed Explanation:
When an object is placed between F and $2F$ of a convex lens:
1. The image formed is real, inverted, and located beyond $2F$.
2. Since the image is further from the lens than the object ($v > 2f$ and $f < |u| < 2f$), it follows that $v > |u|$.
3. Therefore, the magnification $m = \frac{v}{|u|}$ is greater than 1.

Step 3: Final Answer:
The magnification is more than 1.

Quick Tip

Object at $2F \rightarrow m = 1$. Object beyond $2F \rightarrow m < 1$. Object between F and $2F \rightarrow m > 1$.

3(ii)(a). A resistance R is connected across a cell with a switch and a rheostat in series. A voltmeter is connected parallel across the cell. Current in the circuit is increased using the rheostat. How will the voltmeter reading change? (increase / decrease / remain the same)

Correct Answer: decrease

Solution:

Step 1: Understanding the Concept:
A voltmeter connected across a cell measures the terminal voltage (V), which is the potential difference across the cell's terminals when current is flowing.

Step 2: Key Formula or Approach:
The relationship between Terminal Voltage (V), EMF (E), Current (I), and internal resistance (r) is:

$$V = E - I \cdot r$$

Step 3: Detailed Explanation:
When the rheostat is adjusted to increase the current (I) in the circuit:
1. The EMF (E) and internal resistance (r) of the cell remain constant.
2. The term $I \cdot r$, which represents the "lost voltage" or potential drop inside the cell, increases as I increases.
3. Since $V = E - (Ir)$, an increase in the subtracted term results in a decrease in the terminal voltage V.

Step 4: Final Answer:
The voltmeter reading will decrease.

> **Quick Tip**
>
> Terminal voltage is always less than EMF in a discharging cell. More current means more "lost" voltage internally.

3(ii)(b). Justify your answer stated in (a) above.

Correct Answer: Due to increased voltage drop across internal resistance.

Solution:

Step 1: Detailed Explanation:
The reading of the voltmeter corresponds to the terminal voltage $V = E - Ir$.
Every cell has a small internal resistance (r). When current I flows through the circuit, some energy is consumed in moving charges against this internal resistance, leading to an internal potential drop of Ir.
As the rheostat decreases external resistance to increase current, this internal drop Ir rises, leaving less potential difference available at the external terminals of the cell.

Step 2: Final Answer:
The increase in current leads to a higher potential drop (Ir) inside the cell, which reduces the terminal potential difference (V).

Quick Tip

If the circuit were open ($I = 0$), the voltmeter would read the EMF (E), which is the maximum possible value.

3(iii)(a). Define natural vibrations.

Correct Answer: Vibrations in the absence of external resistive or driving forces.

Solution:

Step 1: Understanding the Concept:
A body capable of vibrating will do so with a specific frequency if it is displaced from its mean position and released.

Step 2: Detailed Explanation:
Natural (or free) vibrations are the periodic oscillations of a body when it is displaced from its equilibrium position and allowed to vibrate freely in the absence of any external force, such as air resistance or friction.
In such a state, the body vibrates with its natural frequency, which depends on its shape, size, and material.

Step 3: Final Answer:
Natural vibrations are vibrations of constant amplitude and frequency in a vacuum or a medium with no resistance.

Quick Tip

Natural vibrations are a theoretical ideal; in reality, all vibrations in a medium are damped.

3(iii)(b). How is this vibration different from damped vibrations in terms of their amplitudes?

Correct Answer: Constant vs. Decreasing amplitude.

Solution:

Step 1: Detailed Explanation:
1. **Natural Vibrations:** In an ideal vacuum where there is no resistance, the energy of the vibrating body remains constant. Therefore, the amplitude of vibration remains constant over

time.
2. **Damped Vibrations:** In the presence of a medium (like air), resistive forces do work against the moving body, converting its mechanical energy into heat. As energy is lost, the amplitude of the vibrations continuously decreases until the body stops.

Step 2: Final Answer:
Natural vibrations have a constant amplitude, whereas damped vibrations have an amplitude that decreases with time.

> Quick Tip
>
> Damping is a real-world effect caused by friction and viscosity.

3(iv). A metal piece of thermal capacity 40 $\mathbf{JK^{-1}}$, absorbs 800 J of heat. Calculate the rise in the temperature of this metal piece.

Correct Answer: 20 K (or 20°C)

Solution:

Step 1: Understanding the Concept:
Thermal capacity (or Heat capacity) is the amount of heat required to raise the temperature of the entire body by 1 K.

Step 2: Key Formula or Approach:
The formula relating heat absorbed (Q), thermal capacity (C'), and change in temperature (ΔT) is:

$$Q = C' \cdot \Delta T$$

Step 3: Detailed Explanation:
Given values:
- Heat absorbed, $Q = 800$ J
- Thermal capacity, $C' = 40$ JK^{-1}

Rearranging the formula to find the rise in temperature (ΔT):

$$\Delta T = \frac{Q}{C'}$$

Substituting the values:

$$\Delta T = \frac{800}{40} = 20 \text{ K}$$

Note that a rise of 20 K is equivalent to a rise of 20°C.

Step 4: Final Answer:
The rise in temperature is 20 K.

> Quick Tip
>
> Heat Capacity $C' = \text{mass} \times \text{specific heat capacity}$. Always check if the units of heat and capacity are consistent (Joules vs. calories).

3(v). In an AC generator, name the part which has the following functions:
(a) intensifies the magnetic field.
(b) maintains electrical contact between the rotating parts and the external circuit.

Correct Answer: (a) Soft iron core, (b) Carbon brushes and Slip rings

Solution:

Step 1: Understanding the Concept:
An AC generator converts mechanical energy into electrical energy using electromagnetic induction. Various parts work together to maximize efficiency.

Step 2: Detailed Explanation:
(a) **Soft iron core:** The armature coil is wound around a soft iron core. Because soft iron has high magnetic permeability, it concentrates and intensifies the magnetic field lines through the coil, increasing the induced EMF.
(b) **Carbon brushes and Slip rings:** Slip rings rotate along with the armature coil. Stationary carbon brushes press against these rings, allowing current to flow from the rotating coil to the fixed external circuit without twisting the wires.

Step 3: Final Answer:
(a) Soft iron core (of the armature).
(b) Carbon brushes and Slip rings.

> Quick Tip
>
> DC generators use a split-ring commutator instead of slip rings to provide unidirectional current.

3(vi). Give two differences between nuclear fission and nuclear fusion.

Correct Answer: 1. Splitting vs. Combining, 2. Control vs. High Temperature requirement.

Solution:

Step 1: Understanding the Concept:
Both are nuclear reactions that release massive amounts of energy by changing the binding energy per nucleon.

Step 2: Detailed Explanation:
Two major differences are:
1. **Process:** In nuclear fission, a heavy nucleus (like Uranium-235) splits into two or more lighter nuclei. In nuclear fusion, two or more light nuclei (like Hydrogen isotopes) combine to form a heavier nucleus.
2. **Control and Conditions:** Fission can be controlled in a nuclear reactor using control rods and moderators. Fusion requires extremely high temperatures (approx. 10^7 K) to overcome electrostatic repulsion, making it difficult to control for steady power production on Earth currently.

Step 3: Final Answer:
(i) Fission is splitting of heavy nuclei; Fusion is joining of light nuclei.
(ii) Fission produces radioactive waste; Fusion produces mostly non-radioactive waste (like Helium).

Quick Tip

Fusion produces much more energy per unit mass than fission and is the power source for stars like the Sun.

3(vii). A monochromatic ray strikes the surface of identical prisms (A, B and C) at different angles of incidence. The diagram below shows their refracted rays. Study the path of these refracted rays and identify in which of the diagrams:
(a) the angle of incidence is maximum.
(b) the angle of incidence is minimum.
(c) the angle of incidence is equal to the angle of emergence.

Correct Answer: (a) Prism A, (b) Prism B, (c) Prism C

Solution:

Step 1: Understanding the Concept:
The path of light through a prism depends on the angle of incidence (i). For an isosceles prism,

when the refracted ray is parallel to the base, the prism is in the state of minimum deviation (δ_m).

Step 2: Detailed Explanation:
- **(c)** $i = e$**:** Diagram C shows the refracted ray passing through the prism parallel to its base. This is the specific condition for minimum deviation where the angle of incidence equals the angle of emergence ($i = e$).
- **(b) Minimum incidence:** Diagram B shows the incident ray entering almost normally to the surface (the angle with the normal is very small). Thus, this corresponds to the minimum angle of incidence among the choices.
- **(a) Maximum incidence:** Diagram A shows the ray striking the first surface at a very steep angle (grazing incidence or large angle with the normal), resulting in the most significant bending toward the base.

Step 3: Final Answer:
(a) Diagram A, (b) Diagram B, (c) Diagram C.

Quick Tip

At the position of minimum deviation, the ray inside the prism is always parallel to the base if the prism is isosceles.

4(i)(a). A ray of light enters a glass block from air and comes out from the opposite surface. If the angle of refraction at the first surface is not the same as the angle of incidence at the second surface, then: What is the product of the ratio $\frac{\sin i}{\sin r}$ at the first surface and at the second surface?

Correct Answer: 1

Solution:

Step 1: Understanding the Concept:
According to Snell's Law, the refractive index of glass with respect to air ($_a\mu_g$) is the ratio of the sine of the angle of incidence in air to the sine of the angle of refraction in glass.

Step 2: Key Formula or Approach:
Refractive index of glass with respect to air: $_a\mu_g = \frac{\sin i_1}{\sin r_1}$
Refractive index of air with respect to glass: $_g\mu_a = \frac{\sin i_2}{\sin r_2}$
By the Principle of Reversibility: $_a\mu_g \times_g \mu_a = 1$

Step 3: Detailed Explanation:
At the first surface, the ratio $\frac{\sin i}{\sin r}$ is equal to $_a\mu_g$.

At the second surface, the ray travels from glass to air, so the ratio $\frac{\sin i}{\sin r}$ is equal to ${}_g\mu_a$.
The product of these two ratios is:

$$ {}_a\mu_g \times_g \mu_a = \frac{1}{{}_g\mu_a} \times_g \mu_a = 1 $$

This product is always 1 regardless of whether the surfaces are parallel or not.

Step 4: Final Answer:
The product of the ratios is 1.

> Quick Tip
>
> The product of refractive indices for a series of media starting and ending in the same medium is always unity ($\mu_{12} \times \mu_{23} \times \mu_{31} = 1$).

4(i)(b). State whether the opposite surfaces are parallel or not parallel.

Correct Answer: not parallel

Solution:

Step 1: Understanding the Concept:
In a rectangular glass block with parallel opposite faces, the normals at the point of incidence on both faces are parallel to each other.

Step 2: Detailed Explanation:
If the surfaces were parallel, the ray inside the glass would act as a transversal between two parallel normals.
This would mean the angle of refraction at the first surface (r_1) and the angle of incidence at the second surface (i_2) would be alternate interior angles, making them equal ($r_1 = i_2$).
The question states that r_1 is **not** the same as i_2.
Therefore, the normals are not parallel, which implies the surfaces are not parallel.

Step 3: Final Answer:
The opposite surfaces are not parallel.

> Quick Tip
>
> If the surfaces of a glass block are not parallel, the emergent ray will not be parallel to the incident ray, and a deviation is produced (like in a prism).

4(i)(c). How did you reach the conclusion in (b) above?

Correct Answer: Because the angle of refraction at the first surface is not equal to the angle of incidence at the second surface.

Solution:

Step 1: Understanding the Concept:
Geometrical properties of parallel lines and transversals are applied to the path of light through a medium.

Step 2: Detailed Explanation:
For parallel surfaces, the normal at the first surface is parallel to the normal at the second surface.
The refracted ray inside the medium acts as a transversal.
In such a case, the angle of refraction at the first surface (r) and the angle of incidence at the second surface (i') must be equal as they are alternate interior angles.
Since the question provides that these two angles are not equal ($r \neq i'$), the condition for parallel surfaces is violated.

Step 3: Final Answer:
The conclusion is reached based on the fact that $r \neq i'$, which only happens when the refracting surfaces are inclined at an angle to each other.

Quick Tip

For a parallel-sided slab, the lateral displacement occurs, but the emergent ray remains parallel to the incident ray because $\angle i_1 = \angle e$.

4(ii)(a). Calculate the speed of light in this glass. (Given refractive index = 1.8, speed of light in air = 3×10^8 ms^{-1})

Correct Answer: 1.67×10^8 ms^{-1}

Solution:

Step 1: Understanding the Concept:
The refractive index (μ) of a medium is defined as the ratio of the speed of light in vacuum (or air) to the speed of light in that medium.

Step 2: Key Formula or Approach:

$$\mu = \frac{c}{v} \implies v = \frac{c}{\mu}$$

Step 3: Detailed Explanation:
Given:
Refractive index of glass (μ) = 1.8
Speed of light in air (c) = 3×10^8 ms^{-1}
Calculation:

$$v = \frac{3 \times 10^8}{1.8}$$

$$v = \frac{30}{18} \times 10^8$$

$$v = \frac{5}{3} \times 10^8$$

$$v \approx 1.666... \times 10^8 \text{ ms}^{-1}$$

Rounding to two decimal places: $v = 1.67 \times 10^8$ ms^{-1}.

Step 4: Final Answer:
The speed of light in the glass is 1.67×10^8 ms^{-1}.

Quick Tip

Speed of light decreases in a denser medium. Since $\mu > 1$, the speed v will always be less than 3×10^8 ms^{-1}.

4(ii)(b). If the width of this block is doubled, then what will be the speed of light in the block?

Correct Answer: It will remain the same.

Solution:

Step 1: Understanding the Concept:
The speed of light in a medium is a characteristic property of the material of the medium and the wavelength of light used.

Step 2: Detailed Explanation:
The speed of light in a medium depends on its refractive index ($v = c/\mu$).
The refractive index depends on the nature of the material (optical density) and the frequency/wavelength of the light.
Changing the physical dimensions (width, height, or thickness) of the block does not change the material or the optical density.
Therefore, the refractive index remains 1.8, and the speed of light remains unchanged.

Step 3: Final Answer:
The speed of light in the block remains 1.67×10^8 ms^{-1}.

Quick Tip

Intrinsic properties like refractive index, density, and specific heat capacity do not depend on the size or shape of the object.

4(iii)(a). Name the electromagnetic radiation used to detect fake currency.

Correct Answer: Ultraviolet (UV) radiations

Solution:

Step 1: Understanding the Concept:
Specific electromagnetic radiations can cause certain substances to fluoresce (glow), which is used for security identification.

Step 2: Detailed Explanation:
Genuine currency notes have certain marks or patterns printed with special fluorescent ink.
These marks are invisible under ordinary visible light but become visible and glow when exposed to Ultraviolet (UV) radiations.
Fake currency usually lacks these sophisticated fluorescent security features.

Step 3: Final Answer:
Ultraviolet radiations are used to detect fake currency.

Quick Tip

UV radiations have high energy and short wavelengths, making them ideal for exciting electrons in fluorescent materials.

4(iii)(b). Redraw the diagram given below and complete the path of the light ray AB through the glass prism till it emerges out of the prism. Critical angle of the glass is 42°.

Correct Answer: The ray undergoes Total Internal Reflection (TIR) at the hypotenuse and emerges normally from the other side.

Solution:

Step 1: Understanding the Concept:
When light travels from a denser to a rarer medium, it undergoes Total Internal Reflection (TIR) if the angle of incidence is greater than the critical angle.

Step 2: Detailed Explanation:
1. The ray AB enters the first surface of the right-angled prism normally ($\angle i = 0^\circ$). It travels undeviated and hits the hypotenuse.
2. Based on the prism geometry (angle 30°), the angle of incidence at the hypotenuse is 60°.
3. The critical angle (C) is given as 42°.
4. Since $60^\circ > 42^\circ$, the ray undergoes Total Internal Reflection.
5. The reflected ray follows the law of reflection ($\angle i = \angle r = 60^\circ$) and moves toward the third surface.
6. Depending on the specific geometry of the emergence, it will refract out into the air.

Step 3: Final Answer:
The ray undergoes TIR at the hypotenuse because the angle of incidence (60°) exceeds the critical angle (42°).

Quick Tip

In a right-angled prism, always check the angle of incidence at the internal face. If $i > C$, reflect the ray; if $i < C$, refract it out.

---

5. An object placed in front of a convex lens, forms an image of same size on a screen. Moving the object 12 cm closer to the lens results in the formation of a real image which is three times the size of the object. Calculate the focal length

of the lens.

Correct Answer: 18 cm

Solution:

Step 1: Understanding the Concept:
A convex lens forms a real, inverted image of the same size when the object is at $2f$. Magnification $m = v/u$.

Step 2: Key Formula or Approach:
Magnification for lens: $m = \frac{f}{f+u}$ (Using sign convention)

Step 3: Detailed Explanation:
Case 1: Image same size as object.
This happens when object distance $u_1 = -2f$. Magnification $m_1 = -1$.
Case 2: Object is moved 12 cm closer.
New object distance $u_2 = -(2f - 12) = -2f + 12$.
New magnification $m_2 = -3$ (Real image is inverted).
Using the formula $m = \frac{f}{f+u}$:

$$-3 = \frac{f}{f + (-2f + 12)}$$

$$-3 = \frac{f}{12 - f}$$

$$-3(12 - f) = f$$

$$-36 + 3f = f$$

$$2f = 36 \implies f = 18 \text{ cm}$$

Step 4: Final Answer:
The focal length of the convex lens is 18 cm.

Quick Tip

For convex lenses: $m = 1 \implies u = 2f$. This is a standard result that serves as a starting point for many problems.

4(ii)(a) Atmospheric temperature after a hailstorm is greater than the temperature during the hailstorm. State True or False.

Correct Answer: False

Solution:

Step 1: Understanding the Concept:
Phase change (melting) requires the absorption of latent heat from the surroundings.

Step 2: Detailed Explanation:
After a hailstorm, the hail (ice) on the ground begins to melt.
To melt, ice requires latent heat of fusion (336 J/g). It absorbs this massive amount of heat from the surrounding air.
As the atmosphere loses heat to the melting ice, its temperature drops significantly.
Therefore, the atmosphere feels much colder after the hailstorm than during it.

Step 3: Final Answer:
The statement is False.

Quick Tip

Melting of ice is an endothermic process; it "steals" heat from the environment, causing a cooling effect.

4(ii)(b) Which thermal physical quantity of a frying pan changes by making the base heavier?

Correct Answer: Heat Capacity (or Thermal Capacity)

Solution:

Step 1: Understanding the Concept:
Specific Heat Capacity is independent of mass, but Heat Capacity depends directly on mass.

Step 2: Detailed Explanation:
The thermal energy required to raise the temperature of a body by 1°C is called its Heat Capacity (C').
It is calculated as: $C' = m \times c$, where m is mass and c is specific heat capacity.

By making the base of the frying pan heavier, we are increasing its mass (m).
Since the material is the same, c is constant, but the product $m \times c$ increases.
Therefore, the heat capacity of the pan increases.

Step 3: Final Answer:
The Heat Capacity (Thermal Capacity) of the pan changes (increases).

> Quick Tip
>
> Cooking utensils are often made with thick bases to increase heat capacity, which helps in maintaining a steady temperature and preventing food from burning.

4(ii)(c) State the principle of Calorimetry.

Correct Answer: Heat lost by hot body = Heat gained by cold body.

Solution:

Step 1: Understanding the Concept:
This principle is based on the Law of Conservation of Energy.

Step 2: Detailed Explanation:
The principle of Calorimetry states that when two bodies of different temperatures are placed in thermal contact, heat flows from the hot body to the cold body until thermal equilibrium is reached.
If no heat is lost to the surroundings, then:

$$\text{Heat energy lost by the hot body} = \text{Heat energy gained by the cold body}$$

This assumes the system is perfectly insulated.

Step 3: Final Answer:
The principle states that heat lost equals heat gained in an isolated system.

> Quick Tip
>
> In numericals, always set $m_1c_1(T_1 - T) = m_2c_2(T - T_2)$, where T is the final mixture temperature.

4(iii)(a) The given graph represents the cooling curve of a liquid. State the freezing temperature of the liquid.

Correct Answer: 20°C

Solution:

Step 1: Understanding the Concept:
During a phase change (like freezing), the temperature of a substance remains constant even though it is losing heat.

Step 2: Detailed Explanation:
On a cooling curve (temperature vs. time graph), a phase change is represented by a horizontal plateau (a line with zero slope).
In the provided graph, the segment QR is horizontal.
The temperature corresponding to this horizontal part is 20°C.
This indicates that the liquid is freezing into a solid at this constant temperature.

Step 3: Final Answer:
The freezing temperature is 20°C.

Quick Tip

For a pure substance, the freezing point and the melting point are the same temperature.

4(iii)(b) Name the phase change happening at the region QR.

Correct Answer: Freezing (or Solidification)

Solution:

Step 1: Understanding the Concept:
Cooling involves the removal of heat, leading to a transition from a higher energy state (liquid) to a lower energy state (solid).

Step 2: Detailed Explanation:
The curve starts from a higher temperature (liquid phase PQ).
The region QR is the transition period where temperature is constant while heat is being released (Latent heat of fusion).
Since the substance is being cooled and the temperature is constant, it is changing from the

liquid state to the solid state.
This process is known as freezing or solidification.

Step 3: Final Answer:
The phase change is freezing.

Quick Tip

Horizontal lines in thermal graphs always signify latent heat being exchanged during a change of state.

4(iii)(c) In which state (solid / liquid) does the above substance liberate heat at a faster rate? Justify.

Correct Answer: Solid state

Solution:

Step 1: Understanding the Concept:
The rate of cooling (rate of temperature drop) is indicated by the slope of the cooling curve.

Step 2: Detailed Explanation:
The slope of the curve represents how fast the temperature is changing over time ($\Delta T/\Delta t$).
- Region PQ (Liquid): Temperature drops from 45°C to 20°C in 20 seconds. Slope = 25/20 = 1.25°C/s.
- Region RS (Solid): Temperature drops from 20°C to 0°C in 5 seconds (from 30s to 35s). Slope = 20/5 = 4°C/s.
Since the slope is much steeper in the RS region, the temperature falls much faster in the solid state.
Assuming heat is lost to the same environment, a faster temperature drop implies heat is being liberated at a faster rate or the specific heat is lower.

Step 3: Final Answer:
The substance liberates heat at a faster rate in the solid state because the slope of the curve is steeper in region RS compared to PQ.

Quick Tip

Steeper Slope = Faster Cooling = Faster Heat Liberation. Always compare the "rise over run" of the different diagonal segments.

5. An object placed in front of a convex lens, forms an image of same size on a screen. Moving the object 12 cm closer to the lens results in the formation of a real image which is three times the size of the object. Calculate the focal length of the lens.

Correct Answer: 18 cm

Solution:

Step 1: Understanding the Concept:
For a convex lens, a real image of the same size as the object is formed on a screen when the object is placed at a distance of twice the focal length ($2f$) from the lens.
Magnification (m) is given by the ratio of image distance (v) to object distance (u).

Step 2: Key Formula or Approach:
1. Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
2. Magnification formula: $m = \frac{v}{u} = \frac{f}{f+u}$

Step 3: Detailed Explanation:
Case 1: Image of same size ($m = -1$) on a screen (real image).
This implies $u_1 = -2f$.
Case 2: Object is moved 12 cm closer to the lens.
New object distance, $u_2 = u_1 + 12 = -2f + 12$.
The new image is real and three times the size, so $m = -3$.
Using the magnification formula $m = \frac{f}{f+u}$:

$$-3 = \frac{f}{f + (-2f + 12)}$$

$$-3 = \frac{f}{12 - f}$$

Multiplying both sides by $(12 - f)$:

$$-3(12 - f) = f$$

$$-36 + 3f = f$$

$$2f = 36 \implies f = 18 \text{ cm}$$

Step 4: Final Answer:
The focal length of the lens is 18 cm.

> Quick Tip
>
> Remember that for a real image formed by a lens, magnification is negative. If $m = -1$, the object is at $2f$. Use the $m = \frac{f}{f+u}$ formula to save time in lens problems.

---

ii(a). Atmospheric temperature after a hailstorm is greater than the temperature during the hailstorm. State True or False.

(A) True
(B) False

Correct Answer: (B) False

Solution:

Step 1: Understanding the Concept:
This question involves the concept of Latent Heat of Fusion. Melting is an endothermic process.

Step 2: Detailed Explanation:
After a hailstorm, the hail (ice) present on the ground begins to melt.
To change its state from solid to liquid, ice absorbs a large amount of heat (specific latent heat of fusion = 336 J/g) from the surrounding atmosphere.
Because the surrounding air loses this heat to the melting ice, its temperature drops significantly.
Therefore, the atmosphere becomes much colder after a hailstorm than during it.

Step 3: Final Answer:
The statement is False.

> Quick Tip
>
> Melting of ice always causes cooling of the surroundings because it "steals" energy to break molecular bonds. This is why it feels colder when it starts to thaw after a heavy snowfall.

---

ii(b). Which thermal physical quantity of a frying pan changes by making the base heavier?

Correct Answer: Heat Capacity (or Thermal Capacity)

Solution:

Step 1: Understanding the Concept:
We must distinguish between specific heat capacity and heat capacity. Specific heat is intrinsic to the material, while heat capacity depends on the mass.

Step 2: Key Formula or Approach:
Heat Capacity (C') $= m \times c$, where m is mass and c is specific heat capacity.

Step 3: Detailed Explanation:
By making the base of the frying pan heavier, we are increasing its mass (m).
The material of the pan remains the same, so the specific heat capacity (c) remains constant.
However, since the mass increases, the product $m \times c$ increases.
This product is the heat capacity (or thermal capacity) of the pan.

Step 4: Final Answer:
The physical quantity that changes is the Heat Capacity (Thermal Capacity).

Quick Tip

Heavy-bottomed pans are preferred in cooking because their higher heat capacity allows them to store more thermal energy and distribute it more evenly, preventing food from burning quickly.

---

ii(c). State the principle of Calorimetry.

Correct Answer: Heat lost by hot body = Heat gained by cold body

Solution:

Step 1: Understanding the Concept:
Calorimetry is based on the law of conservation of energy applied to thermal systems.

Step 2: Detailed Explanation:
The principle of calorimetry states that when two bodies of different temperatures are placed in thermal contact, heat flows from the hot body to the cold body until thermal equilibrium is reached.
In an isolated system (where no heat is lost to the surroundings):
Heat lost by the hot body = Heat gained by the cold body.
Mathematically: $m_1 c_1 \Delta T_1 = m_2 c_2 \Delta T_2$.

Step 3: Final Answer:
The principle states that in an insulated system, the total heat lost by a hot body is equal to the total heat gained by a cold body.

> Quick Tip
>
> This principle assumes a "perfectly insulated" environment. In practical exams, always mention that "no heat is lost to the surroundings" for a complete definition.

---

iii(a). The given graph represents the cooling curve of a liquid. State the freezing temperature of the liquid.

Correct Answer: 20°C

Solution:

Step 1: Understanding the Concept:
On a cooling curve (temperature vs. time), a phase change (like freezing) is represented by a horizontal plateau where the temperature remains constant.

Step 2: Detailed Explanation:
Looking at the provided graph:
1. The temperature falls from 50°C to 20°C (Region PQ).
2. From time $t = 20$ s to $t = 30$ s (Region QR), the temperature remains constant at 20°C.
3. This constant temperature period indicates the change of state from liquid to solid.

Step 3: Final Answer:
The freezing temperature of the liquid is 20°C.

> Quick Tip
>
> Horizontal lines in thermal graphs always indicate a phase change (melting, freezing, or boiling) because the temperature does not change while the state is shifting.

---

iii(b). Name the phase change happening at the region QR.

Correct Answer: Freezing (or Solidification)

Solution:

Step 1: Understanding the Concept:
A cooling curve follows a substance as it loses heat. Transitioning from a liquid to a solid at a constant temperature is freezing.

Step 2: Detailed Explanation:
In the region PQ, the substance is a liquid being cooled.
In the region QR, the temperature is constant while the substance continues to lose heat to the surroundings.
This represents the latent heat of fusion being released as the liquid turns into a solid.
This process is called freezing or solidification.

Step 3: Final Answer:
The phase change occurring in region QR is freezing.

Quick Tip

If the graph were going "up" (heating), this region would represent melting. Since it is a cooling curve (going "down"), it is freezing.

---

iii(c). In which state (solid / liquid) does the above substance liberate heat at a faster rate? Justify.

Correct Answer: Solid state

Solution:

Step 1: Understanding the Concept:
The rate of cooling (rate of temperature fall) is represented by the slope of the temperature-time graph. A steeper slope indicates a faster rate of cooling.

Step 2: Detailed Explanation:
1. **Liquid State (PQ):** Temperature falls from 50°C to 20°C in 20 s.
Rate of fall $= \frac{50-20}{20} = \frac{30}{20} = 1.5$°C/s.
2. **Solid State (RS):** Temperature falls from 20°C to 0°C in 5 s (from 30 s to 35 s).
Rate of fall $= \frac{20-0}{5} = 4$°C/s.
Since the slope is much steeper in the RS region than in the PQ region, the substance loses temperature more quickly in the solid state. This implies it liberates heat to the surroundings at a faster rate during this interval.

Step 3: Final Answer:
The substance liberates heat at a faster rate in the solid state because the slope of the cooling curve in region RS is steeper than in region PQ.

Quick Tip

Slope of cooling curve = $\frac{\Delta T}{\Delta t}$. Larger slope $\implies$ faster cooling. This often happens because the specific heat capacity of the solid phase is lower than that of the liquid phase.

6(i)(a). The diagram shows a wheel with a handle. Two forces, F_1 and F_2 of equal magnitudes are acting on the handle as shown in the diagram. Which force produces negative moment?

Correct Answer: (A) Both F_1 and F_2

Solution:

Step 1: Understanding the Concept:
The moment of force (torque) is the turning effect of a force about a pivot.
By convention, clockwise moments are taken as negative, and anti-clockwise moments are taken as positive.

Step 2: Detailed Explanation:
1. Pivot is at point O.
2. Force F_1 acts such that it tends to rotate the wheel in the clockwise direction.
3. Force F_2 also acts such that it tends to rotate the wheel in the clockwise direction.
Since both forces tend to produce a clockwise rotation, both produce a negative moment.

Step 3: Final Answer:
Both forces F_1 and F_2 produce a negative moment because they both cause clockwise rotation about the pivot O.

Quick Tip

Always use the Right-Hand Rule or simply visualize the rotation: Clockwise = Negative ($-$), Anti-clockwise = Positive ($+$).

6(i)(b). Is the wheel in equilibrium? (Yes or No)

Correct Answer: No

Solution:

Step 1: Understanding the Concept:
For a body to be in rotational equilibrium, the algebraic sum of the moments of all forces acting on it about the pivot must be zero.

Step 2: Detailed Explanation:
As identified in part (a), both forces F_1 and F_2 produce clockwise moments.
Net Moment = Moment due to F_1 + Moment due to F_2.
Since both moments have the same sign (negative), their sum cannot be zero.
Because there is a non-zero net moment acting on the wheel, it is not in rotational equilibrium.

Step 3: Final Answer:
No, the wheel is not in equilibrium.

Quick Tip

Equilibrium requires the net force and the net torque to be zero. Here, the net torque is clearly non-zero.

6(i)(c). Justify your answer stated in (b).

Correct Answer: The net moment about the pivot O is not zero.

Solution:

Step 1: Detailed Explanation:
A body is in equilibrium only when the sum of anti-clockwise moments equals the sum of clockwise moments.
In this specific case, both forces F_1 and F_2 are producing moments in the clockwise direction.
Let τ_1 and τ_2 be the magnitudes of the moments. The total moment is $-(\tau_1 + \tau_2)$.
Since $\tau_1 + \tau_2 \neq 0$, the wheel will experience a net clockwise torque and will rotate.

Step 2: Final Answer:
The wheel is not in equilibrium because the total moment acting on the wheel about point O is non-zero (specifically, it is a net clockwise moment).

Quick Tip

In exams, always mention the "Principle of Moments" when justifying rotational equilibrium.

6(ii)(a). Name the unit of work done, used in subatomic scale.

Correct Answer: Electron volt (eV)

Solution:

Step 1: Understanding the Concept:
In subatomic physics (dealing with atoms and particles), the Joule is often too large a unit to be practical.

Step 2: Detailed Explanation:
The electron volt (eV) is defined as the amount of kinetic energy gained or lost by a single electron accelerating from rest through an electric potential difference of one volt.
Relationship with SI unit:
1 eV $= 1.602 \times 10^{-19}$ Joules.

Step 3: Final Answer:
The unit of work/energy used in the subatomic scale is the electron volt (eV).

Quick Tip

Remember 1 eV $= 1.6 \times 10^{-19}$ J. Larger units include keV, MeV, and GeV.

6(ii)(b). To which class of lever does a pair of scissors belong?

Correct Answer: Class I lever

Solution:

Step 1: Understanding the Concept:
Levers are classified based on the relative positions of the Fulcrum (F), Load (L), and Effort (E).

Step 2: Detailed Explanation:
In a pair of scissors:
1. The pivot point (screw) is the Fulcrum, which is located in the middle.
2. The effort is applied at the handles by the fingers.
3. The load (the object being cut) is at the blades.
Since the Fulcrum is between the Effort and the Load, it is a Class I lever.

Step 3: Final Answer:
Scissors belong to Class I levers.

Quick Tip

Mnemonic: FLE 123. (1=F in middle, 2=L in middle, 3=E in middle).

6(ii)(c). A stone is tied to a string and displaced from A to B by application of constant force F in three different ways as shown in the diagram below. Arrange the three cases in ascending order of the work done by the force. (Given AJB is a semi-circle, $0 < \theta < 90^\circ$ and $AB = 20$ m)

Correct Answer: Case 3 < Case 2 < Case 1

Solution:

Step 1: Understanding the Concept:
Work done is defined as the product of the component of force in the direction of displacement and the magnitude of the displacement: $W = F \cdot s \cdot \cos(\theta)$.

Step 2: Key Formula or Approach:
W = Force $\times$ Displacement in the direction of force.

Step 3: Detailed Explanation:
Let F be the constant force magnitude.
1. **Case 2:** Displacement is along the straight line AB. The force F is in the same direction as displacement.
$s = 20$ m. $W_2 = F \times 20 = 20F$.
2. **Case 3:** Displacement is along AB (20 m), but the force acts at an angle θ.
$W_3 = F \cdot \cos(\theta) \times 20 = 20F\cos(\theta)$. Since $0 < \theta < 90^\circ$, $\cos(\theta) < 1$. Thus $W_3 < W_2$.
3. **Case 1:** The stone moves along the semi-circle arc AJB. The force F is shown acting along the tangent at every point (implied by the arrow following the curve).
Distance along arc = $\pi \times$ radius = $\pi \times \frac{20}{2} = 10\pi \approx 31.4$ m.
$W_1 = F \times 10\pi \approx 31.4F$.
Comparing values: $20F\cos(\theta) < 20F < 31.4F$.

Step 4: Final Answer:
The ascending order is Case 3 < Case 2 < Case 1.

Quick Tip

Work depends on the distance moved *along* the line of the force. Curved paths generally involve more distance and thus potentially more work if force follows the path.

6(iii)(a). A ball of mass 20 g falls from a height of 45 m. It rebounds from the ground to a height of 40 m. Calculate the initial potential energy of the ball. [$g = 10$ **m/s**^{2}]

Correct Answer: 9 J

Solution:

Step 1: Understanding the Concept:
Gravitational Potential Energy (P.E.) is the energy possessed by a body due to its position above the ground.

Step 2: Key Formula or Approach:
$P.E. = mgh$

Step 3: Detailed Explanation:
Given:
Mass, $m = 20$ g $= \frac{20}{1000}$ kg $= 0.02$ kg
Height, $h = 45$ m
Acceleration due to gravity, $g = 10$ m/s^2

$$P.E. = 0.02 \times 10 \times 45$$

$$P.E. = 0.2 \times 45 = 9 \text{ J}$$

Step 4: Final Answer:
The initial potential energy of the ball is 9 J.

Quick Tip

Always convert mass to SI units (kg) before substituting into physics formulas to get the answer in Joules.

6(iii)(b). Calculate the speed of the ball at which it hits the ground.

Correct Answer: 30 m/s

Solution:

Step 1: Understanding the Concept:
According to the law of conservation of energy, the potential energy at the top is converted

into kinetic energy at the bottom (neglecting air resistance).

Step 2: Key Formula or Approach:
$mgh = \frac{1}{2}mv^2$ or $v = \sqrt{2gh}$

Step 3: Detailed Explanation:
Initial Height, $h = 45$ m
Gravity, $g = 10$ m/s^2

$$v = \sqrt{2 \times 10 \times 45}$$

$$v = \sqrt{900}$$

$$v = 30 \text{ m/s}$$

Step 4: Final Answer:
The speed of the ball when it hits the ground is 30 m/s.

Quick Tip

The speed of a falling body depends only on the height and gravity, not on the mass of the body.

6(iii)(c). Calculate the loss in kinetic energy on striking the ground.

Correct Answer: 1 J

Solution:

Step 1: Understanding the Concept:
The loss in kinetic energy upon collision is the difference between the energy just before impact and the energy just after rebound.

Step 2: Key Formula or Approach:
Loss in Energy = Initial energy - Final energy after rebound.

Step 3: Detailed Explanation:
1. Total initial energy = 9 J (from part a).
2. Potential energy at rebound height (40 m):

$P.E._{\text{rebound}} = mgh_2 = 0.02 \times 10 \times 40 = 8$ J.
3. Since it reaches 40 m, its kinetic energy just after rebound must have been 8 J.
4. Loss in energy = 9 J − 8 J = 1 J.

Step 4: Final Answer:
The loss in kinetic energy on striking the ground is 1 J.

> Quick Tip
>
> Energy loss during collision is often converted into heat and sound energy.

7(i)(a). To lift a load of 30 kgf, Suhas uses a single fixed pulley, while Radha uses a single movable pulley. The displacement of efforts in both the cases are equal. In an ideal situation calculate the ratio of the efforts in the two cases.

Correct Answer: 2 : 1

Solution:

Step 1: Understanding the Concept:
In an ideal situation, the Mechanical Advantage (M.A.) of a single fixed pulley is 1, and for a single movable pulley, it is 2.

Step 2: Key Formula or Approach:
$M.A. = \frac{\text{Load (L)}}{\text{Effort (E)}}$

Step 3: Detailed Explanation:
Given Load, $L = 30$ kgf.
1. **For Suhas (Fixed Pulley):**
$M.A. = 1 \implies E_{\text{suhas}} = L = 30$ kgf.
2. **For Radha (Movable Pulley):**
$M.A. = 2 \implies E_{\text{radha}} = \frac{L}{2} = \frac{30}{2} = 15$ kgf.
Ratio $= \frac{E_{\text{suhas}}}{E_{\text{radha}}} = \frac{30}{15} = \frac{2}{1}$.

Step 4: Final Answer:
The ratio of the efforts is 2 : 1.

> Quick Tip
>
> A single fixed pulley only changes the direction of effort, whereas a single movable pulley acts as a force multiplier.

7(i)(b). Calculate the ratio of the potential energy gained by the loads in the two cases.

Correct Answer: 2 : 1

Solution:

Step 1: Understanding the Concept:
Potential Energy gained = $mg\Delta h = L \times$ displacement of load.

Step 2: Key Formula or Approach:
Velocity Ratio ($V.R.$) = $\frac{\text{Displacement of Effort } (d_E)}{\text{Displacement of Load } (d_L)}$.

Step 3: Detailed Explanation:
Let the displacement of effort be d in both cases.
1. **Suhas (Fixed Pulley):** $V.R. = 1 \implies d_L = d_E = d$.
Energy Gained ($P.E._1$) = $L \times d$.
2. **Radha (Movable Pulley):** $V.R. = 2 \implies d_L = \frac{d_E}{2} = \frac{d}{2}$.
Energy Gained ($P.E._2$) = $L \times \frac{d}{2}$.
Ratio = $\frac{P.E._1}{P.E._2} = \frac{L \times d}{L \times (d/2)} = \frac{2}{1}$.

Step 4: Final Answer:
The ratio of potential energy gained by the loads is 2 : 1.

Quick Tip

Even if efforts are moved same distance, the load in a movable pulley only rises half as high.

7(i)(c). Calculate the ratio of the efficiencies in the two cases.

Correct Answer: 1 : 1

Solution:

Step 1: Understanding the Concept:
Efficiency (η) is defined as the ratio of Work Output to Work Input.

Step 2: Detailed Explanation:
The question specifies "in an ideal situation". In an ideal situation, there is no friction, and the string/pulley are weightless.

For any ideal machine, the efficiency is always 100% or 1.
$\eta_{\text{suhas}} = 100\%$
$\eta_{\text{radha}} = 100\%$
Ratio = 1 : 1.

Step 3: Final Answer:
The ratio of the efficiencies is 1 : 1.

> Quick Tip
>
> "Ideal situation" is a keywords in physics problems indicating 100% efficiency.

7(ii)(a). One end of a plastic foot ruler is held tightly at the edge of a table and the other end is plucked. Name the vibrations produced in the ruler.

Correct Answer: Damped vibrations (or Free/Natural vibrations if in vacuum)

Solution:

Step 1: Understanding the Concept:
When a body is displaced from its mean position and released, it starts vibrating.

Step 2: Detailed Explanation:
The ruler vibrates with its own natural frequency. However, because it is vibrating in air, it faces air resistance, and energy is lost in every cycle. This causes the amplitude to decrease over time.
Technically, these are **damped vibrations**. If we ignore air resistance for a short duration, they can be called natural or free vibrations.

Step 3: Final Answer: The vibrations produced are damped vibrations (or natural vibrations if damping is ignored).

> Quick Tip
>
> In real-world conditions, all "free" vibrations eventually die out because of damping.

7(ii)(b). Now the ruler is pushed inside partially and plucked again from its free end. State with a reason whether the frequency of vibration increases or decreases.

Correct Answer: Frequency increases.

Solution:

Step 1: Understanding the Concept:
For a vibrating string or strip, the frequency is inversely proportional to the length of the vibrating part.

Step 2: Detailed Explanation:
When the ruler is pushed further onto the table, the length of the part projecting out (the vibrating length l) decreases.
Frequency $f \propto \frac{1}{l}$.
Since the vibrating length is reduced, the frequency of vibration increases. This results in a shriller sound.

Step 3: Final Answer:
The frequency of vibration increases because the vibrating length of the ruler has decreased.

> Quick Tip
>
> Smaller length = Higher frequency = Higher pitch.

7(iii)(a)1. Two persons A and B are standing in front of a cliff in the same line 170 m apart as shown in the diagram. Person B fires the gun and hears the echo in 3 s. Calculate the distance of the person B from the cliff. (The speed of sound in air is 340 m/s.)

Correct Answer: 510 m

Solution:

Step 1: Understanding the Concept:
An echo is heard when sound travels to a reflecting surface and back to the listener.

Step 2: Key Formula or Approach:
$v = \frac{2d}{t} \implies d = \frac{v \times t}{2}$

Step 3: Detailed Explanation:
Speed of sound, $v = 340$ m/s
Time for echo, $t = 3$ s
Let d be the distance of B from the cliff.

$$d = \frac{340 \times 3}{2}$$

$$d = 170 \times 3 = 510 \text{ m}$$

Step 4: Final Answer:
The distance of person B from the cliff is 510 m.

> Quick Tip
>
> For echo problems, distance is always doubled ($2d$) because the sound must go to the wall and come back.

7(iii)(a)2. Calculate the minimum time in which B hears the gunshot fired by A.

Correct Answer: 0.5 s

Solution:

Step 1: Understanding the Concept:
The time taken for sound to travel directly from source to listener is simply Distance / Speed.

Step 2: Detailed Explanation: Distance between A and B = 170 m.
Speed of sound = 340 m/s.
Time = $\frac{\text{Distance}}{\text{Speed}}$
Time = $\frac{170}{340} = 0.5$ s.

Step 3: Final Answer:
Person B hears the gunshot from A after 0.5 s.

> Quick Tip
>
> This is direct sound travel, so do not double the distance!

7(iii)(b). Fill in the blank. The echo is softer (less loud) than the original sound due to the decrease in _____ of the wave. (amplitude / frequency)

Correct Answer: amplitude

Solution:

Step 1: Understanding the Concept:
Loudness is a characteristic of sound that depends on the amplitude of the vibration.

Step 2: Detailed Explanation:
When a sound wave travels through air and reflects off a cliff, some of its energy is absorbed by the air and the surface of the cliff.
A decrease in energy results in a decrease in the amplitude of the wave.
Since loudness $\propto$ Amplitude^2, the sound becomes softer. The frequency (pitch) remains the same as it depends on the source.

Step 3: Final Answer:
The echo is softer due to the decrease in the **amplitude** of the wave.

Quick Tip

Frequency only changes with the source or relative motion (Doppler Effect). Loudness always changes with distance and absorption due to amplitude decay.

8(i)(a). Bulb A rated 160 W, 40 V and Bulb B rated 40 W, 40 V are connected as shown in the diagram. Calculate the ratio $V_1 : V_2$.

Correct Answer: 1 : 1

Solution:

Step 1: Understanding the Concept:
In a parallel combination, the potential difference (voltage) across each component is the same.

Step 2: Detailed Explanation:
The diagram shows Bulb A and Bulb B connected in parallel across a 40 V source.
Voltmeters V_1 and V_2 are connected across Bulb A and Bulb B respectively.
Since they are in parallel:
Voltage across A = Voltage across B = Supply voltage = 40 V.
Therefore, $V_1 = 40$ V and $V_2 = 40$ V.
Ratio = 40 : 40 = 1 : 1.

Step 3: Final Answer:
The ratio $V_1 : V_2$ is 1 : 1.

Quick Tip

In parallel circuits, Voltage is constant. In series circuits, Current is constant.

8(i)(b). If the bulb A fuses, the current in the circuit remains the same. State True or False.

Correct Answer: False

Solution:

Step 1: Understanding the Concept:
Total current in a parallel circuit is the sum of currents in individual branches.

Step 2: Detailed Explanation:
Total Current $I_{\text{total}} = I_A + I_B$.
If Bulb A fuses, the branch with Bulb A becomes an open circuit, and current I_A becomes zero.
The total current drawn from the source will now only be I_B.
Therefore, the total main current decreases. It does not remain the same.

Step 3: Final Answer:
False. The total current in the main circuit decreases when one parallel branch fails.

Quick Tip

In home wiring (parallel), turning off one light reduces the total bill (current) because total resistance increases.

8(ii)(a). The reverse side of a three-pin plug with incorrect connection of wires is shown in the diagram. Identify the fault in the above connection.

Correct Answer: The live (red) and neutral (blue) wires are swapped.

Solution:

Step 1: Understanding the Concept:
Standard color coding and positioning for a three-pin plug (viewed from the back):
- Top pin: Earth (Green/Yellow)
- Right pin: Neutral (Blue/Black)
- Left pin: Live (Red/Brown)
Note: When viewed from the front, L is right and N is left. From the back, it is mirrored.

Step 2: Detailed Explanation:
In the diagram provided:
1. The Earth pin (top) is connected correctly (green).
2. However, looking at the two lower pins from the reverse side, the Red wire (Live) should be on the left and the Blue wire (Neutral) should be on the right.

The diagram shows the Red wire on the right and the Blue wire on the left. They are incorrectly swapped.

Step 3: Final Answer:
The fault is that the Live wire (Red) and Neutral wire (Blue) are connected to the wrong pins (swapped).

Quick Tip

Mnemonic for front view: L is for Live and Left? No! For front view: L is Right, N is Left. Back view: L is Left, N is Right.

8(ii)(b). Mention a risk factor involved, if the user operates the appliance without correcting it.

Correct Answer: The switch/fuse becomes ineffective in cutting off the high potential.

Solution:

Step 1: Understanding the Concept:
Safety devices like switches and fuses are always connected in the Live wire.

Step 2: Detailed Explanation:
If the wires are swapped, the switch of the appliance will now be in the Neutral line.
When the switch is turned 'OFF', the circuit is broken, but the appliance remains connected to the high voltage through the Live wire (which is now connected where the Neutral should be).
A user touching the internal parts of the "OFF" appliance could receive a fatal electric shock.

Step 3: Final Answer:
The main risk is that the appliance remains at a high potential even when switched off, leading to a risk of electric shock.

Quick Tip

Switches must always be in the Live wire so that turning them off makes the appliance "dead" (at 0V).

8(ii)(c). Will the appliance function in the present situation? (Yes or No)

Correct Answer: Yes

Solution:

Step 1: Understanding the Concept:
Most AC appliances require a complete path for current to flow, regardless of the polarity (for simple resistive loads).

Step 2: Detailed Explanation:
The appliance requires a potential difference of 220V between its terminals to operate.
Even with the wires swapped, a complete path exists from the Live terminal through the appliance to the Neutral terminal.
The current will still flow, and the appliance will work, although it is highly unsafe.

Step 3: Final Answer:
Yes, the appliance will function, but it will be extremely dangerous to use.

Quick Tip

"Working" does not mean "Safe". Swapped wiring is a common cause of home accidents.

8(iii)(a). In the combination of resistors shown below, calculate the resistance across AB when the switch S is open.

Correct Answer: 9 Ω

Solution:

Step 1: Understanding the Concept:
When a switch is open, the branch containing it does not conduct current.

Step 2: Detailed Explanation:
If switch S is open, the circuit consists of two parallel branches:
Branch 1 (Top): 12 Ω and 6 Ω in series. $R_1 = 12 + 6 = 18\ \Omega$.
Branch 2 (Bottom): 6 Ω and 12 Ω in series. $R_2 = 6 + 12 = 18\ \Omega$.
Now, R_1 and R_2 are in parallel:

$$\frac{1}{R_{AB}} = \frac{1}{18} + \frac{1}{18} = \frac{2}{18} = \frac{1}{9}$$

$R_{AB} = 9\ \Omega$.

Step 3: Final Answer:
The resistance across AB when S is open is 9 Ω.

> Quick Tip
>
> When two equal resistors R are in parallel, the equivalent resistance is $R/2$. Here, $18/2 = 9\Omega$.

8(iii)(b). Calculate the resistance across AB when the switch S is closed.

Correct Answer: 8 Ω

Solution:

Step 1: Understanding the Concept:
When the switch S is closed, the junctions between the resistors are connected. This reconfigures the series/parallel relationships.

Step 2: Detailed Explanation:
With S closed, the circuit becomes:
1. A parallel pair of 12 Ω and 6 Ω on the left.
Left equivalent resistance $R_L = \frac{12\times6}{12+6} = \frac{72}{18} = 4\ \Omega$.
2. A parallel pair of 6 Ω and 12 Ω on the right.
Right equivalent resistance $R_R = \frac{6\times12}{6+12} = \frac{72}{18} = 4\ \Omega$.
3. These two equivalent resistors are now in series:
$R_{AB} = R_L + R_R = 4 + 4 = 8\ \Omega$.

Step 3: Final Answer:
The resistance across AB when S is closed is 8 Ω.

> Quick Tip
>
> Closing a bridge switch usually decreases the total resistance of the network.

9(i)(a). An electric iron rated 1100 W, 220 V is operated for 5 hours. Calculate the minimum rating of the fuse required.

Correct Answer: 5 A

Solution:

Step 1: Understanding the Concept:
The fuse is a safety device that prevents excessive current from flowing through an appliance. The rating of a fuse is determined by the maximum current the appliance draws during normal operation.

Step 2: Key Formula or Approach:
Electrical Power (P) is the product of Voltage (V) and Current (I).

$$I = \frac{P}{V}$$

Step 3: Detailed Explanation:
Given:
Power (P) = 1100 W
Voltage (V) = 220 V
Substituting the values into the formula:

$$I = \frac{1100}{220}$$

$$I = 5 \text{ A}$$

The current drawn by the electric iron is 5 A. Therefore, a fuse with a minimum rating of 5 A is required to allow the appliance to function normally.

Step 4: Final Answer:
The minimum rating of the fuse required is 5 A.

Quick Tip

In practical scenarios, a fuse rating is chosen to be slightly higher than the operating current (e.g., a 6 A fuse for a 5 A load) to account for minor fluctuations without blowing unnecessarily.

9(i)(b). Calculate the energy consumed in kWh.

Correct Answer: 5.5 kWh

Solution:

Step 1: Understanding the Concept:
Electrical energy is the total power consumed over a specific period. The commercial unit for electrical energy is the kilowatt-hour (kWh).

Step 2: Key Formula or Approach:
Energy (E) in kWh = Power (P) in kW $\times$ Time (t) in hours.

Step 3: Detailed Explanation:
First, convert the power from Watts to Kilowatts:

$$P = \frac{1100}{1000} \text{ kW} = 1.1 \text{ kW}$$

Given time $t = 5$ hours.
Calculate Energy:

$$E = 1.1 \text{ kW} \times 5 \text{ h}$$

$$E = 5.5 \text{ kWh}$$

Step 4: Final Answer:
The energy consumed by the electric iron is 5.5 kWh.

Quick Tip

Always ensure units are consistent. If power is in Watts, divide by 1000 to get kW. If time is in minutes, divide by 60 to get hours.

9(i)(c). Calculate the cost of the energy consumed, if the rate is 10 per unit.

Correct Answer: 55

Solution:

Step 1: Understanding the Concept:
One "unit" of electricity as billed by utility companies is exactly 1 kWh. The total cost is the product of units consumed and the rate per unit.

Step 2: Detailed Explanation:
From the previous calculation, the energy consumed is 5.5 kWh.

Units consumed = 5.5 units.
Rate per unit = 10.

$$\text{Total Cost} = \text{Units} \times \text{Rate}$$

$$\text{Total Cost} = 5.5 \times 10 = 55$$

Step 3: Final Answer:
The total cost of the energy consumed is 55.

> **Quick Tip**
>
> To find monthly costs, calculate energy per day and multiply by the number of days in the month.

9(ii)(a). When the magnet as shown in the diagram, is moved towards the coil at a speed of 5 ms^{-1}, the galvanometer shows a certain deflection to the right. How will the direction and magnitude of deflection change when the coil also moves with a speed of 5 ms^{-1} in the direction of the motion of the magnet?

Correct Answer: There will be no deflection.

Solution:

Step 1: Understanding the Concept:
Faraday's Law of Electromagnetic Induction states that an EMF is induced in a coil only when there is a change in the magnetic flux linked with it. This change is caused by relative motion between the magnet and the coil.

Step 2: Detailed Explanation:
In the given scenario, the magnet moves to the left at 5 ms^{-1} and the coil also moves to the left at 5 ms^{-1}.
Since both are moving with the same velocity in the same direction, the distance between them remains constant.
Relative velocity = 5 ms^{-1} − 5 ms^{-1} = 0 ms^{-1}.
Because there is no relative motion, there is no change in the magnetic flux linked with the coil.
Consequently, no current is induced, and the galvanometer shows zero deflection.

Step 3: Final Answer:
The deflection becomes zero because the relative velocity between the magnet and the coil is zero.

Quick Tip

Induced current depends on $\frac{d\phi}{dt}$. If relative position is constant, flux ϕ is constant, and its derivative is zero.

9(ii)(b). How will the direction and magnitude of deflection change when the coil also moves with a speed of 5 ms^{-1} in the opposite direction of the motion of the magnet?

Correct Answer: Deflection remains to the right but its magnitude increases (doubles).

Solution:

Step 1: Understanding the Concept:
The magnitude of induced EMF is proportional to the rate of relative motion. The direction of induced current depends on whether the magnetic flux is increasing or decreasing.

Step 2: Detailed Explanation:
The magnet moves to the left at 5 ms^{-1}.
The coil moves to the right at 5 ms^{-1}.
Since they move toward each other, their relative speed is the sum of their individual speeds:
Relative Velocity = 5 ms^{-1} + 5 ms^{-1} = 10 ms^{-1}.
1. **Magnitude:** The relative speed is now double the original speed (10 ms^{-1} vs 5 ms^{-1}). Therefore, the rate of change of flux is doubled, leading to a doubling of the induced current and deflection magnitude.
2. **Direction:** The magnet's North pole is still approaching the coil (flux is increasing). According to Lenz's Law, the direction of the induced current will be the same as in the original case (to the right).

Step 3: Final Answer:
The deflection magnitude increases (doubles) and the direction remains to the right.

Quick Tip

Moving towards each other: Relative speed = $v_1 + v_2$. Moving in same direction: Relative speed = $|v_1 - v_2|$.

10(a)1. Which element is used in the lining of the special aprons worn by workers in nuclear power plants?

Correct Answer: Lead (Pb)

Solution:

Step 1: Understanding the Concept:
Nuclear radiation (like Gamma rays) can easily penetrate most materials and damage human tissue. Shielding is required using materials that can effectively absorb or scatter these high-energy photons.

Step 2: Detailed Explanation:
Lead is the standard material used for radiation shielding in medical and nuclear fields. Workers wear aprons lined with lead (lead aprons) to protect their internal organs from accidental exposure to ionizing radiation.

Step 3: Final Answer:
The element used is Lead.

Quick Tip

Lead is used not only in aprons but also in the walls of X-ray rooms and containers for radioactive isotopes.

10(a)2. Why is this element preferred?

Correct Answer: Because of its high density and high atomic number.

Solution:

Step 1: Understanding the Concept:
The absorption of high-energy radiation depends on the interaction of photons with electrons. Denser materials with more electrons per atom provide better protection.

Step 2: Detailed Explanation:
Lead is preferred because:
1. **High Density:** Lead is very dense (11.3 g/cm^3), meaning atoms are packed closely together, leaving very little space for radiation to pass through without collision.

2. **High Atomic Number (Z = 82):** A high atomic number means each atom has many electrons. High-energy radiation interacts more frequently with these electrons via the photoelectric effect and Compton scattering, thus getting absorbed effectively.

Step 3: Final Answer:
Lead is preferred due to its high density and high atomic number, which enable it to absorb harmful ionizing radiation effectively.

Quick Tip

Materials with high "Z" (Atomic Number) are the most efficient at stopping electromagnetic radiations like X-rays and Gamma rays.

10(b)1. $^{24}_{11}Na$ emits a nuclear radiation which does not alter the mass number but is deflected by a magnetic field. Name the type of nuclear radiation emitted by $^{24}_{11}Na$.

Correct Answer: Beta (β) radiation.

Solution:

Step 1: Understanding the Concept:
Radioactive decay involves the emission of Alpha, Beta, or Gamma radiation. These are distinguished by their charge and their effect on the nucleus.

Step 2: Detailed Explanation:
1. **Alpha (α)**: Reduces mass number by 4. Deflected by magnetic field.
2. **Beta (β)**: Consists of electrons (β^-) or positrons (β^+). It has negligible mass, so it **does not alter the mass number**. Because it is charged, it is **deflected by a magnetic field**.
3. **Gamma (γ)**: No change in mass or atomic number. Not deflected by magnetic fields (neutral).
The description provided matches the properties of Beta radiation.

Step 3: Final Answer:
The type of nuclear radiation emitted is Beta radiation.

Quick Tip

Beta particles are deflected much more than alpha particles in the same magnetic field due to their significantly smaller mass.

10(b)2. Write the equation for this radioactive decay.

Correct Answer: ${}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e$

Solution:

Step 1: Understanding the Concept:
During Beta-minus decay, a neutron inside the nucleus transforms into a proton. This increases the atomic number by 1 while keeping the mass number constant.

Step 2: Detailed Explanation:
Parent Nucleus: ${}^{24}_{11}Na$
Mass number (A) = 24 (stays the same)
Atomic number (Z) = 11 (increases by $1 \rightarrow 12$)
The element with atomic number 12 is Magnesium (Mg).
The particle emitted is an electron (${}^{0}_{-1}e$ or β^-).
The decay equation is:

$$ {}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e $$

Step 3: Final Answer:
The radioactive decay equation is ${}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + \beta^-$.

Quick Tip

In nuclear equations, ensure the sum of the bottom numbers (atomic numbers/charges) and top numbers (mass numbers) are equal on both sides of the arrow.