NEET-UG Physics Sample Paper-19

Duration: 1 Hour **Maximum Marks: 180**

Instructions

- This paper contains a total of 45 Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. The dimensional formula of Planck's constant is:

(A) ML^2T^{-1}

(B) ML^2T^{-2}

(C) MLT^{-1}

(D) $M^0L^2T^{-1}$

Q2. A particle moves with velocity $v = 3t^2 + 2t$. Its acceleration at $t = 2\ s$ is:

(A) 10 m/s^2

(B) 14 m/s^2

(C) 16 m/s^2

(D) 20 m/s^2

Q3. A ball is projected vertically upward with initial velocity 20 m/s. Time to reach maximum height is:

(A) 1 s

(B) 2 s

(C) 3 s

(D) 4 s

Q4. A 10 kg body experiences a net force of 50 N. Its acceleration is:

(A) 2 m/s^2

(B) 5 m/s^2

(C) 10 m/s^2

(D) 0.5 m/s^2

Q5. Action and reaction forces:

(A) Act on same body

(B) Are equal and opposite

(C) Cancel each other

(D) Act in same direction

Q6. Work done by a force perpendicular to displacement is:

(A) Maximum

(B) Zero

(C) Minimum

(D) Negative

Q7. If kinetic energy becomes four times, momentum becomes:

(A) 2 times

(B) 4 times

(C) 8 times

(D) Same

Q8. Moment of inertia depends on:

(A) Mass only

(B) Distribution of mass

(C) Velocity

(D) Force

Q9. Torque is defined as:

(A) $F \times r$

(B) $r \times F$

(C) F/r

(D) r/F

Q10. Escape velocity depends on:

(A) Mass of planet

(B) Radius of planet

(C) Both

(D) None

Q11. Value of acceleration due to gravity decreases with:

(A) Depth

(B) Height

(C) Both

(D) None

Q12. Bulk modulus is defined as:

(A) Stress/strain

(B) Volume stress/volume strain

(C) Force/area

(D) Pressure/area

Q13. Surface tension depends on:

(A) Temperature

(B) Nature of liquid

(C) Both

(D) None

Q14. Viscosity is the resistance to:

(A) Motion

(B) Flow

(C) Heat transfer

(D) Pressure

Q15. First law of thermodynamics represents:

(A) Conservation of energy

(B) Entropy increase

(C) Heat only

(D) Work only

Q16. Efficiency of Carnot engine depends on:

(A) Temperature of reservoirs

(B) Pressure

(C) Volume

(D) Work done

Q17. RMS speed of gas molecules is proportional to:

(A) $\sqrt{T}$

(B) T

(C) $1/T$

(D) $1/\sqrt{T}$

Q18. Time period of simple harmonic motion is:

(A) Depends on amplitude

(B) Independent of amplitude

(C) Depends on velocity

(D) None

Q19. Wave speed is given by:

(A) $v = f\lambda$

(B) $v = \lambda/T$

(C) Both

(D) None

Q20. Coulomb's force varies as:

(A) r

(B) r^2

(C) $1/r^2$

(D) $1/r$

Q21. Unit of electric field is:

(A) N/C

(B) Joule

(C) Watt

(D) Volt

Q22. Electric potential is defined as:

(A) Work per unit charge

(B) Force per charge

(C) Energy per unit force

(D) Charge per work

Q23. Ohm's law is given by:

(A) $V = IR$

(B) $I = VR$

(C) $R = VI$

(D) None

Q24. A series circuit has two resistors of 2Ω and 4Ω. Equivalent resistance is:

(A) 2Ω

(B) 4Ω

(C) 6Ω

(D) 8Ω

Q25. Electrical power is given by:

(A) VI

(B) I^2R

(C) V^2/R

(D) All of these

Q26. Resistivity depends on:

(A) Length

(B) Area

(C) Material

(D) Voltage

Q27. SI unit of magnetic field is:

(A) Tesla

(B) Ampere

(C) Volt

(D) Newton

Q28. The direction of magnetic field around a current-carrying conductor is given by:

(A) Fleming's left-hand rule

(B) Right-hand thumb rule

(C) Lenz's law

(D) Faraday's law

Q29. Magnetic field inside a long solenoid is:

(A) Zero

(B) Uniform

(C) Infinite

(D) Variable

Q30. Faraday's law states that induced emf is proportional to:

(A) Change in flux

(B) Flux

(C) Current

(D) Resistance

Q31. Alternating current varies:

(A) Linearly

(B) Sinusoidally

(C) Constantly

(D) Randomly

Q32. Electromagnetic waves travel at:

(A) Speed of sound

(B) Speed of light

(C) Infinite speed

(D) Zero speed

Q33. A convex lens forms image when object is placed beyond $2F$:

(A) Virtual and erect

(B) Real and inverted

(C) Same size

(D) At focus

Q34. Mirror formula is:

(A) $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

(B) $f = uv$

(C) $v = u + f$

(D) None

Q35. Refraction is governed by:

(A) Snell's law

(B) Ohm's law

(C) Newton's law

(D) Hooke's law

Q36. Diffraction occurs due to:

(A) Particle nature

(B) Wave nature

(C) Both

(D) None

Q37. Photoelectric effect supports:

(A) Wave nature

(B) Particle nature

(C) Both

(D) None

Q38. De Broglie wavelength is inversely proportional to:

(A) Momentum

(B) Velocity

(C) Mass

(D) Energy

Q39. Bohr radius is proportional to:

(A) n^2

(B) n

(C) $1/n$

(D) None

Q40. Radioactive decay follows:

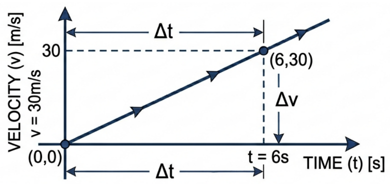
(A) Linear law

(B) Exponential law

(C) Constant law

(D) None

Q41. The figure shows a velocity-time graph of a particle increasing uniformly from 0 to 30 m/s in 6 s. The acceleration of the particle is:



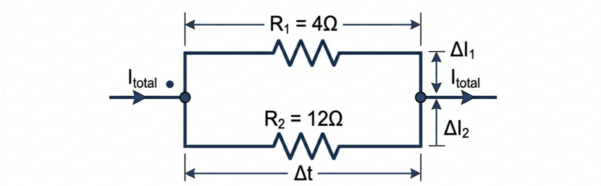
(A) 2 m/s^2

(B) 3 m/s^2

(C) 4 m/s^2

(D) 5 m/s^2

Q42. The figure shows two resistors of 4Ω and 12Ω connected in parallel. The equivalent resistance is:



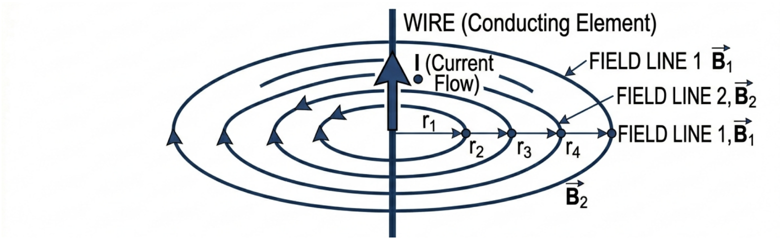
(A) 2Ω

(B) 3Ω

(C) 6Ω

(D) 16Ω

Q43. The figure shows magnetic field lines around a straight current-carrying conductor. The direction of field is given by:



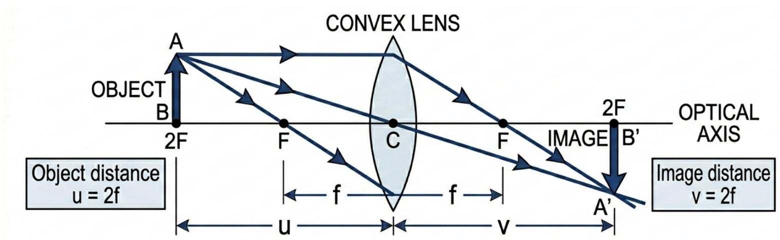
(A) Fleming's left-hand rule

(B) Right-hand thumb rule

(C) Lenz's law

(D) Ampere's law

Q44. The figure shows a convex lens with object placed at $2F$. The image formed will be:



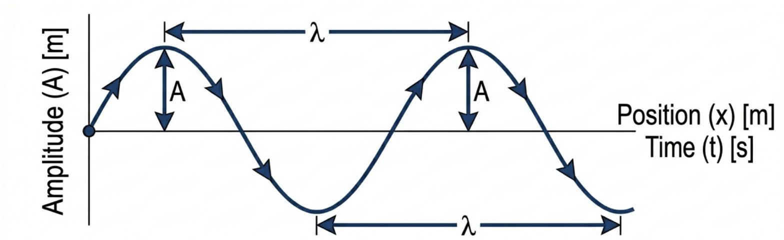
(A) Real, inverted, same size

(B) Virtual and erect

(C) Highly diminished

(D) At infinity

Q45. The figure shows a sinusoidal wave with wavelength λ. If the wave speed is v, the frequency is:



(A) v/λ

(B) λ/v

(C) $v\lambda$

(D) None

Detailed Solutions

Q1.

Solution

Concept: Dimensional analysis is a method used to check the consistency of physical equations and to derive relationships between physical quantities. Every physical quantity can be expressed in terms of fundamental dimensions: Mass (M), Length (L), and Time (T). Planck's constant (h) is a fundamental constant in quantum mechanics, relating the energy of a photon (E) to its frequency (f) via the equation $E = hf$.

Solution: To find the dimensional formula of Planck's constant (h), we use the relation $E = hf$.
First, we rearrange the formula to solve for h: $h = \frac{E}{f}$.
Next, we determine the dimensional formulas for energy (E) and frequency (f).

1. **Dimensional Formula for Energy (E):** Energy is the capacity to do work. Work done is Force × Distance.
Force (F) = Mass (m) × Acceleration (a).
Dimension of Mass [m] = M.
Dimension of Acceleration [a] = Length/Time^2 = LT^2.
So, Dimension of Force [F] = [M][LT^2] = MLT^2.
Dimension of Energy [E] = [Force][Distance] = [MLT^2][L] = ML^{2}T^2.

2. **Dimensional Formula for Frequency (f):** Frequency is the number of occurrences of a repeating event per unit of time. It is the reciprocal of the time period (T).
Dimension of Frequency [f] = 1/[Time Period] = 1/T = T^1.

Now, we substitute these dimensions back into the equation for h:
h
$= \frac{[E]}{[f]} = \frac{ML^2T^{-2}}{T^{-1}}$
Using the rules of exponents ($a^m/a^n = a^{m-n}$):
h
$= ML^2T^{(-2-(-1))} = ML^2T^{(-2+1)} = ML^2T^{-1}$.

Thus, the dimensional formula of Planck's constant is ML^2T^{-1}.

Final Answer : "$[ML^2T^{-1}]$"

Answer: (A)

Q2.

Solution

Concept: In kinematics, acceleration is defined as the rate of change of velocity with respect to time. If the velocity (v) of a particle is given as a function of time (t), its instantaneous acceleration (a) can be found by taking the first derivative of the velocity function with respect to time. Mathematically, this is expressed as:
$a(t) = \frac{dv}{dt}$.

Solution: We are given the velocity of the particle as a function of time:
$v(t) = 3t^2 + 2t$.

To find the acceleration, we need to differentiate this function with respect to time, t. We use the power rule for differentiation, which states that $\frac{d}{dt}(ct^n) = n \cdot ct^{n-1}$.

Applying the rule to each term of the velocity function:
$\frac{d}{dt}(3t^2) = 2 \cdot 3t^{2-1} = 6t$.
$\frac{d}{dt}(2t) = 1 \cdot 2t^{1-1} = 2t^0 = 2$.

So, the acceleration function is:
$a(t) = \frac{dv}{dt} = 6t + 2$.

The question asks for the acceleration at the specific time $t = 2\,s$. We substitute this value into our acceleration function:
$a(2) = 6(2) + 2$.
$a(2) = 12 + 2 = 14$.

The units for acceleration are meters per second squared (m/s^2).

Final Answer : "14 m/s^2"

Answer: (B)

Q3.

Solution

Concept: This problem involves motion under constant acceleration, specifically the motion of an object under the influence of gravity. When a ball is projected vertically upward, its speed decreases due to the constant downward acceleration of gravity (g). At the highest point of its trajectory, the instantaneous vertical velocity of the ball becomes zero. We can use the first equation of motion for uniformly accelerated motion:
$v = u + at$, where v is the final velocity, u is the initial velocity, a is the acceleration, and t is the time elapsed.

Solution: Let's establish a sign convention: upward direction is positive (+) and downward direction is negative (-).

From the problem statement, we have:
- Initial velocity, $u = +20$ m/s (since it's projected upward).
- The acceleration is due to gravity, which acts downward, so $a = -g$. We'll use the approximation $g \approx 10$ m/s^2 for simplicity, which is standard for such problems unless specified otherwise. Thus, $a = -10$ m/s^2.
- At the maximum height, the final velocity is momentarily zero, so $v = 0$ m/s.

We need to find the time (t) it takes to reach this maximum height. We use the kinematic equation:
$v = u + at$.

Substitute the known values into the equation:
$0 = 20 + (-10) \times t$.
$0 = 20 - 10t$.

Now, we solve for t:
$10t = 20$.
$t = \frac{20}{10} = 2$ s.

Therefore, it takes 2 seconds for the ball to reach its maximum height.

Final Answer : "2 s"

Answer: (B)

Q4.

Solution

Concept: Newton's Second Law of Motion is a fundamental principle in classical mechanics. It states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the net force. The law is mathematically expressed as:
$F_{net} = ma$, where F_{net} is the net force in Newtons (N), m is the mass in kilograms (kg), and a is the acceleration in meters per second squared (m/s^2).

Solution: We are given the following information in the problem:
- Mass of the body, $m = 10$ kg.
- Net force experienced by the body, $F = 50$ N.

We need to calculate the acceleration (a) of the body. We can rearrange Newton's Second Law formula to solve for acceleration:
$a = \frac{F}{m}$.

Now, we substitute the given numerical values into this formula:
$a = \frac{50\text{ N}}{10\text{ kg}}$.

Performing the division:
$a = 5$.

The unit of acceleration is m/s^2, as $1\text{ N} = 1\text{ kg}\cdot\text{m/s}^2$. Therefore, $\frac{\text{N}}{\text{kg}} = \frac{\text{kg}\cdot\text{m/s}^2}{\text{kg}} = \text{m/s}^2$.

So, the acceleration of the body is 5 m/s^2.

Final Answer : "5 m/s^2"

Answer: (B)

Q5.

Solution

Concept: Newton's Third Law of Motion describes action-reaction force pairs. The law states that for every action, there is an equal and opposite reaction. This means that if body A exerts a force on body B (the "action"), then body B simultaneously exerts a force on body A (the "reaction") that is equal in magnitude and opposite in direction.

Key characteristics of action-reaction pairs are:

1. They are equal in magnitude.
2. They are opposite in direction.
3. They act on two different bodies.
4. They are of the same nature (e.g., both gravitational or both contact forces).

Solution: Let's analyze the given options in the context of Newton's Third Law:

- (A) Act on same body: This is incorrect. A fundamental property of action-reaction pairs is that they act on different interacting objects. For example, the action force of a book on a table is matched by the reaction force of the table on the book.
- (B) Are equal and opposite: This is the core statement of Newton's Third Law. The forces are equal in magnitude and opposite in direction. This is the correct description.
- (C) Cancel each other: This is a common misconception. Since action and reaction forces act on different bodies, they cannot be added together to find a net force on a single body, and therefore they do not cancel each other out.

Cancellation can only occur for forces acting on the same body.

- (D) Act in same direction: This is incorrect. The law explicitly states the forces are in opposite directions.

Therefore, the correct statement describing action and reaction forces is that they are equal and opposite.

Final Answer : "Are equal and opposite"

Answer: (B)

Q6.

Solution

Concept: In physics, work is done by a force on an object when the force causes a displacement of the object. The amount of work done (W) is given by the dot product of the force vector ($\vec{F}$) and the displacement vector ($\vec{d}$). The formula is:
$W = \vec{F} \cdot \vec{d} = |\vec{F}||\vec{d}| \cos\theta$, where $|\vec{F}|$ is the magnitude of the force, $|\vec{d}|$ is the magnitude of the displacement, and θ is the angle between the force vector and the displacement vector.
The value of $\cos\theta$ determines if the work done is positive, negative, or zero.
- If $0° \leq \theta < 90°$, $\cos\theta$ is positive, and work done is positive.
- If $\theta = 90°$, $\cos\theta = 0$, and work done is zero.
- If $90° < \theta \leq 180°$, $\cos\theta$ is negative, and work done is negative.

Solution: The problem states that the force is perpendicular to the displacement. This means the angle θ between the force vector $\vec{F}$ and the displacement vector $\vec{d}$ is $90°$.

We use the formula for work done:
$W = Fd\cos\theta$.

Substituting $\theta = 90°$ into the formula:
$W = Fd\cos(90°)$.

From trigonometry, we know that $\cos(90°) = 0$.
Therefore, the work done is:
$W = Fd(0) = 0$.

No work is done when the force is perpendicular to the displacement. A classic example is the work done by the centripetal force on an object moving in a circle at a constant speed; the force is always directed towards the center, perpendicular to the object's velocity and displacement.

Final Answer : "Zero"

Answer: (B)

Q7.

Solution

Concept: Kinetic energy (K) and linear momentum (p) are two fundamental quantities describing the motion of an object.

- Linear momentum is the product of mass (m) and velocity (v): $p = mv$.
- Kinetic energy is the energy of motion, given by: $K = \frac{1}{2}mv^2$.

From the momentum equation, we can write velocity as $v = \frac{p}{m}$.
Substituting this into the kinetic energy equation:
$K = \frac{1}{2}m\left(\frac{p}{m}\right)^2 = \frac{1}{2}m\left(\frac{p^2}{m^2}\right) = \frac{p^2}{2m}$.
This relationship, $K = \frac{p^2}{2m}$, can be rearranged to express momentum in terms of kinetic energy:
$p = \sqrt{2mK}$.

Solution: We start with the relationship $p = \sqrt{2mK}$. This shows that for a constant mass, momentum is directly proportional to the square root of the kinetic energy ($p \propto \sqrt{K}$).

Let the initial state be denoted by subscript 1 and the final state by subscript 2.
Initial momentum: p_1
Initial kinetic energy: K_1
So, $p_1 = \sqrt{2mK_1}$.

The problem states that the kinetic energy becomes four times its initial value.
Final kinetic energy: $K_2 = 4K_1$.
Final momentum: p_2.
So, $p_2 = \sqrt{2mK_2}$.

Substitute $K_2 = 4K_1$ into the equation for p_2:
$p_2 = \sqrt{2m(4K_1)}$.

We can separate the square root term:
$p_2 = \sqrt{4} \times \sqrt{2mK_1}$.
Since $\sqrt{4} = 2$, we get:
$p_2 = 2 \times \sqrt{2mK_1}$.

We recognize that $\sqrt{2mK_1}$ is the initial momentum, p_1.
Therefore, $p_2 = 2p_1$.

This shows that if the kinetic energy becomes four times larger, the momentum doubles (becomes 2 times larger).

Final Answer : "2 times"

Answer: (A)

Q8.

Solution

Concept: Moment of inertia (I) is the rotational analog of mass. While mass represents an object's inertia or resistance to linear acceleration, the moment of inertia represents an object's resistance to angular acceleration. It depends not only on the object's mass but also on how that mass is distributed relative to the axis of rotation.

For a collection of discrete particles, the moment of inertia is calculated as the sum of the product of the mass of each particle (m_i) and the square of its perpendicular distance (r_i) from the axis of rotation:

$I = \sum m_i r_i^2$.

For a continuous rigid body, this sum becomes an integral: $I = \int r^2 dm$.

Solution: The formula $I = \sum m_i r_i^2$ clearly shows the factors on which the moment of inertia depends.

1. **Mass (m_i):** The moment of inertia is directly proportional to the mass of the object. A more massive object will generally have a larger moment of inertia than a less massive one, assuming a similar shape and size.

2. **Distribution of mass (r_i^2):** The term r_i^2 indicates that the distance of the mass from the axis of rotation is critically important. Mass that is farther away from the axis of rotation contributes significantly more to the moment of inertia than mass that is closer to the axis, due to the squared term.

Let's consider the options:

- (A) Mass only: Incorrect. Two objects can have the same mass but different moments of inertia if their shapes differ (e.g., a ring and a disk of the same mass and radius).
- (B) Distribution of mass: This is the most complete answer. This term encompasses both the total mass and how it is geometrically arranged around the axis.
- (C) Velocity: Incorrect. Moment of inertia is an intrinsic property of an object's mass and shape, independent of its state of motion (like angular velocity).
- (D) Force: Incorrect. Force causes a change in motion (torque causes angular acceleration), but it does not determine the moment of inertia itself.

Thus, the moment of inertia depends on the distribution of mass.

Final Answer : "Distribution of mass"

Answer: (B)

Q9.

Solution

Concept: Torque, also known as the moment of a force, is the rotational equivalent of linear force. It is a measure of the tendency of a force to cause or change the rotational motion of an object. Torque is a vector quantity. It is defined by the cross product of the position vector ($\vec{r}$) from the axis of rotation to the point where the force is applied, and the force vector ($\vec{F}$) itself.
The mathematical definition is:
$\vec{\tau} = \vec{r} \times \vec{F}$.
The magnitude of the torque is given by $|\vec{\tau}| = |\vec{r}||\vec{F}| \sin\theta$, where θ is the angle between the vectors $\vec{r}$ and $\vec{F}$. The direction of the torque vector is perpendicular to the plane formed by $\vec{r}$ and $\vec{F}$, determined by the right-hand rule.

Solution: The definition of torque is a vector product, specifically a cross product. The order of the vectors in a cross product is crucial because the cross product is not commutative; it is anti-commutative, meaning $\vec{a} \times \vec{b} = -(\vec{b} \times \vec{a})$.
The standard convention in physics defines torque as the position vector crossed with the force vector.
$\vec{\tau} = \vec{r} \times \vec{F}$.

Let's evaluate the given options:
- (A) $F \times r$: This represents $\vec{F} \times \vec{r}$, which is equal to $-\vec{\tau}$. This is a vector with the same magnitude but opposite direction to the correctly defined torque.
- (B) $r \times F$: This represents $\vec{r} \times \vec{F}$, which is the correct mathematical definition of torque.
- (C) F/r: This is a scalar division and does not represent torque.
- (D) r/F: This is also a scalar division and is not the definition of torque.

Therefore, the correct definition of torque is $\vec{r} \times \vec{F}$.
Final Answer : "$\vec{r} \times \vec{F}$"

Answer: (B)

Q10.

Solution

Concept: Escape velocity is the minimum speed an object without propulsion needs to "escape" from the gravitational influence of a massive body, like a planet or star. To escape means to travel infinitely far away from the body. This can be calculated using the principle of conservation of energy. The initial kinetic energy of the object must be equal to the work needed to overcome the gravitational potential energy from the planet's surface to infinity.

The work needed to move a mass m from the surface (radius R) of a planet of mass M to infinity is given by the change in gravitational potential energy, $\Delta U = U_{inf} - U_{surface} = 0 - (-\frac{GMm}{R}) = \frac{GMm}{R}$.

Setting the initial kinetic energy equal to this work:

$\frac{1}{2}mv_e^2 = \frac{GMm}{R}$.

Solving for the escape velocity (v_e):

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

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

Solution: Let's analyze the derived formula for escape velocity:

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

The variables in this formula are:

- G: The universal gravitational constant, which is a constant value throughout the universe.
- M: The mass of the large celestial body (the planet) from which the object is escaping.
- R: The radius of the planet (or more generally, the initial distance of the object from the center of the planet).

The formula clearly shows that the escape velocity is a function of both the mass (M) of the planet and its radius (R).

- A more massive planet (larger M) will have a higher escape velocity.
- A smaller planet (smaller R) for the same mass will also have a higher escape velocity.

It is important to note that the mass of the escaping object, m, cancels out during the derivation, so the escape velocity is independent of the mass of the object trying to escape.

Based on this analysis, escape velocity depends on both the mass of the planet and the radius of the planet.

Final Answer : "Both mass and radius of the planet"

Answer: (C)

Q11.

Solution

Concept: The acceleration due to gravity, g, is the acceleration experienced by an object due to the gravitational force of a massive body, like the Earth. On the Earth's surface, its value is given by $g = \frac{GM}{R^2}$, where G is the universal gravitational constant, M is the mass of the Earth, and R is the radius of the Earth. This value changes with altitude (height) and depth.

Solution: We analyze the variation of g with height and depth separately.
1. **Variation with Height (h):** At a height h above the Earth's surface, the distance from the center is $(R + h)$. The acceleration due to gravity at this height, g_h, is:
$g_h = \frac{GM}{(R+h)^2}$.
Since the denominator $(R + h)^2$ is greater than R^2, it is clear that $g_h < g$. Thus, the value of g decreases as we move up from the surface of the Earth.

2. **Variation with Depth (d):** At a depth d below the Earth's surface, the object is only attracted by the mass of the inner sphere of radius $(R - d)$. Assuming the Earth has a uniform density (ρ), the mass of this inner sphere is $M' = \rho \times \frac{4}{3}\pi(R - d)^3$. The acceleration due to gravity at this depth, g_d, is:
$g_d = \frac{GM'}{(R-d)^2} = \frac{G(\rho\frac{4}{3}\pi(R-d)^3)}{(R-d)^2} = G\rho\frac{4}{3}\pi(R - d)$.
Since g on the surface is $G\rho\frac{4}{3}\pi R$, we can write the relation $g_d = g\frac{(R-d)}{R} = g(1 - \frac{d}{R})$.
As the depth d increases, the term $(1 - d/R)$ decreases, which means $g_d < g$. Thus, the value of g also decreases as we go down from the surface of the Earth.

Since the value of g decreases with both increasing height and increasing depth, the correct option is 'Both'.

Final Answer : "Both height and depth"

Answer: (C)

Q12.

Solution

Concept: Elasticity is the property of a material to resist a distorting influence and to return to its original size and shape when that influence is removed. The modulus of elasticity is a measure of this resistance, defined as the ratio of stress to strain.

- **Stress** is the internal restoring force per unit area in a deformed body.
- **Strain** is the measure of deformation, representing the fractional change in dimension.

Bulk modulus (K) is a specific type of modulus of elasticity that measures a substance's resistance to uniform compression.

Solution: Bulk modulus applies when a body is subjected to a uniform pressure from all sides, causing its volume to change without changing its shape.

- The stress in this case is called **volume stress** or **hydrostatic stress**, which is equal to the change in applied pressure (ΔP).
- The resulting strain is called **volume strain**, which is the fractional change in volume, given by $\frac{\Delta V}{V}$. A positive ΔP (increase in pressure) causes a negative ΔV (decrease in volume).

The bulk modulus (K) is defined as the ratio of volume stress to the magnitude of volume strain:
$K = \frac{\text{Volume Stress}}{\text{Volume Strain}} = \frac{\Delta P}{(-\Delta V/V)} = -V\frac{\Delta P}{\Delta V}$.
Therefore, the bulk modulus is correctly defined as the ratio of volume stress to volume strain.

Final Answer : "Volume stress/volume strain"

Answer: (B)

Q13.

Solution

Concept: Surface tension is the property of the surface of a liquid that allows it to resist an external force. It is caused by the cohesive forces (attraction between like molecules) between the liquid molecules. At the surface, molecules have fewer neighboring molecules to be attracted to compared to molecules in the bulk, resulting in a net inward pull that causes the surface to contract and behave like a stretched membrane.

Solution: The magnitude of the cohesive forces determines the strength of the surface tension. Several factors affect these forces:
1. **Nature of the liquid:** Different liquids have different molecular structures and intermolecular forces. For example, mercury has much stronger cohesive forces than water, and thus a much higher surface tension. So, surface tension is an intrinsic property that depends on the specific liquid.
2. **Temperature:** Increasing the temperature of a liquid increases the kinetic energy of its molecules. This increased motion tends to overcome the cohesive forces holding the molecules together. As the intermolecular attractive forces weaken, the surface tension decreases. Typically, surface tension decreases linearly with an increase in temperature.

Since surface tension is dependent on the intermolecular forces, which are characteristic of the liquid and are affected by temperature, it depends on both the nature of the liquid and its temperature.

Final Answer : "Both nature of liquid and temperature"

Answer: (C)

Q14.

Solution

Concept: Viscosity is a fundamental property of a fluid (a liquid or a gas) that measures its resistance to deformation at a given rate. For fluids, this deformation corresponds to flow. It can be thought of as the "thickness" of a fluid or its internal friction. When a fluid flows, different layers of the fluid move at different velocities, creating what is known as shear. Viscosity arises from the frictional forces between these adjacent layers.

Solution: Viscosity describes a fluid's internal resistance to flow.
- A fluid with high viscosity (like honey) resists flow and appears "thick."
- A fluid with low viscosity (like water) flows easily and appears "thin."

This resistance is due to the intermolecular forces within the fluid. As layers of fluid slide past one another, these forces create a drag effect, opposing the relative motion. Therefore, viscosity is fundamentally the resistance a fluid offers to the motion of its own parts, which is the process of flowing. While this does resist the motion of an object through the fluid, its fundamental definition relates to the fluid's own internal resistance to flow.

Final Answer : "Flow"

Answer: (B)

Q15.

Solution

Concept: The First Law of Thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic systems. It establishes a relationship between the internal energy of a system, the heat transferred into or out of the system, and the work done on or by the system. The law is mathematically stated as:

$\Delta U = Q - W$,

where:
- ΔU is the change in the internal energy of the system.
- Q is the net heat supplied to the system.
- W is the net work done by the system.

Solution: The equation $\Delta U = Q - W$ states that the change in a system's internal energy (ΔU) is equal to the amount of energy added to the system as heat (Q) minus the amount of energy lost from the system in the form of work done on the surroundings (W). This means that energy is not created or destroyed within the system; it is only transferred or converted from one form to another (heat, work, internal energy). This is the principle of the conservation of energy. The first law simply applies this universal principle to a thermodynamic context.

Final Answer : "Conservation of energy"

Answer: (A)

Q16.

Solution

Concept: A Carnot engine is an idealized, theoretical heat engine that operates on the Carnot cycle. It has the maximum possible efficiency that a heat engine can achieve while operating between two heat reservoirs at constant temperatures. The efficiency (η) of a heat engine is defined as the ratio of the work output (W) to the heat input from the hot reservoir (Q_H), $\eta = W/Q_H$. For a Carnot engine, this efficiency can be expressed solely in terms of the absolute temperatures of the reservoirs.

Solution: The formula for the efficiency of a Carnot engine is:
$\eta_{Carnot} = 1 - \frac{T_C}{T_H}$,
where:
- T_H is the absolute temperature (in Kelvin) of the hot reservoir (the source).
- T_C is the absolute temperature (in Kelvin) of the cold reservoir (the sink).

This formula shows that the efficiency of a Carnot engine is determined exclusively by the temperatures of the two reservoirs between which it operates. It does not depend on the nature of the working substance, the pressure or volume of the substance, or the specific amount of work done per cycle. To maximize efficiency, one must make the ratio T_C/T_H as small as possible, which means having the hot reservoir as hot as possible and the cold reservoir as cold as possible.

Final Answer : "Temperature of reservoirs"

Answer: (A)

Q17.

Solution

Concept: The kinetic theory of gases describes a gas as a large number of submicroscopic particles (atoms or molecules), all of which are in constant, rapid, random motion. The temperature of the gas is related to the average kinetic energy of these particles. The root-mean-square (RMS) speed, v_{rms}, is a specific measure of the average speed of the gas particles, calculated as the square root of the average of the squares of the speeds.

Solution: From the kinetic theory of gases, the average translational kinetic energy of a gas molecule is directly proportional to the absolute temperature (T):
$\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$, where k is the Boltzmann constant.
The RMS speed is defined as $v_{rms} = \sqrt{\overline{v^2}}$.
From the energy equation, we can solve for $\overline{v^2}$:
$\overline{v^2} = \frac{3kT}{m}$.
Taking the square root gives the RMS speed:
$v_{rms} = \sqrt{\frac{3kT}{m}}$.
Alternatively, using the molar mass M and the ideal gas constant R ($R = N_A k$, $M = N_A m$), the formula is:
$v_{rms} = \sqrt{\frac{3RT}{M}}$.
In both formulations, the constants (3, k, m, R, M) are fixed for a given gas. Therefore, the RMS speed (v_{rms}) is directly proportional to the square root of the absolute temperature (T).
$v_{rms} \propto \sqrt{T}$.

Final Answer : "$\sqrt{T}$"

Answer: (A)

Q18.

Solution

Concept: Simple Harmonic Motion (SHM) is a specific type of oscillatory motion where the restoring force on the moving object is directly proportional to the magnitude of the object's displacement and acts towards the object's equilibrium position. The time period (T) of an oscillation is the time it takes to complete one full cycle.

Solution: Let's consider the standard examples of SHM:
1. **Mass-Spring System:** A mass 'm' attached to a spring with spring constant 'k'. The time period is given by:
$T = 2\pi\sqrt{\frac{m}{k}}$.
2. **Simple Pendulum:** A point mass 'm' suspended by a massless string of length 'L' (for small oscillations).
The time period is given by:
$T = 2\pi\sqrt{\frac{L}{g}}$.

In both these fundamental equations, the time period 'T' depends only on the physical properties of the system (mass, spring constant, length, acceleration due to gravity). The amplitude of the motion (the maximum displacement from the equilibrium position) does not appear in these equations. This independence of the period from the amplitude is a defining characteristic of Simple Harmonic Motion.

Final Answer : "Independent of amplitude"

Answer: (B)

Q19.

Solution

Concept: A wave is a disturbance that propagates through a medium or space. The speed of a wave (v) is related to its fundamental properties: wavelength (λ), frequency (f), and period (T).
- **Wavelength (λ):** The spatial period of the wave, the distance over which the wave's shape repeats.
- **Period (T):** The time required for one complete cycle of the wave to pass a point.
- **Frequency (f):** The number of cycles that pass a point per unit time. Frequency is the reciprocal of the period, $f = 1/T$.

Solution: The speed of any object or phenomenon is defined as the distance traveled per unit time. For a wave, we can consider the distance traveled during one complete cycle.
- The distance traveled in one cycle is one wavelength, λ.
- The time taken for one cycle is one period, T.

Using the definition of speed:
Speed = $\frac{\text{Distance}}{\text{Time}} \implies v = \frac{\lambda}{T}$. This is the first correct relationship.

Now, we know that frequency is the reciprocal of the period, $f = \frac{1}{T}$. We can substitute this into the first equation:
$v = \lambda \times \left(\frac{1}{T}\right) = \lambda \times f = f\lambda$. This is the second correct relationship, commonly known as the wave equation.

Since both $v = f\lambda$ and $v = \lambda/T$ are correct and equivalent expressions for the wave speed, the correct option is 'Both'.

Final Answer : "Both $v = f\lambda$ and $v = \lambda/T$ are correct"

Answer: (C)

Q20.

Solution

Concept: Coulomb's Law is a fundamental law in electrostatics that describes the force between two stationary, electrically charged particles. The law states that the magnitude of the electrostatic force of attraction or repulsion between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

Solution: The mathematical expression for Coulomb's Law is:
$F = k\frac{|q_1 q_2|}{r^2}$, where:
- F is the magnitude of the electrostatic force.
- q_1 and q_2 are the magnitudes of the two point charges.
- r is the distance separating the two charges.
- k is Coulomb's constant ($k \approx 8.987 \times 10^9\ \mathrm{N \cdot m^2/C^2}$).

From this formula, we can see the relationship between the force F and the distance r. Assuming the charges q_1 and q_2 are constant, the force is inversely proportional to the square of the distance: $F \propto \frac{1}{r^2}$.
This is known as an inverse-square law. It means that if you double the distance between the charges, the force between them decreases by a factor of $2^2 = 4$. If you triple the distance, the force decreases by a factor of $3^2 = 9$.

Final Answer : "$1/r^2$"

Answer: (C)

Q21.

Solution

Concept: An electric field is a vector field surrounding an electric charge that exerts a force on other charges that are placed in the field. The electric field strength, E, at a specific point in space is defined as the force, F, that would be exerted on a small positive test charge, q_0, placed at that point, divided by the magnitude of the test charge itself.

Solution: The definition of the electric field gives us the formula to determine its units:
$\vec{E} = \frac{\vec{F}}{q_0}$.
To find the SI unit of the electric field, we look at the SI units of the quantities on the right side of the equation:
- The SI unit for force ($\vec{F}$) is the Newton (N).
- The SI unit for electric charge (q_0) is the Coulomb (C).

Therefore, the unit of the electric field ($\vec{E}$) is the unit of force divided by the unit of charge:
Unit of E = $\frac{\text{Unit of F}}{\text{Unit of } q_0} = \frac{\text{Newton}}{\text{Coulomb}}$ = N/C.

An equivalent unit for the electric field is Volts per meter (V/m), but among the given options, N/C is present.

Final Answer : "N/C"

Answer: (A)

Q22.

Solution

Concept: Electric potential (or voltage) at a point in an electric field is a scalar quantity that represents the amount of potential energy per unit of charge at that point. It is defined as the work required by an external force to move a unit positive charge from a reference point (usually infinity) to the specific point in the field without producing any acceleration.

Solution: By definition, the electric potential, V, is the work done (W) in moving a charge (q) from a reference point to a point in an electric field, divided by the magnitude of the charge. The formula is:
$V = \frac{W}{q}$.
This can also be expressed as the electric potential energy (U) per unit charge, $V = \frac{U}{q}$.
From this relationship, we can see that electric potential is dimensionally 'Work per unit charge' or 'Energy per unit charge'. Option (B), Force per charge, defines the electric field strength. Options (C) and (D) are dimensionally incorrect.

Final Answer : "Work per unit charge"

Answer: (A)

Q23.

Solution

Concept: Ohm's law is a fundamental principle in the study of electric circuits. It states that for many materials (known as ohmic materials), the electric current flowing through them is directly proportional to the voltage applied across them, provided that physical conditions such as temperature remain constant.

Solution: According to Ohm's law, the relationship between voltage (V), current (I), and resistance (R) is expressed as:
Voltage is proportional to Current, or $V \propto I$.
The constant of proportionality is the resistance, R. This gives the mathematical equation:
$V = I \times R$.
This equation can be rearranged to find current ($I = V/R$) or resistance ($R = V/I$), but the form $V = IR$ is the most common statement of the law. The other options, $I = VR$ and $R = VI$, are incorrect rearrangements of the formula.

Final Answer : "$V = IR$"

Answer: (A)

Q24.

Solution

Concept: When resistors are connected in a series circuit, they are connected end-to-end, providing only one path for the current to flow. The total or equivalent resistance (R_{eq}) of resistors in series is the sum of their individual resistances.

Solution: The formula for the equivalent resistance of resistors in series is:
$R_{eq} = R_1 + R_2 + R_3 + \dots$
In this problem, we have two resistors connected in series:
$R_1 = 2\,\Omega$
$R_2 = 4\,\Omega$
We can calculate the equivalent resistance by adding the individual resistances:
$R_{eq} = R_1 + R_2 = 2\,\Omega + 4\,\Omega = 6\,\Omega$.
Therefore, the equivalent resistance of the series circuit is $6\,\Omega$.

Final Answer : "$6\,\Omega$"

Answer: (C)

Q25.

Solution

Concept: Electrical power (P) is the rate at which electrical energy is converted into another form, such as heat, light, or mechanical energy. The fundamental formula for power is the product of voltage (V) and current (I). Other forms can be derived using Ohm's Law ($V = IR$).

Solution: We start with the basic definition of electrical power:
1. $P = V \times I$
This formula is given in option (A).

Now, we can use Ohm's Law ($V = IR$) to derive other forms.
2. Substitute $V = IR$ into the power formula:
$P = (IR) \times I = I^2R$. This matches option (B).
3. Rearrange Ohm's Law to $I = V/R$ and substitute it into the power formula: $P = V \times (V/R) = V^2/R$. This matches option (C).

Since all three expressions, VI, I^2R, and V^2/R, are valid formulas for calculating electrical power, the correct answer is "All of these".

Final Answer : "All of these"

Answer: (D)

Q26.

Solution

Concept: Resistivity (ρ) is an intrinsic property of a material that measures how strongly it resists the flow of electric current. It is different from resistance (R), which is an extrinsic property of an object. The resistance of a uniform conductor is related to its resistivity, length (L), and cross-sectional area (A) by the formula $R = \rho\frac{L}{A}$.

Solution: From the formula $R = \rho\frac{L}{A}$, we can express resistivity as $\rho = R\frac{A}{L}$. This shows that resistance (R) depends on the material's resistivity, length, and area. However, resistivity (ρ) is a fundamental property of the substance itself. It quantifies the material's inherent ability to oppose current flow, independent of its shape or size. For example, copper will always have the same resistivity at a given temperature, whether it's a long, thin wire or a short, thick block. Therefore, resistivity depends on the nature of the material (and also on temperature, which is not an option).

Final Answer : "Material"

Answer: (C)

Q27.

Solution

Concept: The magnetic field (more formally, magnetic flux density or magnetic induction, denoted by B) is a vector field that describes the magnetic influence on moving electric charges, electric currents, and magnetic materials. The strength of this field has a standard unit in the International System of Units (SI).

Solution: The SI unit for magnetic field strength (B) is the Tesla, named after Nikola Tesla. One Tesla (T) is defined as one Newton per Ampere-meter. The other units listed are:
- Ampere (A): SI unit of electric current.
- Volt (V): SI unit of electric potential and electromotive force.
- Newton (N): SI unit of force.

Therefore, the correct SI unit for the magnetic field is the Tesla.

Final Answer : "Tesla"

Answer: (A)

Q28.

Solution

Concept: When an electric current flows through a conductor, it creates a magnetic field around it. There are specific "hand rules" in physics to help determine the direction of this magnetic field relative to the direction of the current.

Solution: The rule used to determine the direction of the magnetic field produced by a current-carrying wire is the Right-Hand Thumb Rule (also known as the Right-Hand Grip Rule).
- **Right-Hand Thumb Rule:** If you point the thumb of your right hand in the direction of the conventional current flow in a conductor, the direction in which your fingers curl represents the direction of the magnetic field lines.
- **Fleming's Left-Hand Rule** is used to find the direction of the force experienced by a current-carrying conductor placed in an external magnetic field.
- **Lenz's Law** and **Faraday's Law** deal with electromagnetic induction (generating a current from a changing magnetic field).

Final Answer : "Right-hand thumb rule"

Answer: (B)

Q29.

Solution

Concept: A solenoid is a coil of wire wound into a tightly packed helix. When current flows through the wire, it creates a magnetic field. A "long solenoid" refers to an ideal case where the length of the solenoid is much greater than its diameter.

Solution: For a long (ideal) solenoid, the magnetic field lines inside are nearly parallel to the axis, straight, and evenly spaced. This indicates that the magnetic field inside the solenoid is strong and highly uniform (constant in both magnitude and direction). The magnitude of the field inside is given by $B = \mu_0 nI$, where μ_0 is the permeability of free space, n is the number of turns per unit length, and I is the current. Outside the solenoid, the magnetic field is very weak, approaching zero for an infinitely long solenoid. Therefore, the field inside is best described as uniform.

Final Answer : "Uniform"

Answer: (B)

Q30.

Solution

Concept: Faraday's Law of Electromagnetic Induction is a fundamental law of electromagnetism that predicts how a changing magnetic field will interact with an electric circuit to produce an electromotive force (emf) — a phenomenon known as electromagnetic induction.

Solution: Faraday's Law states that the magnitude of the induced electromotive force ($\mathcal{E}$) in any closed circuit is equal to the negative of the time rate of change of the magnetic flux (Φ_B) through the circuit.
Mathematically: $\mathcal{E} = -\frac{d\Phi_B}{dt}$.
This means that the induced emf is directly proportional to the *rate of change* of magnetic flux. A constant magnetic flux, no matter how strong, will not induce an emf. It is the change in flux over time that is crucial. Among the given options, "Change in flux" is the key element that the induced emf is proportional to.

Final Answer : "Change in flux"

Answer: (A)

Q31.

Solution

Concept: Electric current can be classified as Direct Current (DC) or Alternating Current (AC). DC is a unidirectional flow of electric charge, while AC is a current that periodically reverses direction.

Solution: Alternating Current (AC) is characterized by its magnitude and direction varying cyclically over time. The most common waveform for AC in power distribution systems is a sine wave. This means the current (or voltage) can be described by a sinusoidal function of time, such as $I(t) = I_{max}\sin(\omega t + \phi)$, where I_{max} is the peak current, ω is the angular frequency, and ϕ is the phase angle. This periodic, smooth variation is described as sinusoidal.
- Linearly: Implies a straight-line graph, which is not AC.
- Constantly: Describes DC, not AC.
- Randomly: Implies no predictable pattern.

Final Answer : "Sinusoidally"

Answer: (B)

Q32.

Solution

Concept: Electromagnetic (EM) waves are synchronized oscillations of electric and magnetic fields that propagate at the speed of light through a vacuum. The electromagnetic spectrum includes all types of EM radiation, from radio waves to gamma rays, with visible light being a small part of this spectrum.

Solution: A cornerstone of James Clerk Maxwell's theory of electromagnetism is the prediction that electromagnetic waves travel through a vacuum at a constant speed, denoted by 'c'. This speed can be calculated from fundamental constants as $c = 1/\sqrt{\mu_0\epsilon_0}$ and is precisely the speed of light. All electromagnetic waves, regardless of their frequency or wavelength (e.g., radio waves, microwaves, X-rays, visible light), travel at this same speed 'c' in a vacuum, which is approximately 3×10^8 meters per second.

Final Answer : "Speed of light"

Answer: (B)

Q33.

Solution

Concept: A convex lens is a converging lens, meaning it bends parallel light rays so that they converge at a focal point. The characteristics of the image formed by a convex lens (real/virtual, erect/inverted, magnified/diminished) depend on the position of the object relative to the focal point (F) and the center of curvature (2F).

Solution: We can determine the image characteristics using ray tracing rules for an object placed beyond 2F (twice the focal length):
1. A ray from the top of the object traveling parallel to the principal axis will refract through the lens and pass through the focal point F on the other side.
2. A ray from the top of the object passing through the optical center of the lens will continue in a straight line without deviation.
The point where these two refracted rays intersect gives the location and nature of the image. When the object is placed beyond 2F, the rays intersect between F and 2F on the opposite side of the lens. The image formed has the following properties:
- **Real:** The rays of light actually converge at the image location.
- **Inverted:** The image is upside down relative to the object.
- **Diminished:** The image is smaller than the object.
Therefore, the correct description is "Real and inverted".

Final Answer : "Real and inverted"

Answer: (B)

Q34.

Solution

Concept: The mirror formula is a fundamental equation in geometric optics that establishes a relationship between the object distance (u), the image distance (v), and the focal length (f) of a spherical mirror (either concave or convex).

Solution: The mirror formula is derived using the principles of reflection and similar triangles from ray diagrams. It is given by the equation:
$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$.
It is crucial to use a consistent sign convention when applying this formula. In the commonly used Cartesian sign convention, distances are measured from the pole of the mirror, and distances in the direction of incident light are positive, while those against it are negative. This formula holds true for both concave and convex mirrors.

Final Answer : "$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$"

Answer: (A)

Q35.

Solution

Concept: Refraction is the phenomenon of a wave changing its direction of propagation when it passes from one medium to another in which its speed is different. This bending of light is governed by a specific physical law.

Solution: The law that governs the refraction of light (or any wave) is Snell's Law.
- **Snell's Law** provides a quantitative relationship between the angle of incidence (θ_1) and the angle of refraction (θ_2) with respect to the refractive indices (n_1 and n_2) of the two media: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$.
- **Ohm's Law** relates to electrical circuits.
- **Newton's Laws** relate to motion, forces, and gravity.
- **Hooke's Law** relates to the force in springs and elastic materials.

Therefore, refraction is governed by Snell's law.

Final Answer : "Snell's law"

Answer: (A)

Q36.

Solution

Concept: Diffraction is a phenomenon observed with waves. It is the apparent bending of waves as they pass around small obstacles or spread out as they pass through small openings (apertures). This effect is a defining characteristic of wave behavior.

Solution: Diffraction cannot be explained by a simple particle model of light (geometric optics), which predicts that light travels in straight lines and would cast sharp shadows. The spreading of light into the "shadow" region when passing through a narrow slit is a clear demonstration that light behaves as a wave. This phenomenon is a fundamental property of all waves, including sound waves, water waves, and electromagnetic waves like light. While quantum mechanics shows that particles like electrons can also exhibit diffraction, this is precisely because they possess wave-like properties (wave-particle duality). The phenomenon of diffraction itself is a direct consequence of the wave nature.

Final Answer : "Wave nature"

Answer: (B)

Q37.

Solution

Concept: The photoelectric effect is the emission of electrons when electromagnetic radiation, such as light, hits a material. The explanation of this effect was a key step in the development of quantum mechanics and demonstrated the wave-particle duality of light.

Solution: Classical wave theory of light could not explain several key features of the photoelectric effect, such as the instantaneous emission of electrons and the existence of a threshold frequency below which no electrons are emitted, regardless of the light's intensity. Albert Einstein explained the effect in 1905 by postulating that light energy is carried in discrete quantized packets called photons. The energy of a single photon is $E = hf$. According to this model, one photon interacts with one electron. If the photon's energy (hf) is greater than the material's work function, the electron is ejected. This model successfully explains why the effect is instantaneous and why there is a threshold frequency. This "particle" description of light was a major departure from the classical wave model and provided strong evidence for the particle nature of light.

Final Answer : "Particle nature"

Answer: (B)

Q38.

Solution

Concept: In 1924, Louis de Broglie proposed the hypothesis of wave-particle duality for matter, suggesting that all particles (like electrons, protons, etc.) exhibit wave-like properties. He associated a wavelength with every particle, known as the de Broglie wavelength.

Solution: The de Broglie wavelength (λ) of a particle is given by the relation:
$\lambda = \frac{h}{p}$,
where 'h' is Planck's constant and 'p' is the momentum of the particle. From this equation, it is evident that the de Broglie wavelength is inversely proportional to the momentum of the particle ($\lambda \propto \frac{1}{p}$). Since momentum is the product of mass (m) and velocity (v), $p = mv$, the wavelength is also inversely proportional to both mass and velocity, but the fundamental relationship is with momentum.

Final Answer : "Momentum"

Answer: (A)

Q39.

Solution

Concept: The Bohr model of the atom, proposed by Niels Bohr in 1913, describes the atom as a central nucleus with electrons orbiting it in specific, quantized energy levels. The radius of these allowed orbits is not arbitrary but is determined by a quantum number.

Solution: According to the Bohr model, the radius of the n-th stationary orbit (r_n) in a hydrogen-like atom is given by the formula:
$r_n = a_0\frac{n^2}{Z}$,
where:
- n is the principal quantum number (n = 1, 2, 3, ...).
- Z is the atomic number of the element.
- a_0 is the Bohr radius, the radius of the first orbit in hydrogen ($a_0 \approx 5.29 \times 10^{-11}$ m).

For a specific atom (where Z is constant), the formula shows that the radius of the orbit is directly proportional to the square of the principal quantum number, n.
$r_n \propto n^2$.

Final Answer : "n^2"

Answer: (A)

Q40.

Solution

Concept: Radioactive decay is the process by which an unstable atomic nucleus loses energy by emitting radiation. The decay of a large number of identical nuclei is a random process, but it can be described statistically by a well-defined mathematical law.

Solution: The law of radioactive decay states that the rate at which nuclei decay is directly proportional to the number of undecayed nuclei (N) present at that instant. This can be written as a differential equation:
$\frac{dN}{dt} = -\lambda N$, where λ is the decay constant.
The solution to this equation gives the number of undecayed nuclei at any time t:
$N(t) = N_0 e^{-\lambda t}$,
where N_0 is the initial number of nuclei at t=0. This equation describes an exponential decay. The number of nuclei decreases exponentially with time, meaning it follows an exponential law.

Final Answer : "Exponential law"

Answer: (B)

Q41.

Solution

Concept: For motion with uniform acceleration, the acceleration is the rate of change of velocity. In a velocity-time graph, the acceleration is represented by the slope (or gradient) of the line. The slope is calculated as the change in the vertical axis (velocity) divided by the change in the horizontal axis (time).

Solution: The graph is a straight line, which indicates uniform acceleration. The initial point on the graph is at $(t_1, v_1) = (0\text{ s}, 0\text{ m/s})$. The final point is at $(t_2, v_2) = (6\text{ s}, 30\text{ m/s})$.
The formula for acceleration (a) is the slope of the v-t graph:
$a = \frac{\text{Change in Velocity}}{\text{Change in Time}} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$.
Substituting the given values:
$a = \frac{30\text{ m/s} - 0\text{ m/s}}{6\text{ s} - 0\text{ s}} = \frac{30}{6}\text{ m/s}^2$.
$a = 5\text{ m/s}^2$.
Thus, the acceleration of the particle is 5 m/s^2.

Final Answer : "5 m/s^2"

Answer: (D)

Q42.

Solution

Concept: When resistors are connected in parallel, the reciprocal of the total or equivalent resistance (R_{eq}) is equal to the sum of the reciprocals of the individual resistances. For two resistors, the formula is:

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

Solution: We are given two resistors connected in parallel:

$R_1 = 4\,\Omega$

$R_2 = 12\,\Omega$

Using the formula for parallel resistors:

$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{12}$.

To add these fractions, we find a common denominator, which is 12.

$\frac{1}{R_{eq}} = \frac{3}{12} + \frac{1}{12} = \frac{3+1}{12} = \frac{4}{12}$.

Simplifying the fraction:

$\frac{1}{R_{eq}} = \frac{1}{3}$.

To find R_{eq}, we take the reciprocal of this result:

$R_{eq} = 3\,\Omega$.

Alternatively, for two resistors in parallel, we can use the product-over-sum formula:

$R_{eq} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{4\times 12}{4+12} = \frac{48}{16} = 3\,\Omega$.

Final Answer : "3 Ω"

Answer: (B)

Q43.

Solution

Concept: A current flowing through a straight conductor creates a magnetic field around it. The magnetic field lines are concentric circles in a plane perpendicular to the conductor. The direction of these magnetic field lines can be determined using a specific rule.

Solution: The direction of the magnetic field around a straight current-carrying conductor is given by the Right-Hand Thumb Rule (or Right-Hand Grip Rule).
- Rule Statement: Imagine holding the conductor in your right hand such that your thumb points in the direction of the conventional current. The direction in which your fingers curl around the conductor gives the direction of the magnetic field lines.
- Fleming's Left-Hand Rule is for finding the direction of the force on a conductor in a magnetic field.
- Lenz's Law determines the direction of an induced current.
- Ampere's Law relates the magnetic field to the current, but the simple directional rule is the Right-Hand Thumb Rule.

Final Answer : "Right-hand thumb rule"

Answer: (B)

Q44.

Solution

Concept: The properties of an image formed by a convex lens depend on the position of the object relative to the lens's focal point (F) and the center of curvature (2F). There are standard cases for image formation that can be determined by ray tracing.

Solution: When an object is placed at 2F on the principal axis of a convex lens, the image is formed at 2F on the other side of the lens. The characteristics of this image are:
1. Real: It is formed by the actual intersection of refracted light rays and can be projected onto a screen. 2. Inverted: The image is upside down compared to the object.
3. Same size: The size of the image is exactly the same as the size of the object. The magnification is -1 (the negative sign indicates inversion).
This specific case is important in applications like photocopiers and telescopes that use relay lenses.

Final Answer : "Real, inverted, same size"

Answer: (A)

Q45.

Solution

Concept: The fundamental wave equation relates the speed of a wave (v), its frequency (f), and its wavelength (λ). The speed of a wave is the product of its frequency and its wavelength.

Solution: The relationship between wave speed, frequency, and wavelength is given by the formula:
$v = f \times \lambda$.
The question asks to find the frequency (f) of the wave, given its speed (v) and wavelength (λ). To do this, we need to rearrange the wave equation to solve for f.
Dividing both sides of the equation by λ:
$f = \frac{v}{\lambda}$.
Therefore, the frequency is equal to the wave speed divided by the wavelength.

Final Answer : "v/λ"

Answer: (A)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	B	3	B	4	B	5	B
6	B	7	A	8	B	9	B	10	C
11	C	12	B	13	C	14	B	15	A
16	A	17	A	18	B	19	C	20	C
21	A	22	A	23	A	24	C	25	D
26	C	27	A	28	B	29	B	30	A
31	B	32	B	33	B	34	A	35	A
36	B	37	B	38	A	39	A	40	B
41	D	42	B	43	B	44	A	45	A