

# WBJEE Physics Sample Paper-18

Duration: 60 Minutes

Maximum Marks: 50

## Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Sections**.
- **Section 1 (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **–0.25** marks. Only **one** correct option.
- **Section 2 (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **–0.5** marks. Only **one** correct option.
- **Section 3 (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

**Section–A — 30 Questions × 1 Mark Each**  
**(Negative Marking: –0.25) [Single Correct]**

**Q1.** A body projected vertically upward reaches maximum height when:

- (A) Velocity becomes zero
- (B) Acceleration becomes zero
- (C) Kinetic energy becomes maximum
- (D) Potential energy becomes zero

**Q2.** The SI unit of impulse is:

- (A) N s
- (B) N/s
- (C) kg/m
- (D) J/s



**Q3.** Coefficient of friction is:

- (A) Dimensionless
- (B) Vector quantity
- (C) SI unit dependent
- (D) Always greater than 1

**Q4.** Centripetal acceleration is directed:

- (A) Towards center
- (B) Away from center
- (C) Along tangent
- (D) Vertically upward

**Q5.** Work done by conservative force in a closed path is:

- (A) Zero
- (B) Positive
- (C) Negative
- (D) Infinite

**Q6.** Escape velocity from Earth depends on:

- (A) Radius of Earth
- (B) Mass of projectile
- (C) Temperature
- (D) Density of air

**Q7.** Young's modulus has dimensions of:

- (A) Pressure
- (B) Force
- (C) Energy



(D) Density

**Q8.** Pressure in a liquid increases with:

(A) Depth

(B) Area

(C) Volume

(D) Shape

**Q9.** In an isothermal process for an ideal gas, temperature remains:

(A) Constant

(B) Zero

(C) Infinite

(D) Variable

**Q10.** RMS speed of gas molecules depends on:

(A) Temperature

(B) Pressure only

(C) Volume only

(D) Shape of container

**Q11.** Time period of SHM is independent of:

(A) Amplitude

(B) Mass

(C) Spring constant

(D) Length

**Q12.** Sound waves in air are:

(A) Longitudinal

(B) Transverse



- (C) Electromagnetic
- (D) Stationary

**Q13.** Electric potential is a:

- (A) Scalar quantity
- (B) Vector quantity
- (C) Tensor quantity
- (D) Dimensionless quantity

**Q14.** Drift velocity of electrons is of the order of:

- (A) Very small
- (B) Speed of light
- (C) Infinite
- (D) Negative

**Q15.** Heat produced in a resistor is given by:

- (A)  $I^2Rt$
- (B)  $IR$
- (C)  $V/R$
- (D)  $I/R$

**Q16.** Magnetic field lines never:

- (A) Intersect each other
- (B) Form closed curves
- (C) Originate from north pole
- (D) Terminate at south pole

**Q17.** Force on a current carrying conductor depends on:

- (A) Magnetic field



- (B) Current
- (C) Length of conductor
- (D) Resistance only

**Q18.** Unit of magnetic flux is:

- (A) Weber
- (B) Tesla
- (C) Henry
- (D) Coulomb

**Q19.** In a purely inductive AC circuit, current:

- (A) Lags voltage
- (B) Leads voltage
- (C) Is in phase
- (D) Becomes zero

**Q20.** Power of a concave lens is:

- (A) Negative
- (B) Positive
- (C) Zero
- (D) Infinite

**Q21.** Magnifying power of microscope increases when:

- (A) Focal length decreases
- (B) Focal length increases
- (C) Aperture decreases
- (D) Object size decreases



- Q22.** Diffraction is more noticeable when wavelength is:
- (A) Large
  - (B) Small
  - (C) Zero
  - (D) Infinite
- Q23.** Photon energy is given by:
- (A)  $h\nu$
  - (B)  $mc^2$
  - (C)  $p\nu$
  - (D)  $\frac{1}{2}mv^2$
- Q24.** Hydrogen spectrum is explained by:
- (A) Bohr model
  - (B) Thomson model
  - (C) Rutherford model
  - (D) Classical mechanics
- Q25.** Radioactive decay is:
- (A) Random
  - (B) Periodic
  - (C) Reversible
  - (D) Deterministic
- Q26.** Intrinsic semiconductor at absolute zero behaves like:
- (A) Insulator
  - (B) Conductor
  - (C) Superconductor



(D) Semiconductor

**Q27.** Modulation is necessary for:

- (A) Long distance transmission
- (B) Decreasing frequency
- (C) Reducing information
- (D) Increasing noise

**Q28.** Which of the following is a derived quantity?

- (A) Force
- (B) Length
- (C) Mass
- (D) Time

**Q29.** Dimensional formula of force is:

- (A)  $MLT^{-2}$
- (B)  $ML^2T^{-2}$
- (C)  $ML^{-1}T^{-1}$
- (D)  $M^0LT^{-1}$

**Q30.** Least count of an instrument determines:

- (A) Precision
- (B) Accuracy
- (C) Range
- (D) Dimension



**Section-B — 5 Questions × 1 Mark Each**  
**(Negative Marking: -0.5) [Single Correct]**

**Q31.** Maximum range of projectile occurs at angle:

- (A)  $45^\circ$
- (B)  $30^\circ$
- (C)  $60^\circ$
- (D)  $90^\circ$

**Q32.** Linear momentum is conserved when:

- (A) External force is zero
- (B) Velocity is constant
- (C) Acceleration is maximum
- (D) Work done is zero

**Q33.** Surface tension decreases with increase in:

- (A) Temperature
- (B) Pressure
- (C) Density
- (D) Volume

**Q34.** A perfect black body absorbs:

- (A) All incident radiation
- (B) Only visible light
- (C) Only infrared radiation
- (D) No radiation

**Q35.** Output of NAND gate is LOW only when:

- (A) Both inputs are HIGH



- (B) Both inputs are LOW
- (C) Inputs are different
- (D) One input is HIGH

**Section C — 5 Questions × 2 Marks Each (No  
Negative Marking) [One or More Correct]**

**Q36.** Which of the following are vector quantities?

- (A) Velocity
- (B) Force
- (C) Work
- (D) Acceleration

**Q37.** Which of the following affect resistance of a conductor?

- (A) Length
- (B) Area
- (C) Material
- (D) Temperature

**Q38.** Properties of electromagnetic waves include:

- (A) They are transverse
- (B) They can travel in vacuum
- (C) They carry energy
- (D) They require material medium

**Q39.** In photoelectric effect, kinetic energy of emitted electrons depends on:

- (A) Frequency of incident light
- (B) Work function
- (C) Intensity only



(D) Stopping potential

**Q40.** For a body in equilibrium:

(A) Net force is zero

(B) Net torque is zero

(C) Acceleration is zero

(D) Velocity must be zero



**Detailed Solutions****Q1.****Solution**

**Concept:** When a body is projected vertically upward, its velocity decreases due to gravity until it reaches its maximum height, at which point its velocity momentarily becomes zero before it starts to fall back down.

**Solution:** Step 1: Consider the motion of a body projected vertically upward. The initial velocity is positive (upward), and the acceleration due to gravity is negative (downward).

Step 2: As the body moves upward, its velocity decreases because the acceleration is acting in the opposite direction to its velocity.

Step 3: The body reaches its maximum height when its upward velocity becomes zero. At this instant, the body momentarily stops before changing direction and falling back down.

Step 4: Analyze the other options:

- Acceleration becomes zero: Acceleration due to gravity is approximately constant near the Earth's surface, so it does not become zero at the maximum height.
- Kinetic energy becomes maximum: Kinetic energy is given by  $\frac{1}{2}mv^2$ . At maximum height, velocity is zero, so kinetic energy is minimum (zero). Kinetic energy is maximum at the point of projection (initial upward velocity).
- Potential energy becomes zero: Potential energy is relative, but if we take the ground level as zero potential energy, then at the maximum height, the potential energy is maximum, not zero.

**Final Answer:**

**Answer:** (A)

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Q2.

**Solution**

**Concept:** Impulse is defined as the change in momentum of an object. It can also be expressed as the product of the average force acting on an object and the time interval over which the force acts.

**Solution:** Step 1: Recall the definition of impulse ( $J$ ). Impulse is the change in momentum:  
 $J = \Delta p$ .

Step 2: Momentum ( $p$ ) is given by the product of mass ( $m$ ) and velocity ( $v$ ):  $p = mv$ . The SI unit of momentum is  $\text{kg}\cdot\text{m/s}$ .

Step 3: Therefore, the SI unit of impulse is also  $\text{kg}\cdot\text{m/s}$ .

Step 4: Alternatively, impulse is defined as the average force ( $F_{avg}$ ) multiplied by the time interval ( $\Delta t$ ) over which the force acts:  $J = F_{avg} \Delta t$ .

Step 5: The SI unit of force is Newton (N), and the SI unit of time is seconds (s).

Step 6: Therefore, the SI unit of impulse is Newton-second (N·s).

Step 7: We can confirm that N·s is equivalent to  $\text{kg}\cdot\text{m/s}$ :

$$1 \text{ N} = 1 \text{ kg}\cdot\text{m/s}^2.$$

$$\text{So, } 1 \text{ N}\cdot\text{s} = (1 \text{ kg}\cdot\text{m/s}^2) \cdot \text{s} = 1 \text{ kg}\cdot\text{m/s}.$$

Step 8: Consider the given options:

- N·s: This matches our derived unit.
- N/s: This is the unit of acceleration divided by time, which is incorrect.
- kg/m: This is incorrect.
- J/s: This is the unit of power (Watt).

**Final Answer:** N s

**Answer:** (A)

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Q3.

**Solution**

**Concept:** The coefficient of friction (static or kinetic) is a dimensionless quantity that represents the ratio of the force of friction between two surfaces to the normal force pressing the surfaces together.

**Solution:** Step 1: Recall the definition of the coefficient of friction ( $\mu$ ). The force of friction ( $F_f$ ) between two surfaces is related to the normal force ( $N$ ) pressing them together by:

$$F_f = \mu N$$

where  $\mu$  is the coefficient of friction.

Step 2: Rearrange the formula to express  $\mu$ :

$$\mu = \frac{F_f}{N}$$

Step 3: Analyze the units. Force has units of Newtons (N). Therefore, the ratio of two forces (friction force and normal force) is dimensionless:

$$\mu = \frac{\text{Newtons}}{\text{Newtons}} = \text{dimensionless}$$

Step 4: Consider the other options:

- Vector quantity: Friction force and normal force are vectors, but the coefficient of friction itself is a scalar.
- SI unit dependent: Since it's dimensionless, it doesn't depend on the SI system of units. It's a ratio.
- Always greater than 1: The coefficient of friction can be less than 1, equal to 1, or greater than 1, depending on the nature of the surfaces in contact. For many common surfaces, it is less than 1.

**Final Answer:**

**Answer: (A)**

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Q4.

**Solution**

**Concept:** Centripetal acceleration is the acceleration experienced by an object moving in a curved path, specifically in circular motion. It is always directed towards the center of the circle.

**Solution:** Step 1: Understand circular motion. An object moving in a circle at a constant speed is still accelerating because its velocity (which is a vector with both magnitude and direction) is continuously changing direction.

Step 2: Define centripetal acceleration. Centripetal acceleration is the acceleration that causes an object to change its direction of motion, keeping it moving in a circular path.

Step 3: Determine the direction of centripetal acceleration. The acceleration is always directed towards the center of the circle. This inward acceleration is what continuously changes the direction of the velocity vector, keeping it tangential to the circle at every point. The formula for centripetal acceleration is  $a_c = \frac{v^2}{r}$ , where  $v$  is the speed and  $r$  is the radius of the circular path. The direction is radial and inward.

Step 4: Consider the other options:

- Away from center: This would be centrifugal acceleration, which is a fictitious force felt in a rotating frame of reference.
- Along tangent: The velocity vector is along the tangent, but the acceleration is perpendicular to the velocity in uniform circular motion.
- Vertically upward: This direction is irrelevant to the plane of circular motion unless the motion is in a vertical plane, but even then, the centripetal acceleration is always towards the center of the circle of motion.

**Final Answer:**

**Answer:** (A)

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Q5.

**Solution**

**Concept:** A conservative force is a force for which the work done in moving an object between two points is independent of the path taken. As a consequence, the work done by a conservative force over any closed path is always zero.

**Solution:** Step 1: Understand the definition of a conservative force. A force is conservative if the work done by it on an object moving between two points is path-independent. Equivalently, if a conservative force does work on an object, that work can be expressed as the negative change in a potential energy function associated with the force ( $W_c = -\Delta U$ ).

Step 2: Consider a closed path. A closed path is one where the object starts and ends at the same point.

Step 3: Apply the definition of a conservative force to a closed path. If the work done is path-independent, then moving from point A to point B and then back from point B to point A along the same path (or a different path) results in the same amount of work done by the force in the first leg and the negative of the work done in the second leg (since the displacement is reversed). Thus, the net work done over a closed path is zero.

$$W_{closed} = W_{A \rightarrow B} + W_{B \rightarrow A} = W_{A \rightarrow B} + (-W_{A \rightarrow B}) = 0$$

Alternatively, using potential energy:

$$W_c = -\Delta U = -(U_{final} - U_{initial})$$

For a closed path, the initial and final positions are the same, so  $U_{initial} = U_{final}$ . Therefore,  $\Delta U = 0$ , and  $W_c = 0$ .

Step 4: Examples of conservative forces include gravitational force, elastic spring force, and electrostatic force. Non-conservative forces like friction and air resistance do work that depends on the path and do not have an associated potential energy function.

**Final Answer:**

**Answer:** (A)

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Q6.

**Solution**

**Concept:** Escape velocity is the minimum speed required to overcome a celestial body's gravitational pull. It is derived from energy conservation and depends on the mass and radius of the body.

**Solution:** Step 1: Escape velocity ( $v_e$ ) is the speed at which an object's kinetic energy equals its gravitational potential energy's magnitude, allowing it to escape to infinity.

Step 2: The formula for escape velocity is:

$$v_e = \sqrt{\frac{2GM}{R}}$$

where  $G$  is the gravitational constant,  $M$  is the mass of the celestial body, and  $R$  is its radius.

Step 3: From the formula, escape velocity depends on the mass ( $M$ ) and radius ( $R$ ) of the celestial body. It does not depend on the mass of the escaping object.

**Final Answer:**

**Answer: (A)**

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Q7.

**Solution**

**Concept:** Young's modulus ( $Y$ ) is a measure of the stiffness of a material. It is defined as the ratio of tensile stress to tensile strain within the elastic limit of the material. Stress is force per unit area, and strain is fractional change in length.

**Solution:** Step 1: Recall the definition of Young's modulus ( $Y$ ):

$$Y = \frac{\text{Tensile Stress}}{\text{Tensile Strain}}$$

Step 2: Define Tensile Stress ( $\sigma$ ). Stress is the force ( $F$ ) applied per unit area ( $A$ ):

$$\sigma = \frac{F}{A}$$

The dimensions of stress are  $[MLT^{-2}]/[L^2] = [ML^{-1}T^{-2}]$ .

Step 3: Define Tensile Strain ( $\epsilon$ ). Strain is the fractional change in length, which is the change in length ( $\Delta L$ ) divided by the original length ( $L$ ):

$$\epsilon = \frac{\Delta L}{L}$$

Since strain is a ratio of two lengths, it is dimensionless:  $[\text{Strain}] = [L]/[L] = [1]$ .

Step 4: Determine the dimensions of Young's modulus by dividing the dimensions of stress by the dimensions of strain:

$$[Y] = \frac{[\text{Stress}]}{[\text{Strain}]} = \frac{[ML^{-1}T^{-2}]}{[1]} = [ML^{-1}T^{-2}]$$

Step 5: Analyze the dimensions of the given options:

- Pressure: Pressure is force per unit area, so its dimensions are  $[ML^{-1}T^{-2}]$ . This matches the dimensions of Young's modulus.
- Force: Dimensions are  $[MLT^{-2}]$ .
- Energy: Dimensions are  $[ML^2T^{-2}]$ .
- Density: Dimensions are  $[ML^{-3}]$ .

Step 6: Conclude that Young's modulus has the same dimensions as pressure.

**Final Answer:**

**Answer: (A)**

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Q8.

**Solution**

**Concept:** In a fluid at rest, pressure varies with depth. The deeper you go into a liquid, the greater the pressure, due to the weight of the liquid column above that point.

**Solution:** Step 1: Consider a fluid at rest. Pressure at any point in the fluid is the force per unit area exerted by the fluid.

Step 2: The pressure in a liquid is due to the weight of the liquid column above that point.

Consider a point at a depth  $h$  from the surface of a liquid of density  $\rho$ . The volume of the liquid column above this point with a unit cross-sectional area is  $V = \text{Area} \times \text{depth} = 1 \times h = h$ .

Step 3: The mass of this liquid column is  $m = \text{density} \times \text{volume} = \rho h$ . Step 4: The weight of this liquid column is  $W = mg = (\rho h)g$ .

Step 5: The pressure ( $P$ ) at depth  $h$  is the weight per unit area:

$$P = \frac{W}{\text{Area}} = \frac{\rho hg}{1} = \rho hg$$

Step 6: This formula shows that the pressure ( $P$ ) is directly proportional to the depth ( $h$ ), the density of the liquid ( $\rho$ ), and the acceleration due to gravity ( $g$ ).

Step 7: Therefore, pressure in a liquid increases with depth. It does not depend on the area, volume, or shape of the container, as long as the depth is considered.

**Final Answer:**

**Answer:** (A)

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Q9.

**Solution**

**Concept:** An isothermal process is a thermodynamic process in which the temperature of the system remains constant throughout the process.

**Solution:** Step 1: Define an isothermal process. In thermodynamics, an isothermal process is one where the temperature of the system remains constant ( $T = \text{constant}$ ).

Step 2: Consider the implications of a constant temperature for an ideal gas. The ideal gas law states  $PV = nRT$ , where  $P$  is pressure,  $V$  is volume,  $n$  is the number of moles,  $R$  is the ideal gas constant, and  $T$  is the absolute temperature.

Step 3: If  $T$  is constant, then the product  $PV$  is also constant for a fixed amount of gas ( $n$  is constant). This means that as the volume of the gas changes, its pressure changes inversely to keep the product  $PV$  constant.

Step 4: The key characteristic of an isothermal process is that the temperature does not change.

Step 5: Analyze the options:

- Constant: This matches the definition of an isothermal process.
- Zero: Temperature can be zero Kelvin, but it doesn't have to be zero to be constant.
- Infinite: Temperature cannot be infinite.
- Variable: This is the opposite of constant.

**Final Answer:**

**Answer:** (A)

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## Q10.

**Solution**

**Concept:** The root-mean-square (RMS) speed of gas molecules is related to the average kinetic energy of the molecules, which in turn is directly proportional to the absolute temperature of the gas.

**Solution:** Step 1: Recall the kinetic theory of gases. The average kinetic energy of molecules in an ideal gas is directly proportional to the absolute temperature ( $T$ ) of the gas.

$$KE_{avg} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}k_B T$$

where  $m$  is the mass of a molecule,  $v_{rms}$  is the RMS speed,  $k_B$  is the Boltzmann constant, and  $T$  is the absolute temperature.

Step 2: From the equation, we can see that the RMS speed ( $v_{rms}$ ) is related to the temperature ( $T$ ):

$$v_{rms}^2 = \frac{3k_B T}{m}$$

$$v_{rms} = \sqrt{\frac{3k_B T}{m}}$$

Step 3: Analyze the formula. The RMS speed of gas molecules is directly proportional to the square root of the absolute temperature ( $v_{rms} \propto \sqrt{T}$ ). It also depends on the mass of the molecules ( $m$ ).

Step 4: Consider the given options:

- Temperature: Yes, RMS speed depends on temperature.
- Pressure only: Pressure is related to temperature and volume by the ideal gas law ( $PV = nRT$ ). While pressure and temperature are related, RMS speed is directly a function of temperature (and molecular mass), not pressure alone. For example, at constant temperature, increasing pressure by decreasing volume does not change the RMS speed.
- Volume only: Volume is not directly in the formula for RMS speed.
- Shape of container: The shape of the container does not affect the RMS speed of the gas molecules.

**Final Answer:**

**Answer:** (A)

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Q11.

**Solution**

**Concept:** The time period of a simple harmonic oscillator (like a mass-spring system or a simple pendulum) is the time taken for one complete oscillation. It depends on the properties of the system but not on the amplitude of the oscillation (for small amplitudes in the case of a pendulum).

**Solution:** Step 1: Recall the formula for the time period ( $T$ ) of a mass-spring system undergoing SHM:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where  $m$  is the mass and  $k$  is the spring constant.

Step 2: Recall the formula for the time period ( $T$ ) of a simple pendulum (for small oscillations):

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where  $L$  is the length of the pendulum and  $g$  is the acceleration due to gravity.

Step 3: Analyze the formulas to identify the quantities that affect the time period.

- For a mass-spring system, the time period depends on mass ( $m$ ) and spring constant ( $k$ ). It is independent of amplitude.
- For a simple pendulum, the time period depends on length ( $L$ ) and acceleration due to gravity ( $g$ ). It is independent of the mass of the bob and amplitude (for small angles).

Step 4: Consider the options provided in the context of a general SHM oscillator or specific examples.

- Amplitude: The time period of SHM is generally independent of amplitude (except for very large amplitudes where the motion might not be perfectly harmonic).
- Mass: For a mass-spring system, mass is a factor.
- Spring constant: For a mass-spring system, the spring constant is a factor.
- Length: For a pendulum, length is a factor.

Step 5: The question asks what the time period is independent of. Based on both common examples, amplitude is the quantity that does not affect the time period of SHM.

**Final Answer:** Amplitude

**Answer: (A)**

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Q12.

**Solution**

**Concept:** Wave types are classified based on the direction of oscillation of the particles of the medium relative to the direction of wave propagation.

**Solution:** Step 1: Define longitudinal waves. In longitudinal waves, the particles of the medium oscillate parallel to the direction of wave propagation. Examples include sound waves in gases, liquids, and solids, and P-waves in seismic activity.

Step 2: Define transverse waves. In transverse waves, the particles of the medium oscillate perpendicular to the direction of wave propagation. Examples include light waves (electromagnetic waves) and waves on a string.

Step 3: Define electromagnetic waves. Electromagnetic waves, such as light, radio waves, and X-rays, are transverse waves. They do not require a medium for propagation and consist of oscillating electric and magnetic fields perpendicular to each other and to the direction of propagation.

Step 4: Define stationary waves. Stationary waves (or standing waves) are formed by the superposition of two identical waves traveling in opposite directions. They appear to oscillate in place and do not propagate energy.

Step 5: Apply these definitions to sound waves in air. Sound waves are produced by vibrations that cause compressions and rarefactions in the medium (like air). The air molecules are pushed together (compression) and then pulled apart (rarefaction), causing them to oscillate back and forth parallel to the direction the sound is traveling. Therefore, sound waves in air are longitudinal waves.

**Final Answer:**

**Answer: (A)**

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Q13.

**Solution**

**Concept:** Electric potential is a scalar quantity that describes the amount of electric potential energy per unit charge at a point in an electric field.

**Solution:** Step 1: Recall the definition of electric potential ( $V$ ). Electric potential at a point in an electric field is defined as the amount of work done per unit charge to move a test charge from infinity (or a reference point) to that point.

$$V = \frac{W}{\text{charge}}$$

Step 2: Analyze the nature of the quantities involved. Work ( $W$ ) is a scalar quantity (energy). Charge is also a scalar quantity.

Step 3: Since electric potential is defined as the ratio of two scalar quantities (work and charge), it is itself a scalar quantity. It has magnitude but no direction.

Step 4: Contrast with vector quantities. Vector quantities, such as electric field ( $\vec{E}$ ) and force ( $\vec{F}$ ), have both magnitude and direction. Electric potential difference is related to the work done by the electric field, which can be determined by integrating the electric field (a vector) along a path.

Step 5: Consider the options:

- Scalar quantity: Matches our definition.
- Vector quantity: Electric potential does not have a direction.
- Tensor quantity: While related to fields, potential itself is a scalar.
- Dimensionless quantity: Electric potential has dimensions of energy per charge (e.g., Joules per Coulomb, which is Volts), so it is not dimensionless.

**Final Answer:**

**Answer:** (A)

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Q14.

**Solution**

**Concept:** Drift velocity is the average velocity attained by charged particles (like electrons in a conductor) under the influence of an electric field. It is typically very slow, much slower than the random thermal motion of the particles or the speed of light.

**Solution:** Step 1: Understand drift velocity. It's the net velocity of charge carriers in a conductor when an electric field is applied. This velocity is superimposed on the much faster random thermal motion of the electrons.

Step 2: Consider the factors affecting drift velocity. The formula for drift velocity ( $v_d$ ) is  $v_d = \frac{qE\tau}{m}$ , where  $q$  is the charge of the carrier,  $E$  is the electric field,  $\tau$  is the average time between collisions, and  $m$  is the mass of the carrier.

Step 3: Analyze the magnitudes. Electrons collide with atoms in the conductor very frequently (on the order of  $10^{14}$  times per second). However, the electric field is usually relatively weak, and the collisions tend to randomize the direction of motion. This results in a very small net drift velocity. Typical values for drift velocity in metals under normal conditions are of the order of millimeters per second or even less.

Step 4: Compare with other speeds.

- Speed of light: Approximately  $3 \times 10^8$  m/s. Drift velocity is many orders of magnitude smaller.
- Infinite: Velocity cannot be infinite.
- Negative: Velocity can be negative if direction is defined, but its magnitude is very small.

Step 5: Conclude that the drift velocity of electrons is very small.

**Final Answer:**

**Answer: (A)**

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Q15.

**Solution**

**Concept:** The heat produced in a resistor when electric current flows through it is given by Joule's law of heating.

**Solution:** Step 1: Recall Joule's law of heating. It states that the heat ( $H$ ) produced in a resistor is directly proportional to the square of the current ( $I$ ), the resistance ( $R$ ), and the time ( $t$ ) for which the current flows.

Step 2: The formula for heat produced is:

$$H = I^2 R t$$

Step 3: Analyze the other options:

- $IR$ : This is the voltage drop across a resistor (Ohm's Law).
- $V/R$ : This is the current through a resistor (Ohm's Law).
- $I/R$ : This does not represent a standard physical quantity in this context.

**Final Answer:**  $I^2 R t$

**Answer:** (A)

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## Q16.

**Solution**

**Concept:** Magnetic field lines are a visual representation of the magnetic field. They have specific properties that help in understanding the nature and direction of the magnetic field.

**Solution:** Step 1: Recall the properties of magnetic field lines.

- They form closed loops: Magnetic field lines emerge from the north pole and enter the south pole outside a magnet, and form a closed loop by continuing from the south pole to the north pole inside the magnet.
- They never intersect each other: If two field lines intersected, it would imply that the magnetic field has two different directions at the same point, which is impossible.
- The density of field lines represents the strength of the magnetic field: Closer lines indicate a stronger field.
- They originate from the north pole and terminate at the south pole (outside the magnet).

Step 2: Evaluate the options based on these properties.

- Intersect each other: Magnetic field lines never intersect. This is a true statement about their behavior.
- Form closed curves: This is a true property of magnetic field lines.
- Originate from north pole: This is true (outside the magnet).
- Terminate at south pole: This is also true (outside the magnet).

Step 3: The question asks what magnetic field lines never do. Therefore, the statement that is always true is that they never intersect each other. The other statements describe properties they do have.

**Final Answer:**

**Answer:** (A)

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Q17.

**Solution**

**Concept:** The force experienced by a current-carrying conductor in a magnetic field is determined by the magnetic field strength, the current, the length of the conductor, and the angle between the current and the field.

**Solution:** Step 1: Recall the formula for the force ( $\vec{F}$ ) on a straight conductor of length ( $L$ ) carrying current ( $I$ ) in a uniform magnetic field ( $\vec{B}$ ):

$$\vec{F} = I(\vec{L} \times \vec{B})$$

The magnitude of this force is  $F = ILB \sin \theta$ , where  $\theta$  is the angle between the current direction and the magnetic field.

Step 2: From this formula, the force clearly depends on:

- Magnetic field ( $B$ )
- Current ( $I$ )
- Length of conductor ( $L$ )
- The angle ( $\theta$ ) between the current and the magnetic field.

Step 3: The option "Resistance only" is incorrect because resistance does not directly determine the force on the conductor; rather, it affects the current for a given voltage. The force depends on the current itself, along with other factors.

Step 4: If forced to choose a single answer and given that Magnetic field, Current, and Length are all crucial factors, any one of them could be considered a dependency. However, in many physics contexts, the magnetic field is often emphasized as the external agent causing the force. Let's choose Magnetic Field as a representative single correct answer.

**Final Answer:**

**Answer:** (A)

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Q18.

**Solution**

**Concept:** Magnetic flux is a measure of the total magnetic field passing through a given surface area. Its SI unit is the Weber.

**Solution:** Step 1: Recall the definition of magnetic flux ( $\Phi_B$ ). It is given by the integral of the magnetic field ( $\vec{B}$ ) over a surface ( $A$ ):  $\Phi_B = \int \vec{B} \cdot d\vec{A}$ .

Step 2: The SI unit of magnetic field ( $B$ ) is Tesla (T).

Step 3: The SI unit of area ( $A$ ) is square meters ( $m^2$ ).

Step 4: Therefore, the unit of magnetic flux is Tesla-meter squared ( $T \cdot m^2$ ).

Step 5: The SI unit of magnetic flux is defined as the Weber (Wb). So,  $1 \text{ Wb} = 1 \text{ T} \cdot m^2$ .

Step 6: Consider the other options:

- Tesla (T): This is the unit of magnetic field strength.
- Henry (H): This is the unit of inductance.
- Coulomb (C): This is the unit of electric charge.

**Final Answer:**

**Answer:** (A)

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Q19.

**Solution**

**Concept:** In a purely inductive AC circuit, the inductor opposes changes in current. This opposition leads to a phase difference between the voltage across the inductor and the current through it.

**Solution:** Step 1: Consider an AC circuit containing only an inductor ( $L$ ).

Step 2: The voltage across an inductor is related to the rate of change of current through it:

$$V_L = L \frac{dI}{dt}.$$

Step 3: For a sinusoidal current  $I(t) = I_{peak} \sin(\omega t)$ , the voltage is  $V_L(t) = L \frac{d}{dt}(I_{peak} \sin(\omega t)) = LI_{peak}\omega \cos(\omega t)$ .

Step 4: We can rewrite  $\cos(\omega t)$  as  $\sin(\omega t + \frac{\pi}{2})$ .

So,  $V_L(t) = LI_{peak}\omega \sin(\omega t + \frac{\pi}{2})$ .

Step 5: This shows that the voltage across the inductor leads the current by a phase angle of  $\frac{\pi}{2}$  radians (or  $90^\circ$ ). In other words, the current lags the voltage by  $90^\circ$ .

**Final Answer:**

**Answer:** (A)

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Q20.

**Solution**

**Concept:** A concave lens is a diverging lens. It spreads out parallel rays of light. The focal length of a diverging lens is considered negative.

**Solution:** Step 1: Understand the definition of a concave lens. A concave lens is thinner at the center and thicker at the edges. It causes parallel rays of light to diverge.

Step 2: Define focal length. The focal length ( $f$ ) of a lens is the distance from the optical center of the lens to the principal focus. The principal focus is where parallel rays of light converge (for a converging lens) or appear to diverge from (for a diverging lens) after passing through the lens.

Step 3: Sign convention for lenses. By convention, for a converging lens (like a convex lens), the focal length is taken as positive. For a diverging lens (like a concave lens), the focal length is taken as negative. This convention is crucial for the lens formula.

Step 4: Therefore, the power of a concave lens, which is the reciprocal of its focal length ( $P = 1/f$ ), will also be negative because its focal length is negative.

**Final Answer:**

**Answer:** (A)

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Q21.

**Solution**

**Concept:** The magnifying power of a microscope is its ability to produce a larger image than the actual object. It depends on the focal lengths of the objective and eyepiece lenses and the length of the tube.

**Solution:** Step 1: Recall the formula for the magnifying power ( $M$ ) of a compound microscope. In normal adjustment (final image at infinity), the magnifying power is given by:

$$M = \frac{L}{f_o} \left( 1 + \frac{D}{f_e} \right)$$

where:

- $L$  is the tube length.
- $f_o$  is the focal length of the objective lens.
- $D$  is the least distance of distinct vision (usually 25 cm).
- $f_e$  is the focal length of the eyepiece lens.

Step 2: Analyze how changes in the focal lengths affect magnifying power.

- Focal length of objective lens ( $f_o$ ): Magnifying power is inversely proportional to  $f_o$  ( $M \propto \frac{1}{f_o}$ ). If  $f_o$  decreases,  $M$  increases.
- Focal length of eyepiece lens ( $f_e$ ): Magnifying power is inversely proportional to  $f_e$  (in the term  $\frac{D}{f_e}$ ). If  $f_e$  decreases,  $\frac{D}{f_e}$  increases, and thus  $M$  increases.

Step 3: Consider the options:

- Focal length decreases: If either  $f_o$  or  $f_e$  decreases, the magnifying power increases.
- Focal length increases: If either  $f_o$  or  $f_e$  increases, the magnifying power decreases.
- Aperture decreases: Aperture affects the resolution and brightness, but not directly the magnifying power formula.
- Object size decreases: The magnification formula gives the overall magnification relative to the object, but the magnifying power itself is a property of the instrument's design, not the object size.

Step 4: Therefore, the magnifying power of a microscope increases when its focal lengths (both objective and eyepiece) decrease.

**Final Answer:** Focal length decreases

**Answer:** (A)

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Q22.

**Solution**

**Concept:** Diffraction is the phenomenon of bending of waves as they pass around an obstacle or through an aperture. The extent of diffraction depends on the size of the obstacle or aperture relative to the wavelength of the wave.

**Solution:** Step 1: Understand diffraction. Diffraction occurs when waves encounter an obstacle or an opening. The wave bends and spreads out into the region that would otherwise be in the geometrical shadow.

Step 2: Analyze the condition for noticeable diffraction. For diffraction to be significant, the size of the obstacle or aperture should be comparable to or smaller than the wavelength of the wave.

Step 3: If the wavelength is large compared to the size of the opening or obstacle, the bending effect is more pronounced. If the wavelength is very small compared to the size of the opening, the bending is negligible, and the wave essentially travels in straight lines (like light passing through a large window).

Step 4: Therefore, diffraction is more noticeable when the wavelength of the wave is large compared to the size of the aperture or obstacle.

**Final Answer:**

**Answer:** (A)

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Q23.

**Solution**

**Concept:** A photon is a quantum of electromagnetic radiation. Its energy is directly proportional to its frequency, as described by Planck's relation.

**Solution:** Step 1: Recall that light can be considered as packets of energy called photons. Step 2: According to Planck's quantum theory, the energy ( $E$ ) of a photon is directly proportional to its frequency ( $\nu$ ). The constant of proportionality is Planck's constant ( $h$ ).

$$E = h\nu$$

Step 3: Consider the other options:

- $mc^2$ : This is Einstein's famous equation for the rest mass energy of a particle. While photons have energy, they are massless particles; this equation is typically applied to particles with rest mass. The energy of a photon is related to its momentum ( $p$ ) by  $E = pc$ , where  $p = h/\lambda$ .
- $p\nu$ : This combination of momentum and velocity does not directly represent photon energy in standard physics.
- $\frac{1}{2}mv^2$ : This is the classical formula for kinetic energy, which applies to particles with mass, not massless photons.

**Final Answer:**  $h\nu$

**Answer:** (A)

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Q24.

**Solution**

**Concept:** The hydrogen spectrum consists of discrete lines, which can be explained by the atomic model that incorporates quantized energy levels. Bohr's model was the first successful model to explain these spectral lines.

**Solution:** Step 1: Understand the hydrogen spectrum. When hydrogen gas is excited, it emits light at specific, discrete wavelengths, forming a line spectrum.

Step 2: Evaluate the historical models of the atom.

- Classical mechanics: According to classical electromagnetism, an orbiting electron should continuously radiate energy and spiral into the nucleus, leading to a continuous spectrum, not discrete lines.
- Thomson model (Plum Pudding model): This model had limitations and could not explain the scattering of alpha particles or the hydrogen spectrum.
- Rutherford model: This model proposed a nucleus and orbiting electrons but also suffered from the problem of continuous radiation and instability of the atom, thus failing to explain the discrete spectrum.
- Bohr model: Niels Bohr proposed a model for the hydrogen atom that incorporated quantum ideas. He postulated that electrons orbit the nucleus in specific quantized energy levels and emit or absorb photons only when transitioning between these levels. The energy differences between these levels correspond to the frequencies of the emitted spectral lines, successfully explaining the hydrogen spectrum.

Step 3: Conclude that the Bohr model successfully explained the observed hydrogen spectrum.

**Final Answer:**

**Answer:** (A)

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Q25.

**Solution**

**Concept:** Radioactive decay is a spontaneous process where an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic waves. This process is governed by probabilistic laws.

**Solution:** Step 1: Understand radioactive decay. It is a nuclear process where an unstable nucleus transforms into a more stable one by emitting particles (alpha, beta) or energy (gamma rays).

Step 2: Consider the nature of this process. Radioactive decay is a probabilistic phenomenon.

For a given unstable nucleus, it is impossible to predict exactly when it will decay. However, for a large number of identical nuclei, the rate of decay can be predicted statistically.

Step 3: Analyze the options:

- Random: This accurately describes the unpredictable nature of decay for an individual nucleus.
- Periodic: Radioactive decay does not occur at fixed time intervals.
- Reversible: Radioactive decay is generally not reversible. Once a nucleus decays, it has transformed into a different nuclide.
- Deterministic: This implies that the decay time for each nucleus can be precisely predicted, which is not the case.

Step 4: Therefore, radioactive decay is a random process.

**Final Answer:**

**Answer:** (A)

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Q26.

**Solution**

**Concept:** An intrinsic semiconductor has very few charge carriers (electrons and holes) at absolute zero temperature. These carriers are generated by thermal excitation. At absolute zero, there is no thermal energy, so no charge carriers are available for conduction.

**Solution:** Step 1: Understand the behavior of intrinsic semiconductors. Intrinsic semiconductors have a valence band and a conduction band separated by a band gap. At absolute zero temperature (0 K), all electrons are in the valence band, and the conduction band is empty.

Step 2: For electrical conduction to occur, electrons must be able to move into the conduction band. This requires energy to overcome the band gap.

Step 3: At absolute zero temperature, there is no thermal energy available to excite electrons across the band gap. Consequently, there are no free electrons in the conduction band and no holes in the valence band to contribute to current flow.

Step 4: A material that does not allow electric current to flow is called an insulator.

Step 5: Therefore, an intrinsic semiconductor at absolute zero behaves like an insulator.

**Final Answer:**

**Answer:** (A)

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Q27.

**Solution**

**Concept:** Modulation is the process of encoding information onto a carrier wave. It is necessary for efficient long-distance transmission of signals, especially when the original signal's frequency is too low to propagate effectively through the transmission medium.

**Solution:** Step 1: Understand the purpose of modulation. In telecommunications, the original information signal (like voice or data) often has a low frequency. For efficient transmission over long distances, especially through the atmosphere or using radio waves, this low-frequency signal needs to be superimposed onto a high-frequency carrier wave.

Step 2: Explain why modulation is necessary for long-distance transmission:

- **Antenna Size:** For efficient radiation of electromagnetic waves, the antenna size should be comparable to the wavelength of the signal. Low-frequency signals have very long wavelengths, requiring impractically large antennas. By modulating the low-frequency signal onto a high-frequency carrier, the effective wavelength is reduced, allowing for smaller and more practical antennas.
- **Bandwidth Allocation:** Different communication channels are assigned specific frequency bands. Modulating a signal allows it to be transmitted within a designated frequency band.
- **Noise Reduction:** Modulation techniques can help in reducing the impact of noise during transmission.
- **Multiplexing:** Modulation allows multiple signals to be transmitted simultaneously over the same medium without interfering with each other by assigning different carrier frequencies.

Step 3: Evaluate the other options:

- **Decreasing frequency:** Modulation generally uses a higher carrier frequency, not decreases the information signal's frequency.
- **Reducing information:** Modulation is about encoding information, not reducing it.
- **Increasing noise:** Modulation techniques are often designed to minimize noise, not increase it.

**Final Answer:** Long distance transmission

**Answer: (A)**

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Q28.

**Solution**

**Concept:** Physical quantities are classified into fundamental and derived quantities. Fundamental quantities are those that are independent and are not defined in terms of other quantities, while derived quantities are defined and calculated from fundamental quantities.

**Solution:** Step 1: Define fundamental quantities. These are the basic physical quantities that are defined independently and are used to define derived quantities. The seven SI base units are: meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (thermodynamic temperature), mole (amount of substance), and candela (luminous intensity).

Step 2: Define derived quantities. These are quantities that can be expressed as a combination of fundamental quantities through mathematical operations (multiplication, division, etc.).

Step 3: Examine the given options:

- Force: Force is defined by Newton's second law as mass times acceleration ( $F = ma$ ). Acceleration is the rate of change of velocity, and velocity is the rate of change of displacement. Thus, force is derived from mass, length, and time ( $[Force] = [MLT^{-2}]$ ).
- Length: Length is a fundamental quantity (SI unit: meter).
- Mass: Mass is a fundamental quantity (SI unit: kilogram).
- Time: Time is a fundamental quantity (SI unit: second).

Step 4: Conclude that force is a derived quantity, while length, mass, and time are fundamental quantities.

**Final Answer:**

**Answer: (A)**

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Q29.

**Solution**

**Concept:** Force is defined by Newton's second law of motion as the product of mass and acceleration. By determining the dimensions of mass and acceleration, we can find the dimensional formula of force.

**Solution:** Step 1: Recall Newton's second law of motion:  $F = ma$ , where  $F$  is force,  $m$  is mass, and  $a$  is acceleration.

Step 2: Determine the dimensions of mass. Mass is a fundamental quantity with dimensions  $[M]$ .

Step 3: Determine the dimensions of acceleration. Acceleration is the rate of change of velocity, and velocity is the rate of change of displacement.

- Displacement has dimensions  $[L]$ .

- Velocity has dimensions  $[L]/[T] = [LT^{-1}]$ .

- Acceleration has dimensions  $[LT^{-1}]/[T] = [LT^{-2}]$ .

Step 4: Substitute the dimensions of mass and acceleration into the formula for force:

$$[F] = [m][a] = [M][LT^{-2}] = [MLT^{-2}]$$

**Final Answer:**  $MLT^{-2}$

**Answer: (A)**

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Q30.

**Solution**

**Concept:** The least count of a measuring instrument is the smallest measurement that can be accurately made with it. It determines the precision of the instrument.

**Solution:** Step 1: Define the least count of a measuring instrument. The least count (LC) is the smallest value that can be measured by the instrument. For example, a ruler with millimeter markings has a least count of 1 mm. A vernier caliper typically has a least count of 0.1 mm or 0.01 cm.

Step 2: Understand precision. Precision refers to the degree of exactness or refinement of a measurement. A measurement is precise if it is made with a measuring instrument that has a small least count, meaning it can measure very small differences.

Step 3: Understand accuracy. Accuracy refers to how close a measurement is to the true value. While precision contributes to accuracy, accuracy itself is about closeness to the true value, not just the fineness of the measurement.

Step 4: Analyze the relationship. An instrument with a smaller least count can make more precise measurements. For example, a vernier caliper (small LC) is more precise than a ruler (larger LC).

Step 5: Consider the other options.

- Accuracy: Least count contributes to accuracy, but it's not the sole determinant, and precision is a more direct consequence.
- Range: The range is the maximum value the instrument can measure. Least count is independent of the range.
- Dimension: Dimension refers to the fundamental units of a physical quantity.

**Final Answer:** Precision

**Answer:** (A)

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Q31.

**Solution**

**Concept:** The range of a projectile is the horizontal distance it travels before returning to its initial launch height. For a given initial speed, the range is maximum when the launch angle is  $45^\circ$ .

**Solution:** Step 1: Recall the formula for the range ( $R$ ) of a projectile launched with initial velocity ( $u$ ) at an angle ( $\theta$ ) with the horizontal, neglecting air resistance:

$$R = \frac{u^2 \sin(2\theta)}{g}$$

where  $g$  is the acceleration due to gravity.

Step 2: To find the maximum range, we need to maximize the value of  $\sin(2\theta)$ , since  $u$  and  $g$  are constants for a given launch.

Step 3: The maximum value of the sine function is 1.

Step 4:  $\sin(2\theta) = 1$  when  $2\theta = 90^\circ$ .

Step 5: Solving for  $\theta$ :

$$\theta = \frac{90^\circ}{2} = 45^\circ$$

Step 6: Therefore, the maximum range of a projectile occurs when the launch angle is  $45^\circ$ .

**Final Answer:**

**Answer:** (A)

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Q32.

**Solution**

**Concept:** Conservation of linear momentum states that if no net external force acts on a system, its total linear momentum remains constant.

**Solution:** Step 1: Recall the impulse-momentum theorem, which states that the impulse acting on an object is equal to the change in its linear momentum:  $J = \Delta p$ . Impulse is also given by  $J = F_{ext} \Delta t$ , where  $F_{ext}$  is the net external force.

Step 2: So,  $F_{ext} \Delta t = \Delta p$ .

Step 3: If the net external force ( $F_{ext}$ ) acting on the system is zero, then  $0 \cdot \Delta t = \Delta p$ , which implies  $\Delta p = 0$ .

Step 4: If the change in momentum ( $\Delta p$ ) is zero, it means the momentum ( $p$ ) is constant.

Step 5: Linear momentum ( $p$ ) is conserved when the net external force acting on the system is zero.

Step 6: Consider the other options:

- Velocity is constant: This implies zero acceleration and thus zero net force, which is a condition for momentum conservation, but momentum conservation is defined by the force being zero.
- Acceleration is maximum: This implies a large net force, so momentum is not conserved.
- Work done is zero: Work done being zero does not necessarily mean momentum is conserved (e.g., if a force acts over zero displacement, or if forces cancel out over a path).

**Final Answer:** External force is zero

**Answer:** (A)

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Q33.

**Solution**

**Concept:** Surface tension is a property of liquids that arises from the cohesive forces between liquid molecules. It causes the liquid surface to behave like a stretched elastic membrane. Surface tension generally decreases with an increase in temperature.

**Solution:** Step 1: Understand surface tension. It is the tendency of liquid surfaces to shrink into the minimum surface area possible. It arises due to the cohesive forces between liquid molecules. At the surface, molecules are attracted inwards more than outwards, creating a net inward force.

Step 2: Analyze the effect of temperature. As the temperature of a liquid increases, the kinetic energy of the molecules increases. This leads to greater molecular motion and weakens the intermolecular cohesive forces.

Step 3: With weaker cohesive forces, the net inward pull on the surface molecules is reduced, leading to a decrease in surface tension.

Step 4: Consider the effect of pressure, density, and volume. While pressure can indirectly affect surface tension through its effect on density and temperature, the direct relationship of surface tension with pressure is not as significant or universally direct as with temperature. Density is related, but temperature is the primary factor. Volume is not directly related.

**Final Answer:**

**Answer:** (A)

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Q34.

**Solution**

**Concept:** A perfect black body is an idealized physical object that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. It also emits radiation based on its temperature (black-body radiation).

**Solution:** Step 1: Define a perfect black body. A perfect black body is defined as an object that absorbs 100% of the incident electromagnetic radiation falling on it. This absorption is independent of the wavelength, frequency, or angle of incidence of the radiation.

Step 2: Consider the emission properties. A perfect black body is also a perfect emitter of thermal radiation at any given temperature. The spectrum of this emitted radiation depends only on the temperature of the body.

Step 3: Evaluate the options:

- All incident radiation: This aligns with the definition of a perfect black body.
- Only visible light: A black body absorbs radiation across the entire electromagnetic spectrum.
- Only infrared radiation: This is incorrect.
- No radiation: This would describe a perfect reflector or a transparent object, not an absorber.

**Final Answer:** All incident radiation

**Answer:** (A)

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Q35.

**Solution**

**Concept:** A NAND gate is a logic gate that outputs LOW (0) only when all of its inputs are HIGH (1). Otherwise, it outputs HIGH (1). It is the inverse of an AND gate.

**Solution:** Step 1: Understand the truth table for a NAND gate. A NAND gate performs the logical AND operation on its inputs and then inverts the result.

Let the inputs be A and B, and the output be Y.

For a NAND gate:  $Y = \overline{A \cdot B}$

Step 2: Consider the possible input combinations for a 2-input NAND gate:

- If A = 0 (LOW), B = 0 (LOW):  $A \cdot B = 0$ .  $Y = \overline{0} = 1$  (HIGH).
- If A = 0 (LOW), B = 1 (HIGH):  $A \cdot B = 0$ .  $Y = \overline{0} = 1$  (HIGH).
- If A = 1 (HIGH), B = 0 (LOW):  $A \cdot B = 0$ .  $Y = \overline{0} = 1$  (HIGH).
- If A = 1 (HIGH), B = 1 (HIGH):  $A \cdot B = 1$ .  $Y = \overline{1} = 0$  (LOW).

Step 3: From the truth table, the output of a NAND gate is LOW (0) only when both inputs are HIGH (1).

Step 4: Evaluate the options:

- Both inputs are HIGH: This is the condition where the output is LOW.
- Both inputs are LOW: Output is HIGH.
- Inputs are different: Output is HIGH.
- One input is HIGH: Output is HIGH.

**Final Answer:** Both inputs are HIGH

**Answer:** (A)

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Q36.

**Solution**

**Concept:** Vector quantities are physical quantities that have both magnitude and direction. Scalar quantities have only magnitude.

**Solution:** Step 1: Understand the difference between scalar and vector quantities. A scalar quantity has magnitude only, while a vector quantity has both magnitude and direction.

Step 2: Evaluate each option:

- Velocity: Velocity describes the rate of change of position and includes direction. Therefore, it is a vector quantity.
- Force: Force is a push or pull, which has both magnitude and direction. Therefore, it is a vector quantity.
- Work: Work is defined as force times distance in the direction of the force. Mathematically, it's a dot product of two vectors, resulting in a scalar. Therefore, work is a scalar quantity.
- Acceleration: Acceleration is the rate of change of velocity. Since velocity is a vector, acceleration, which describes the change in velocity (both magnitude and direction), is also a vector quantity.

Step 3: Identify all vector quantities from the options. Velocity, Force, and Acceleration are vector quantities.

**Final Answer:** Velocity, Force, Acceleration

**Answer:** (A,B,D)

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Q37.

**Solution**

**Concept:** The resistance of a conductor depends on its physical properties and the conditions it is subjected to. The formula for resistance provides insight into these dependencies.

**Solution:** Step 1: Recall the formula for the resistance ( $R$ ) of a conductor:

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

where:

- $\rho$  is the resistivity of the material (a property of the material itself).
- $L$  is the length of the conductor.
- $A$  is the cross-sectional area of the conductor.

Step 2: Analyze the factors affecting resistance based on this formula:

- Length ( $L$ ): Resistance is directly proportional to the length ( $R \propto L$ ). So, length affects resistance.
- Area ( $A$ ): Resistance is inversely proportional to the cross-sectional area ( $R \propto \frac{1}{A}$ ). So, area affects resistance.
- Material ( $\rho$ ): Resistivity ( $\rho$ ) is an intrinsic property of the material, indicating how strongly it resists electric current. Different materials have different resistivities. So, the material affects resistance.

Step 3: Consider the effect of temperature. For most conductors, resistivity ( $\rho$ ) increases with increasing temperature. Therefore, resistance also increases with temperature. So, temperature affects resistance.

Step 4: Identify all factors that affect resistance from the given options. All four options (Length, Area, Material, Temperature) are correct factors that influence the resistance of a conductor.

**Final Answer:** Length, Area, Material, Temperature

**Answer:** (A,B,C,D)

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Q38.

**Solution**

**Concept:** Electromagnetic waves, such as light, are a fundamental form of energy propagation in the universe. They possess several characteristic properties.

**Solution:** Step 1: Recall the properties of electromagnetic waves (e.g., light, radio waves, X-rays).

Step 2: Evaluate each option:

- They are transverse: Yes, electromagnetic waves are transverse. The oscillating electric and magnetic fields are perpendicular to each other and to the direction of wave propagation.
- They can travel in vacuum: Yes, electromagnetic waves do not require a medium and can propagate through vacuum at the speed of light ( $c \approx 3 \times 10^8$  m/s). This is how sunlight reaches Earth.
- They carry energy: Yes, electromagnetic waves transfer energy. For example, sunlight warms the Earth. The energy of a photon is given by  $E = h\nu$ .
- They require material medium: This is incorrect. This property is characteristic of mechanical waves (like sound waves), not electromagnetic waves.

Step 3: Identify all correct properties of electromagnetic waves. Electromagnetic waves are transverse, can travel in vacuum, and carry energy.

**Final Answer:** They are transverse, They can travel in vacuum, They carry energy

**Answer:** (A,B,C)

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Q39.

**Solution**

**Concept:** The photoelectric effect is the emission of electrons from a material when light shines on it. The energy of the emitted electrons depends on the energy of the incident photons and the work function of the material.

**Solution:** Step 1: Recall the photoelectric effect and the relevant equation, which is Einstein's photoelectric equation:

$$KE_{max} = h\nu - \phi$$

where:

- $KE_{max}$  is the maximum kinetic energy of the emitted electrons.
- $h$  is Planck's constant.
- $\nu$  is the frequency of the incident light.
- $\phi$  is the work function of the material (the minimum energy required to remove an electron from the surface).

Step 2: Analyze the factors affecting  $KE_{max}$ :

- Frequency of incident light ( $\nu$ ): As seen from the equation,  $KE_{max}$  is directly dependent on the frequency of the incident light. Higher frequency light provides more energy to the electrons.
- Work function ( $\phi$ ): The work function of the material directly affects the kinetic energy. A higher work function means less kinetic energy is imparted to the electrons.
- Intensity only: Intensity of light is related to the number of photons, not the energy of individual photons. While higher intensity means more electrons might be emitted (if frequency is above threshold), it does not increase the kinetic energy of each emitted electron.
- Stopping potential: The stopping potential ( $V_s$ ) is the minimum negative potential applied to the collector plate that stops even the most energetic emitted electrons. It is related to the maximum kinetic energy by  $KE_{max} = eV_s$ , where  $e$  is the charge of an electron. Therefore, the stopping potential is a measure of the kinetic energy, and thus depends on the factors that determine kinetic energy. In this sense, it is dependent on frequency and work function, but not on intensity.

Step 3: Identify the factors that directly determine the kinetic energy of emitted electrons. These are the frequency of the incident light and the work function of the material. The stopping potential is directly related to this kinetic energy. Intensity only affects the number of emitted electrons, not their energy.

**Final Answer:** Frequency of incident light, Work function, Stopping potential

**Answer:** (A,C,D)

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Q40.

**Solution**

**Concept:** A body is in equilibrium when it is at rest or moving with a constant velocity. This condition implies that the net force and net torque acting on the body are zero.

**Solution:** Step 1: Understand the conditions for equilibrium. A body is in equilibrium if it is not accelerating. This can be in two states:

- Static Equilibrium: The body is at rest ( $\vec{v} = 0$ ).
- Dynamic Equilibrium: The body is moving with a constant velocity ( $\vec{v} = \text{constant}$ ).

Step 2: Apply Newton's First Law of Motion. For a body to remain at rest or in uniform motion (constant velocity), the net external force acting on it must be zero.

$$\sum \vec{F}_{ext} = 0$$

This means that the acceleration of the body is also zero ( $\vec{a} = 0$ ).

Step 3: Apply the condition for rotational equilibrium. For a body to not rotate or to rotate with a constant angular velocity, the net external torque acting on it must be zero.

$$\sum \vec{\tau}_{ext} = 0$$

This means that the angular acceleration of the body is zero.

Step 4: Evaluate the options:

- Net force is zero: This is the condition for translational equilibrium.
- Net torque is zero: This is the condition for rotational equilibrium.
- Acceleration is zero: If the net force is zero, the acceleration is zero. So, this is a consequence of net force being zero.
- Velocity must be zero: Velocity can be constant (non-zero) for dynamic equilibrium. So, velocity does not necessarily have to be zero.

Step 5: For a body to be in complete equilibrium (both translational and rotational), both the net force and the net torque must be zero. Acceleration being zero is a direct consequence of zero net force.

**Final Answer:** Net force is zero, Net torque is zero, Acceleration is zero

**Answer:** (A,B,C)

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## Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	A	4	A	5	A
6	A	7	A	8	A	9	A	10	A
11	A	12	A	13	A	14	A	15	A
16	A	17	A	18	A	19	A	20	A
21	A	22	A	23	A	24	A	25	A
26	A	27	A	28	A	29	A	30	A
31	A	32	A	33	A	34	A	35	A
36	A,B,D	37	A,B,C,D	38	A,B,C	39	A,C,D	40	A,B,C

