

WBJEE Physics Sample Paper-8

Duration: 60 Minutes

Maximum Marks: 50

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Categories**.
- **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. The dimensional formula of angular momentum is:

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

Q2. A particle starts from rest with constant acceleration 4 m/s^2 . The distance travelled in 5 s is:

- (A) 25 m
- (B) 50 m



- (C) 75 m
- (D) 100 m

Q3. A force of 20 N acts on a body of mass 5 kg. The acceleration produced is:

- (A) 2 m/s^2
- (B) 4 m/s^2
- (C) 5 m/s^2
- (D) 10 m/s^2

Q4. The coefficient of static friction between two surfaces is 0.5. The angle of friction is:

- (A) 26.5°
- (B) 30°
- (C) 45°
- (D) 60°

Q5. The kinetic energy of a particle becomes nine times its initial value. The momentum becomes:

- (A) 3 times
- (B) 6 times
- (C) 9 times
- (D) 12 times

Q6. A body moves in a circle of radius 2 m with speed 4 m/s. Its centripetal acceleration is:

- (A) 2 m/s^2
- (B) 4 m/s^2
- (C) 8 m/s^2
- (D) 16 m/s^2



Q7. The acceleration due to gravity on the Moon is nearly:

- (A) $\frac{g}{2}$
- (B) $\frac{g}{4}$
- (C) $\frac{g}{6}$
- (D) $\frac{g}{8}$

Q8. The time period of a simple pendulum on Earth is 2 s. Its frequency is:

- (A) 0.25 Hz
- (B) 0.5 Hz
- (C) 1 Hz
- (D) 2 Hz

Q9. The speed of sound in air increases with:

- (A) Pressure
- (B) Humidity
- (C) Decrease in temperature
- (D) Density only

Q10. According to Bernoulli's principle, pressure in a fluid decreases when:

- (A) Velocity decreases
- (B) Velocity increases
- (C) Density decreases
- (D) Height decreases

Q11. For an ideal gas, internal energy depends only on:

- (A) Pressure
- (B) Volume



- (C) Temperature
- (D) Density

Q12. Black bodies are good absorbers and emitters of:

- (A) Heat radiation
- (B) Sound waves
- (C) Electric current
- (D) Magnetic field

Q13. The refractive index of a medium is 1.5. Speed of light in the medium is:

- (A) 2×10^8 m/s
- (B) 3×10^8 m/s
- (C) 1.5×10^8 m/s
- (D) 4.5×10^8 m/s

Q14. An object is placed at the centre of curvature of a concave mirror. The image formed is:

- (A) Virtual and erect
- (B) Real and inverted
- (C) Real and magnified
- (D) Virtual and diminished

Q15. In Young's double slit experiment, fringe width is directly proportional to:

- (A) Slit separation
- (B) Wavelength
- (C) Reciprocal of wavelength
- (D) Reciprocal of screen distance



Q16. The SI unit of electric field is:

- (A) N/C
- (B) C/N
- (C) Volt
- (D) Joule

Q17. Two capacitors of equal capacitance connected in parallel have equivalent capacitance:

- (A) Half
- (B) Same
- (C) Double
- (D) Four times

Q18. The SI unit of resistivity is:

- (A) Ω
- (B) Ωm
- (C) Ω/m
- (D) Ωm^2

Q19. The magnetic force on a moving charge is maximum when the angle between velocity and magnetic field is:

- (A) 0°
- (B) 30°
- (C) 60°
- (D) 90°

Q20. The SI unit of magnetic flux is:

- (A) Tesla



- (B) Weber
- (C) Henry
- (D) Ampere

Q21. According to Lenz's law, induced emf always opposes the:

- (A) Current
- (B) Cause producing it
- (C) Resistance
- (D) Magnetic field only

Q22. The average value of alternating current over one complete cycle is:

- (A) Maximum
- (B) Minimum
- (C) Zero
- (D) Infinite

Q23. Electromagnetic waves are:

- (A) Longitudinal
- (B) Transverse
- (C) Mechanical
- (D) Stationary

Q24. Einstein's photoelectric equation is based on conservation of:

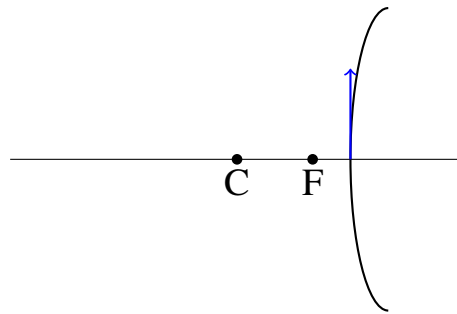
- (A) Momentum
- (B) Angular momentum
- (C) Energy
- (D) Charge



- Q25.** The angular momentum of an electron in Bohr orbit is quantized in units of:
- (A) h
 - (B) $\frac{h}{2\pi}$
 - (C) $\frac{h}{4\pi}$
 - (D) $2\pi h$
- Q26.** In β -decay, the emitted particle is:
- (A) Helium nucleus
 - (B) Electron
 - (C) Proton
 - (D) Neutron
- Q27.** The forbidden energy gap in conductors is:
- (A) Large
 - (B) Small
 - (C) Zero
 - (D) Infinite
- Q28.** Modulation is required in communication systems to:
- (A) Reduce noise
 - (B) Increase antenna height
 - (C) Enable long distance transmission
 - (D) Increase frequency of signal

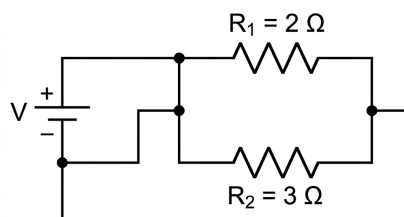


Q29. The following diagram shows a concave mirror. The image formed for an object between focus and pole is:



- (A) Real and inverted
- (B) Virtual and erect
- (C) Real and diminished
- (D) Virtual and diminished

Q30. In the following circuit, the equivalent resistance is:



- (A) 1.2Ω
- (B) 2Ω
- (C) 5Ω
- (D) 6Ω

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

Q31. The phase difference between displacement and acceleration in SHM is:

- (A) 0
- (B) $\pi/2$



- (C) π
- (D) 2π

Q32. Young's modulus is the ratio of:

- (A) Stress to strain
- (B) Strain to stress
- (C) Force to area
- (D) Pressure to volume

Q33. The potential energy of a satellite in circular orbit is:

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

Q34. The de Broglie wavelength associated with a particle depends on:

- (A) Mass only
- (B) Velocity only
- (C) Momentum
- (D) Charge

Q35. A soft iron core is used in transformers because it has:

- (A) High retentivity
- (B) Low permeability
- (C) High permeability
- (D) Large coercivity



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

- Q36.** Which of the following quantities are vectors?
- (A) Velocity
 - (B) Work
 - (C) Momentum
 - (D) Torque
- Q37.** Which of the following statements regarding SHM are correct?
- (A) Velocity is maximum at mean position
 - (B) Acceleration is zero at extreme position
 - (C) Total energy remains constant
 - (D) Potential energy is maximum at extreme position
- Q38.** Which of the following electromagnetic waves can travel through vacuum?
- (A) X-rays
 - (B) Radio waves
 - (C) Sound waves
 - (D) Microwaves
- Q39.** Which of the following statements regarding photoelectric effect are correct?
- (A) Threshold frequency exists
 - (B) Emission depends on frequency
 - (C) Emission is instantaneous
 - (D) Intensity affects stopping potential



- Q40.** Which of the following statements regarding a p-n junction diode are correct?
- (A) Forward bias decreases depletion layer
 - (B) Reverse bias increases depletion layer
 - (C) Current flows easily in reverse bias
 - (D) A diode can act as a rectifier



Detailed Solutions

Q1.

Solution

Concept: Angular momentum is a vector quantity that represents the product of a body's linear momentum and its perpendicular distance from the axis of rotation. It is a fundamental concept in rotational dynamics, analogous to linear momentum in linear dynamics.

Solution: Step 1: Recall the definition of linear momentum.

Linear momentum (p) is given by the product of mass (m) and velocity (v):

$$p = mv$$

The dimensional formula for linear momentum is $[MLT^{-1}]$.

Step 2: Recall the definition of angular momentum.

Angular momentum (L) is given by the product of linear momentum (p) and the perpendicular distance (r) from the axis of rotation:

$$L = r \times p$$

Or, in terms of mass, velocity, and radius:

$$L = mvr$$

Step 3: Determine the dimensions of each component.

The dimensions of mass (m) are $[M]$.

The dimensions of velocity (v) are $[LT^{-1}]$.

The dimensions of radius (r), which is a distance, are $[L]$.

Step 4: Combine the dimensions to find the dimensional formula for angular momentum.

$$[L] = [m] \times [v] \times [r]$$

$$[L] = [M] \times [LT^{-1}] \times [L]$$

$$[L] = [ML^2T^{-1}]$$

Step 5: Compare with the given options.

The dimensional formula for angular momentum is $[ML^2T^{-1}]$.

Options B, C, and D are incorrect as they do not match the derived dimensional formula. Option B represents linear momentum. Option C represents energy or work. Option D is missing the mass dimension.

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

Answer: (A)

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Q2.

Solution

Concept: This problem involves the kinematics of a particle moving with constant acceleration. We can use the standard equations of motion to find the distance travelled.

Solution: Step 1: Identify the given information.

Initial velocity (u) = 0 m/s (since the particle starts from rest).

Constant acceleration (a) = 4 m/s².

Time (t) = 5 s.

Step 2: Choose the appropriate equation of motion.

The equation of motion that relates initial velocity, acceleration, time, and distance is:

$$s = ut + \frac{1}{2}at^2$$

where s is the distance travelled.

Step 3: Substitute the given values into the equation.

$$s = (0 \text{ m/s})(5 \text{ s}) + \frac{1}{2}(4 \text{ m/s}^2)(5 \text{ s})^2$$

Step 4: Calculate the distance.

$$s = 0 + \frac{1}{2}(4 \text{ m/s}^2)(25 \text{ s}^2)$$

$$s = \frac{1}{2}(100 \text{ m})$$

$$s = 50 \text{ m}$$

Step 5: Compare with the given options.

The distance travelled is 50 m.

Options A, C, and D are incorrect.

Final Answer:

Answer: (B)

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Q3.

Solution

Concept: This problem is based on Newton's second law of motion, which relates force, mass, and acceleration.

Solution: Step 1: State Newton's second law of motion.

Newton's second law states that the acceleration (a) of an object is directly proportional to the net force (F) acting on it and inversely proportional to its mass (m). Mathematically, this is expressed as:

$$F = ma$$

Step 2: Identify the given values.

$$\text{Force } (F) = 20 \text{ N.}$$

$$\text{Mass } (m) = 5 \text{ kg.}$$

Step 3: Rearrange the formula to solve for acceleration.

$$a = \frac{F}{m}$$

Step 4: Substitute the given values into the rearranged formula.

$$a = \frac{20 \text{ N}}{5 \text{ kg}}$$

Step 5: Calculate the acceleration.

$$a = 4 \text{ m/s}^2$$

Step 6: Compare with the given options.

The acceleration produced is 4 m/s^2 .

Options A, C, and D are incorrect.

Final Answer: 4 m/s^2

Answer: (B)

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Q4.

Solution

Concept: The angle of friction is the angle that the resultant of the force of static friction and the normal force makes with the normal force, when the body is just about to slide. It is related to the coefficient of static friction.

Solution: Step 1: Recall the relationship between the coefficient of static friction (μ_s) and the angle of friction (λ).

The angle of friction is defined by the tangent of the angle. When a body is on an inclined plane and just about to slide, the component of gravity parallel to the plane is balanced by the maximum static friction.

$$mg \sin \theta = \mu_s mg \cos \theta$$

$$\tan \theta = \mu_s$$

Here, θ is the angle of friction.

Step 2: Identify the given value.

The coefficient of static friction (μ_s) = 0.5.

Step 3: Calculate the angle of friction.

$$\tan \lambda = \mu_s$$

$$\tan \lambda = 0.5$$

Step 4: Find the angle whose tangent is 0.5.

$$\lambda = \arctan(0.5)$$

Step 5: Calculate the value of the angle.

Using a calculator, $\arctan(0.5) \approx 26.565^\circ$.

Step 6: Compare with the given options.

The closest option is 26.5° .

Options B, C, and D are incorrect.

Final Answer:

Answer: (A)

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Q5.

Solution

Concept: This problem involves the relationship between kinetic energy and momentum. We will use their definitions and derived relationship to solve it.

Solution: Step 1: Define kinetic energy and momentum.

Kinetic energy (K) is given by $K = \frac{1}{2}mv^2$.

Momentum (p) is given by $p = mv$.

Step 2: Express kinetic energy in terms of momentum.

From the momentum formula, $v = \frac{p}{m}$. Substituting this into the kinetic energy formula:

$$K = \frac{1}{2}m \left(\frac{p}{m}\right)^2 = \frac{1}{2}m \frac{p^2}{m^2} = \frac{p^2}{2m}.$$

$$\text{So, } K = \frac{p^2}{2m}.$$

Step 3: Analyze the given information.

The kinetic energy becomes nine times its initial value. Let K_i and p_i be the initial kinetic energy and momentum, and K_f and p_f be the final values.

$$K_f = 9K_i.$$

Step 4: Apply the relationship from Step 2 to both initial and final states.

$$K_i = \frac{p_i^2}{2m} \text{ and } K_f = \frac{p_f^2}{2m}.$$

Step 5: Substitute these into the given condition $K_f = 9K_i$.

$$\frac{p_f^2}{2m} = 9 \left(\frac{p_i^2}{2m}\right).$$

Step 6: Simplify and solve for p_f .

Canceling $\frac{1}{2m}$ from both sides gives $p_f^2 = 9p_i^2$.

Taking the square root, $p_f = 3p_i$.

Step 7: Conclusion.

The momentum becomes 3 times its initial value.

Final Answer: 3 times

Answer: (A)

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Q6.

Solution

Concept: This problem involves uniform circular motion. The centripetal acceleration is the acceleration required to keep an object moving in a circular path.

Solution: Step 1: Recall the formula for centripetal acceleration.

The centripetal acceleration (a_c) of an object moving in a circle of radius (r) with speed (v) is given by:

$$a_c = \frac{v^2}{r}$$

Step 2: Identify the given values.

Radius (r) = 2 m.

Speed (v) = 4 m/s.

Step 3: Substitute the given values into the formula.

$$a_c = \frac{(4 \text{ m/s})^2}{2 \text{ m}}$$

Step 4: Calculate the centripetal acceleration.

$$a_c = \frac{16 \text{ m}^2/\text{s}^2}{2 \text{ m}}$$

$$a_c = 8 \text{ m/s}^2$$

Step 5: Compare with the given options.

The centripetal acceleration is 8 m/s^2 .

Options A, B, and D are incorrect.

Final Answer: 8 m/s^2

Answer: (C)

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Q7.

Solution

Concept: The acceleration due to gravity (g) on the surface of a celestial body is directly proportional to its mass (M) and inversely proportional to the square of its radius (R), according to the formula $g = \frac{GM}{R^2}$. We compare the Moon's gravity to Earth's by considering their respective masses and radii.

Solution: Step 1: Recall the formula for acceleration due to gravity.

The acceleration due to gravity on the surface of any celestial body is given by $g = \frac{GM}{R^2}$, where G is the gravitational constant, M is the mass of the body, and R is its radius.

Step 2: Consider the relative properties of the Moon and Earth.

We know that the mass of the Moon (M_M) is approximately $\frac{1}{81}$ times the mass of the Earth (M_E), and the radius of the Moon (R_M) is approximately $\frac{1}{4}$ times the radius of the Earth (R_E).

So, $M_M = \frac{M_E}{81}$ and $R_M = \frac{R_E}{4}$.

Step 3: Write the expression for acceleration due to gravity on Earth (g_E) and the Moon (g_M).

For Earth: $g_E = \frac{GM_E}{R_E^2}$.

For the Moon: $g_M = \frac{GM_M}{R_M^2}$.

Step 4: Substitute the relative properties of the Moon into the formula for g_M .

$$g_M = \frac{G\left(\frac{M_E}{81}\right)}{\left(\frac{R_E}{4}\right)^2}$$

Step 5: Simplify the expression.

$$g_M = \frac{G \cdot \frac{M_E}{81}}{\frac{R_E^2}{16}} = \frac{GM_E}{R_E^2} \cdot \frac{16}{81}$$

Step 6: Relate g_M to g_E .

Since $g_E = \frac{GM_E}{R_E^2}$, we can substitute this into the expression for g_M :

$$g_M = g_E \cdot \frac{16}{81}$$

Step 7: Approximate the value and compare with options.

$\frac{16}{81} \approx 0.1975$. So, $g_M \approx 0.1975g_E$.

This value is closest to $\frac{1}{6}g_E \approx 0.167g_E$. The commonly accepted approximation for the Moon's gravity is indeed about one-sixth of Earth's gravity.

Step 8: Choose the closest option.

The option $\frac{g}{6}$ is the closest to our calculated value and aligns with the known approximation.

Final Answer: $\frac{g}{6}$

Answer: (C)

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Q8.

Solution

Concept: The frequency of a periodic motion is the number of cycles or oscillations per unit time, and it is the reciprocal of the time period.

Solution: Step 1: Identify the given information.

Time period (T) of the simple pendulum on Earth = 2 s.

Step 2: Recall the relationship between frequency (f) and time period (T).

Frequency is the reciprocal of the time period:

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

Step 3: Substitute the given time period into the formula.

$$f = \frac{1}{2\text{ s}}$$

Step 4: Calculate the frequency.

$$f = 0.5\text{ s}^{-1}$$

The unit s^{-1} is also known as Hertz (Hz).

$$f = 0.5\text{ Hz}$$

Step 5: Compare with the given options.

The frequency is 0.5 Hz.

Options A, C, and D are incorrect.

Final Answer:

Answer: (B)

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Q9.

Solution

Concept: The speed of sound in a gas depends on temperature and composition.

Solution: Step 1: The speed of sound in an ideal gas is $v = \sqrt{\frac{\gamma RT}{M}}$.

- Speed increases with temperature (T).
- Speed increases with humidity because moist air has a lower average molar mass (M) than dry air.

Step 2: Evaluate options.

- Pressure: At constant temperature, pressure increase also increases density, so speed is largely unaffected.
- Humidity: Increases speed.
- Decrease in temperature: Decreases speed.
- Density only: Not a complete factor.

Step 3: Select the option that increases speed.

Humidity increases the speed of sound.

Final Answer: *Humidity*

Answer: (B)

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Q10.

Solution

Concept: Bernoulli's principle states that for an incompressible and non-viscous fluid flowing steadily, the total mechanical energy per unit volume remains constant. Thus, an increase in the speed of the fluid results in a decrease in pressure.

Solution: Step 1: Write Bernoulli's equation for horizontal flow. For a fluid flowing horizontally,

$$P + \frac{1}{2}\rho v^2 = \text{constant}$$

where:

- P = pressure of the fluid
- ρ = density of the fluid
- v = speed of the fluid

Step 2: Analyze the relation between pressure and velocity. From the equation,

$$P + \frac{1}{2}\rho v^2 = \text{constant}$$

If the velocity v increases, the kinetic energy term

$$\frac{1}{2}\rho v^2$$

increases. To keep the total value constant, pressure P must decrease.

Step 3: Conclusion. Hence, pressure decreases when the velocity of the fluid increases.

Final Answer:

Answer: (B)

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Q11.

Solution

Concept: For an ideal gas, intermolecular forces are neglected. Therefore, the internal energy of the gas is due only to the kinetic energy of its molecules, which depends on absolute temperature.

Solution: Step 1: Understand internal energy of an ideal gas.

The internal energy of an ideal gas is the sum of kinetic energies of all its molecules.

Since ideal gas molecules do not exert intermolecular forces on each other, there is no potential energy contribution.

Step 2: Relation with temperature.

The average kinetic energy of gas molecules is directly proportional to absolute temperature:

$$KE \propto T$$

Therefore, internal energy also depends only on temperature.

Step 3: Conclusion.

Thus, changing pressure or volume alone does not directly change the internal energy unless temperature changes.

Final Answer:

Answer: (C)

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Q12.

Solution

Concept: A black body is an idealized physical body that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. It is also a perfect emitter of thermal radiation.

Solution: Step 1: Define a black body. A black body is a theoretical object that absorbs 100% of incident electromagnetic radiation. This absorption is not selective of frequency or angle.

Step 2: Understand the property of emission for a black body.

Kirchhoff's law of thermal radiation states that for an object in thermal equilibrium with its surroundings, the emissivity of the object is equal to its absorptivity. Since a black body has an absorptivity of 1 (it absorbs all incident radiation), its emissivity must also be 1.

Step 3: Relate emissivity to thermal radiation.

Emissivity is a measure of an object's ability to radiate energy. A perfect emitter (emissivity = 1) radiates thermal energy efficiently. The radiation emitted by a black body is called black-body radiation.

Step 4: Consider the types of radiation mentioned in the options.

- Heat radiation: This is electromagnetic radiation emitted by all objects at a temperature above absolute zero, carrying thermal energy. This is precisely what a black body is a perfect emitter of.
- Sound waves: These are mechanical waves and are not related to thermal radiation or the properties of a black body.
- Electric current: This is the flow of electric charge.
- Magnetic field: This is a field of force produced by moving electric charges.

Step 5: Conclude based on the definition.

Since a black body is a perfect emitter of thermal radiation, it is a good emitter of heat radiation. It is also a good absorber of heat radiation.

Step 6: Choose the correct option.

Black bodies are good absorbers and emitters of heat radiation.

Options B, C, and D are incorrect as they are not related to the electromagnetic radiation emitted or absorbed by a black body.

Final Answer: *Heat radiation*

Answer: (A)

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Q13.

Solution

Concept: The refractive index of a medium (n) is defined as the ratio of the speed of light in vacuum (c) to the speed of light in the medium (v). This relationship is given by $n = \frac{c}{v}$.

Solution: Step 1: State the definition of refractive index.

The refractive index (n) of a medium is given by:

$$n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in the medium}}$$

$$n = \frac{c}{v}$$

Step 2: Identify the given values.

Refractive index of the medium (n) = 1.5.

Speed of light in vacuum (c) is approximately 3×10^8 m/s.

Step 3: Rearrange the formula to solve for the speed of light in the medium (v).

$$v = \frac{c}{n}$$

Step 4: Substitute the given values into the formula.

$$v = \frac{3 \times 10^8 \text{ m/s}}{1.5}$$

Step 5: Calculate the speed of light in the medium.

$$v = \frac{3}{1.5} \times 10^8 \text{ m/s}$$

$$v = 2 \times 10^8 \text{ m/s}$$

Step 6: Compare with the given options.

The speed of light in the medium is 2×10^8 m/s.

Options B, C, and D are incorrect.

Final Answer: 2×10^8 m/s

Answer: (A)

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Q14.

Solution

Concept: This question concerns the image formation by a concave mirror. We need to determine the nature, position, and size of the image when the object is placed at the center of curvature.

Solution: Step 1: Recall the properties of a concave mirror.

A concave mirror is a converging mirror. The principal focus (F) is halfway between the pole (P) and the center of curvature (C).

Step 2: Consider the ray diagrams for object placement at the center of curvature (C).

When an object is placed at the center of curvature (C) of a concave mirror:

- A ray from the object parallel to the principal axis passes through the principal focus (F) after reflection.
- A ray passing through the principal focus (F) becomes parallel to the principal axis after reflection.
- A ray directed towards the pole (P) is reflected back along the same path.
- A ray passing through the center of curvature (C) strikes the mirror normally and is reflected back along the same path.

Step 3: Analyze the image formed when the object is at C .

If an object is placed at C , the rays originating from a point on the object at C and incident on the mirror will converge at C after reflection. This means the image is also formed at the center of curvature (C).

Step 4: Determine the nature of the image.

- Position: The image is formed at the center of curvature (C).
- Size: For an object at C , the image is of the same size as the object. The magnification (m) is -1 .
- Nature: Rays from the object actually converge at the image location, so the image is real. Since the image is formed by rays converging after reflection, it is also inverted.

Step 5: Evaluate the given options.

- Virtual and erect: Incorrect, the image is real.
- Real and inverted: Correct, the image is formed at C , is real, and is inverted (magnification is -1).
- Real and magnified: Incorrect, the image is of the same size as the object.
- Virtual and diminished: Incorrect, the image is real and of the same size.

Final Answer: *Real and inverted*

Answer: (B)

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Q15.

Solution

Concept: This question relates to Young's double-slit experiment, which demonstrates the wave nature of light through interference. The fringe width is a key parameter in this experiment.

Solution: Step 1: Recall the formula for fringe width in Young's double-slit experiment.

The fringe width (β) in Young's double-slit experiment is given by:

$$\beta = \frac{\lambda D}{d}$$

where:

λ is the wavelength of the light.

D is the distance between the slits and the screen.

d is the separation between the two slits.

Step 2: Analyze the proportionality of fringe width with other parameters.

From the formula, we can see that:

- Fringe width (β) is directly proportional to the wavelength (λ).
- Fringe width (β) is directly proportional to the screen distance (D).
- Fringe width (β) is inversely proportional to the slit separation (d).

Step 3: Examine the given options in relation to these proportionalities.

- Slit separation: Fringe width is inversely proportional to slit separation, not directly proportional.
- Wavelength: Fringe width is directly proportional to wavelength.
- Reciprocal of wavelength: Fringe width is directly proportional to wavelength, not its reciprocal.
- Reciprocal of screen distance: Fringe width is directly proportional to screen distance, not its reciprocal.

Step 4: Select the correct option.

The fringe width is directly proportional to the wavelength of light.

Options A, C, and D are incorrect.

Final Answer: *Wavelength*

Answer: (B)

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Q16.

Solution

Concept: The electric field is a vector field surrounding an electric charge that exerts a force on other charges. Its strength is measured in terms of the force it exerts per unit charge.

Solution: Step 1: Recall the definition of the electric field.

The electric field (E) at a point is defined as the force (F) experienced by a unit positive test charge (q_0) placed at that point:

$$E = \frac{F}{q_0}$$

Step 2: Determine the units of force and charge.

The SI unit of force is the Newton (N).

The SI unit of charge is the Coulomb (C).

Step 3: Combine the units to find the SI unit of the electric field.

Based on the definition $E = \frac{F}{q_0}$, the SI unit of electric field is:

$$\frac{\text{Newton}}{\text{Coulomb}} = \text{N/C}$$

Step 4: Consider other possible units or related concepts.

The electric potential (V) is defined as the work done per unit charge, $V = \frac{W}{q_0}$.

The unit of electric potential is the Volt (V).

Since Work = Force \times Distance, $W = F \times d$.

$$\text{So, } V = \frac{F \times d}{q_0}$$

Rearranging this, we can see that $F/q_0 = V/d$.

Therefore, the electric field can also be expressed in units of Volts per meter (V/m). Note that 1 N/C is equivalent to 1 V/m.

Step 5: Evaluate the given options.

- N/C: This is a correct SI unit for electric field.
- C/N: This is the reciprocal of N/C and is not the unit for electric field.
- Volt: This is the unit of electric potential, not electric field.
- Joule: This is the unit of energy or work.

Step 6: Select the SI unit for electric field among the options.

The SI unit of electric field is N/C.

Final Answer: N/C

Answer: (A)

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Q17.

Solution

Concept: This problem concerns the equivalent capacitance of capacitors connected in parallel.

Solution: Step 1: Recall the formula for the equivalent capacitance of capacitors connected in parallel.

When capacitors are connected in parallel, the equivalent capacitance (C_{eq}) is the sum of the individual capacitances. If there are n capacitors with capacitances C_1, C_2, \dots, C_n , the equivalent capacitance is:

$$C_{eq} = C_1 + C_2 + \dots + C_n$$

Step 2: Apply the formula to the case of two capacitors of equal capacitance.

Let the capacitance of each of the two capacitors be C . So, $C_1 = C$ and $C_2 = C$.

The equivalent capacitance (C_{eq}) is:

$$C_{eq} = C_1 + C_2$$

$$C_{eq} = C + C$$

$$C_{eq} = 2C$$

Step 3: Compare the equivalent capacitance with the individual capacitance.

The equivalent capacitance ($2C$) is twice the capacitance of a single capacitor (C).

Step 4: Relate this to the options provided.

The equivalent capacitance is "Double" the capacitance of one of the capacitors.

Options A, B, and D are incorrect.

Final Answer: *Double*

Answer: (C)

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Q18.

Solution

Concept: Resistivity (or specific resistance) is an intrinsic property of a material that quantifies how strongly it resists electric current. It is related to the resistance of a conductor by the formula $R = \rho \frac{L}{A}$.

Solution: Step 1: Recall the formula relating resistance, resistivity, length, and area.

The resistance (R) of a conductor is given by:

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

where:

R is the resistance.

ρ (rho) is the resistivity of the material.

L is the length of the conductor.

A is the cross-sectional area of the conductor.

Step 2: Rearrange the formula to solve for resistivity (ρ).

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

Step 3: Determine the SI units of each quantity in the rearranged formula.

The SI unit of resistance (R) is Ohm (Ω).

The SI unit of area (A) is square meters (m^2).

The SI unit of length (L) is meters (m).

Step 4: Substitute these units into the formula for resistivity.

$$\text{Unit of } \rho = (\text{Unit of } R) \times \frac{\text{Unit of } A}{\text{Unit of } L}$$

$$\text{Unit of } \rho = \Omega \times \frac{\text{m}^2}{\text{m}}$$

$$\text{Unit of } \rho = \Omega \times \text{m}$$

$$\text{Unit of } \rho = \Omega\text{m}$$

Step 5: Compare with the given options.

The SI unit of resistivity is Ωm .

Options A, C, and D are incorrect.

Final Answer: Ωm

Answer: (B)

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Q19.

Solution

Concept: The magnetic force on a moving charge is described by the Lorentz force law. The magnitude of this force depends on the charge, its velocity, the magnetic field strength, and the angle between the velocity and the magnetic field.

Solution: Step 1: State the formula for the magnetic force on a moving charge.

The magnetic force (F_m) on a charge (q) moving with velocity (v) in a magnetic field (B) is given by the vector cross product:

$$\vec{F}_m = q(\vec{v} \times \vec{B})$$

Step 2: Write the magnitude of the magnetic force.

The magnitude of the force is given by:

$$F_m = |q|vB \sin \theta$$

where θ is the angle between the velocity vector (\vec{v}) and the magnetic field vector (\vec{B}).

Step 3: Determine when the force is maximum.

The sine function ($\sin \theta$) has a maximum value of 1. This occurs when $\theta = 90^\circ$.

Therefore, the magnetic force is maximum when $\sin \theta = 1$.

Step 4: Calculate the maximum force.

$$F_{m,\max} = |q|vB(1) = |q|vB$$

Step 5: Determine when the force is zero (minimum).

The sine function has a minimum value of 0 when $\theta = 0^\circ$ or $\theta = 180^\circ$. In these cases, the force is zero.

Step 6: Evaluate the given options for the maximum force condition.

The magnetic force is maximum when the angle θ is 90° .

Options A (0°), B (30°), and C (60°) result in a force less than the maximum.

Final Answer:

Answer: (D)

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Q20.

Solution

Concept: Magnetic flux is a measure of the total magnetic field passing through a given area. It is a fundamental quantity in electromagnetic induction.

Solution: Step 1: Recall the definition of magnetic flux.

Magnetic flux (Φ_B) through a surface is given by the integral of the magnetic field (\vec{B}) over the area (A) of the surface:

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

For a uniform magnetic field perpendicular to a flat surface, it simplifies to:

$$\Phi_B = BA$$

Step 2: Determine the SI units of magnetic field and area.

The SI unit of magnetic field strength (B) is the Tesla (T).

The SI unit of area (A) is square meters (m^2).

Step 3: Combine the units to find the SI unit of magnetic flux.

$$\text{Unit of } \Phi_B = (\text{Unit of } B) \times (\text{Unit of } A)$$

$$\text{Unit of } \Phi_B = \text{Tesla} \times m^2$$

$$\text{Unit of } \Phi_B = T m^2$$

Step 4: Recall the SI unit for magnetic flux.

The SI unit of magnetic flux is the Weber (Wb).

It is defined such that 1 Weber is the magnetic flux through a surface of area $1 m^2$ when the magnetic field is uniform and perpendicular to the surface with a strength of 1 Tesla.

$$\text{So, } 1 \text{ Wb} = 1 T m^2.$$

Step 5: Evaluate the given options.

- Tesla: Unit of magnetic field strength.
- Weber: Correct SI unit of magnetic flux.
- Henry: Unit of inductance.
- Ampere: Unit of electric current.

Step 6: Select the correct SI unit for magnetic flux.

Final Answer: Weber

Answer: (B)

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Q21.

Solution

Concept: Lenz's law describes the direction of the induced electromotive force (emf) and the resulting induced current in a conductor experiencing a change in magnetic flux. It is a consequence of the conservation of energy.

Solution: Step 1: State Lenz's law.

Lenz's law states that the direction of the induced current in a conductor is such that it creates a magnetic field that opposes the change in magnetic flux that produced it.

Step 2: Understand what "opposes the change" means.

The induced current will flow in a direction that attempts to counteract the original disturbance. For example, if the magnetic flux is increasing, the induced current will create a magnetic field in the opposite direction to try and reduce the flux. If the magnetic flux is decreasing, the induced current will create a magnetic field in the same direction to try and maintain the flux.

Step 3: Relate this to the cause of the induced emf.

The change in magnetic flux is the "cause" that produces the induced emf. Lenz's law essentially states that the induced emf (and the resulting current) will act in a direction that opposes this cause.

Step 4: Consider the options.

- Current: The induced emf opposes the change in flux, not the current itself directly. The current is a consequence of the emf.
- Cause producing it: This aligns with the statement of Lenz's law. The cause is the change in magnetic flux.
- Resistance: Resistance affects the magnitude of the induced current, but not the direction dictated by Lenz's law.
- Magnetic field only: The induced emf opposes the change in magnetic flux, which involves the magnetic field, but it's more precise to say it opposes the cause of that change.

Step 5: Choose the most accurate description.

Lenz's law states that the induced emf opposes the cause producing it, which is the change in magnetic flux.

Final Answer: *Cause producing it*

Answer: (B)

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Q22.

Solution

Concept: Alternating current (AC) is a type of electric current where the direction of charge flow reverses periodically. The average value of such a current over a full cycle is zero.

Solution: Step 1: Understand alternating current (AC).

An alternating current can be represented by a sinusoidal function, such as $I(t) = I_m \sin(\omega t + \phi)$, where I_m is the peak current, ω is the angular frequency, and ϕ is the phase angle.

Step 2: Define the average value of a function over an interval.

The average value of a function $f(t)$ over an interval $[a, b]$ is given by $\frac{1}{b-a} \int_a^b f(t) dt$.

Step 3: Calculate the average value of AC over one complete cycle.

Let the time period of one complete cycle be T . The average current (I_{avg}) over one complete cycle (from $t = 0$ to $t = T$) is:

$$I_{avg} = \frac{1}{T} \int_0^T I_m \sin(\omega t + \phi) dt$$

Step 4: Evaluate the integral.

The integral of a sinusoidal function over a complete period is zero.

$$\int_0^T \sin(\omega t + \phi) dt = 0$$

This is because the positive and negative halves of the sine wave cancel each other out.

Step 5: Calculate the average current.

$$I_{avg} = \frac{1}{T} \times 0 = 0$$

Step 6: Consider the meaning of the result.

The average value of an alternating current over one complete cycle is zero because the current flows in one direction for half the cycle and in the opposite direction for the other half, with equal magnitudes over each half-cycle (assuming a symmetrical waveform like a sine wave).

Step 7: Evaluate the options.

- Maximum: The average value is not the maximum value.
- Minimum: The average value is not the minimum value.
- Zero: This is the calculated average value.
- Infinite: The average value is finite.

Final Answer: Zero

Answer: (C)

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Q23.

Solution

Concept: Electromagnetic waves are a fundamental part of physics, encompassing light, radio waves, X-rays, etc. Their nature (longitudinal or transverse) is a key characteristic.

Solution: Step 1: Understand the nature of electromagnetic waves.

Electromagnetic waves are produced by oscillating electric charges. They consist of oscillating electric and magnetic fields that are perpendicular to each other and to the direction of propagation of the wave.

Step 2: Define longitudinal and transverse waves.

- Longitudinal waves: In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave propagation (e.g., sound waves in air).
- Transverse waves: In transverse waves, the particles of the medium vibrate perpendicular to the direction of wave propagation (e.g., waves on a string, light waves).

Step 3: Apply the definition to electromagnetic waves.

Since the oscillating electric and magnetic fields in an electromagnetic wave are perpendicular to the direction of propagation, electromagnetic waves are classified as transverse waves.

Step 4: Consider the options.

- Longitudinal: Incorrect.
- Transverse: Correct.
- Mechanical: Incorrect. Electromagnetic waves do not require a medium for propagation; they can travel through a vacuum. Mechanical waves, like sound, do require a medium.
- Stationary: Stationary waves are formed by the superposition of two identical waves traveling in opposite directions. Electromagnetic waves as described here are propagating waves.

Final Answer: *Transverse*

Answer: (B)

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Q24.

Solution

Concept: The photoelectric effect is the emission of electrons from a metal when light shines on it. Einstein's explanation of this phenomenon, which won him the Nobel Prize, is based on the quantum nature of light.

Solution: Step 1: Understand Einstein's explanation of the photoelectric effect.

Einstein proposed that light consists of discrete packets of energy called photons. The energy of a photon is given by $E = hf$, where h is Planck's constant and f is the frequency of the light.

Step 2: Describe the photoelectric equation.

When a photon strikes a metal surface, its energy is transferred to an electron. If the photon's energy is sufficient to overcome the work function (ϕ) of the metal (the minimum energy required to escape the surface), the electron is emitted. The kinetic energy (K_{max}) of the emitted electron is given by:

$$hf = \phi + K_{max}$$

This is Einstein's photoelectric equation.

Step 3: Analyze the conservation principle involved.

The equation represents the conservation of energy. The total energy of the incident photon (hf) is accounted for by the work function (energy used to escape the metal) and the kinetic energy of the emitted electron.

Step 4: Consider the options.

- Momentum: While momentum is conserved in any interaction, the photoelectric equation itself is a direct application of energy conservation. Photon energy is transferred to electron kinetic energy and work function.
- Angular momentum: This is relevant in rotational systems and atomic orbits, not directly in the primary explanation of the photoelectric effect's energy balance.
- Energy: This is the fundamental principle underlying Einstein's equation. The photon's energy is converted into work function and electron kinetic energy.
- Charge: Charge is conserved in any process, but the photoelectric equation specifically addresses the energy transfer.

Step 5: Select the conservation principle that Einstein's equation is based on.

Einstein's photoelectric equation is a direct manifestation of the conservation of energy.

Final Answer: *Energy*

Answer: (C)

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Q25.

Solution

Concept: The Bohr model of the atom postulates that electrons orbit the nucleus in specific, quantized energy levels. The angular momentum of an electron in these allowed orbits is also quantized.

Solution: Step 1: Recall Bohr's postulate on quantization of angular momentum.

One of the key postulates of the Bohr model is that the angular momentum (L) of an electron in an allowed orbit is quantized. This means that the electron can only exist in orbits where its angular momentum has specific discrete values.

Step 2: State Bohr's quantization condition for angular momentum.

Bohr's second postulate states that the angular momentum of an electron in any orbit is an integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant.

Mathematically, this is expressed as:

$$L = n \frac{h}{2\pi}$$

where:

L is the angular momentum of the electron.

n is a positive integer ($n = 1, 2, 3, \dots$), called the principal quantum number.

h is Planck's constant.

Step 3: Interpret the quantization unit.

The angular momentum is quantized in units of $\frac{h}{2\pi}$. This means the allowed values of angular momentum are $\frac{h}{2\pi}$, $2\frac{h}{2\pi}$, $3\frac{h}{2\pi}$, and so on.

Step 4: Evaluate the given options.

- h : This is Planck's constant itself, not the unit of quantized angular momentum.
- $\frac{h}{2\pi}$: This is the fundamental unit in which angular momentum is quantized according to Bohr's model.
- $\frac{h}{4\pi}$: This is not the unit of quantization for angular momentum in the Bohr model.
- $2\pi h$: This is not the unit of quantization.

Step 5: Select the correct unit of quantization.

The angular momentum of an electron in a Bohr orbit is quantized in units of $\frac{h}{2\pi}$.

Final Answer: $\frac{h}{2\pi}$

Answer: (B)

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Q26.

Solution

Concept: Beta decay is a type of radioactive decay in which a beta particle (an electron or a positron) is emitted from an atomic nucleus. There are two main types: β^- decay and β^+ decay.

Solution: Step 1: Understand β -decay.

Beta decay involves the transformation of a nucleon (proton or neutron) within the nucleus.

- In β^- decay, a neutron transforms into a proton, an electron, and an antineutrino. The electron is emitted from the nucleus.
- In β^+ decay, a proton transforms into a neutron, a positron (antiparticle of electron), and a neutrino. The positron is emitted from the nucleus.

Step 2: Identify the emitted particle in β -decay.

The question refers to β -decay generally, but commonly in introductory physics, it refers to β^- decay where an electron is emitted. The emitted electron is often called a beta particle.

Step 3: Consider the options.

- Helium nucleus: This is an alpha particle, emitted during alpha decay.
- Electron: This is the particle emitted in β^- decay.
- Proton: Protons are constituents of the nucleus; they are not typically emitted as fundamental particles in beta decay, though they are formed.
- Neutron: Neutrons are constituents of the nucleus; they are not typically emitted as fundamental particles in beta decay, though they are formed.

Step 4: Choose the correct emitted particle for β -decay.

In β^- decay, an electron is emitted.

Final Answer: *Electron*

Answer: (B)

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Q27.

Solution

Concept: The forbidden energy gap (or band gap) is the energy range in a solid where no electron states can exist. In conductors, the valence band and conduction band overlap, meaning there is no forbidden gap.

Solution: Step 1: Understand energy bands in solids.

In solids, electron energy levels are grouped into bands: the valence band (where electrons are normally bound) and the conduction band (where electrons can move freely to conduct electricity). The energy gap between these bands is called the forbidden energy gap.

Step 2: Classify materials based on their band structure.

- Conductors: In conductors, the valence band and the conduction band overlap, or the valence band is only partially filled. This means there is no energy gap, or the gap is effectively zero. Electrons can easily move into the conduction band with minimal energy input.
- Semiconductors: In semiconductors, there is a small but non-zero forbidden energy gap between the valence band and the conduction band. Electrons need a certain amount of energy (e.g., from heat or light) to jump this gap and conduct electricity.
- Insulators: In insulators, there is a large forbidden energy gap between the valence band and the conduction band. It requires a very large amount of energy for electrons to cross this gap, making them poor conductors.

Step 3: Determine the forbidden energy gap in conductors.

As explained above, in conductors, there is no energy gap between the valence band and the conduction band. They either overlap or the valence band is partially filled.

Step 4: Evaluate the options.

- Large: This describes insulators.
- Small: This describes semiconductors.
- Zero: This describes conductors.
- Infinite: This is not a standard description for energy gaps.

Final Answer:

Answer: (C)

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Q28.

Solution

Concept: Modulation is a technique in communication systems that adapts a signal for efficient transmission over a medium.

Solution: Step 1: Purpose of communication systems.

To transmit information signals from source to receiver.

Step 2: Limitations of baseband signals.

Original signals (baseband) often have low frequencies, making them unsuitable for direct long-distance transmission (e.g., requiring impractically large antennas).

Step 3: Define modulation.

Modulation is varying properties of a high-frequency carrier signal using a low-frequency information signal.

Step 4: Reasons for modulation.

- Long-distance transmission: Superimposing a low-frequency signal onto a high-frequency carrier allows for efficient transmission over long distances with less attenuation and requires smaller antennas.
- Adaptation to medium: Enables signals to be sent via different media (e.g., radio waves, optical fibers).
- Multiplexing: Allows multiple signals to share a channel.

Step 5: Evaluate options.

- Reduce noise: Not the primary goal.
- Increase antenna height: Modulation enables *smaller* antennas.
- Enable long distance transmission: This is a primary benefit.
- Increase frequency of signal: A consequence, but not the core reason.

Step 6: Select the main purpose.

The key reason for modulation is to enable efficient long-distance transmission.

Final Answer: *Enable long distance transmission*

Answer: (C)

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Q29.

Solution

Concept: This question asks about the nature of the image formed by a concave mirror when the object is placed between the focal point (F) and the pole (P).

Solution: Step 1: Recall the ray diagram for a concave mirror with the object between F and P .

When an object is placed between the focal point (F) and the pole (P) of a concave mirror:

- A ray from the object parallel to the principal axis is reflected through the focus (F).
- A ray passing through the center of curvature (C) is reflected back along the same path.
- A ray directed towards the pole (P) is reflected symmetrically with respect to the principal axis.

Step 2: Analyze the reflected rays.

When the object is between F and P , the reflected rays diverge from the mirror. They do not actually meet on the other side of the mirror.

Step 3: Determine where the image is formed.

To find the image location, we extend the diverging reflected rays backward on the same side as the object. These extended rays appear to originate from a point behind the mirror.

Step 4: Determine the nature of the image.

- Position: The image is formed behind the mirror.
- Nature: Since the reflected rays do not actually converge but only appear to diverge from a point behind the mirror, the image is virtual.
- Orientation: The image formed behind the mirror by a concave mirror is always erect (upright) when the object is between F and P .
- Size: The image formed in this case is always magnified (larger than the object).

Step 5: Evaluate the given options.

- Real and inverted: Incorrect, the image is virtual.
- Virtual and erect: Correct, this matches our analysis.
- Real and diminished: Incorrect, the image is virtual and magnified.
- Virtual and diminished: Incorrect, the image is virtual and magnified.

Final Answer: *Virtual and erect*

Answer: (B)

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Q30.

Solution

Concept: This problem involves calculating the equivalent resistance of resistors connected in a circuit. The diagram shows two resistors connected in parallel.

Solution: Step 1: Identify the type of circuit connection.

The diagram shows two resistors connected in parallel. The top resistor has a resistance of 2Ω , and the bottom resistor has a resistance of 3Ω .

Step 2: Recall the formula for equivalent resistance of resistors in parallel.

For two resistors R_1 and R_2 connected in parallel, the equivalent resistance (R_{eq}) is given by:

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

Alternatively, this can be written as:

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

Step 3: Identify the given resistances.

Let $R_1 = 2\Omega$ and $R_2 = 3\Omega$.

Step 4: Substitute the values into the formula.

Using the product over sum formula:

$$R_{eq} = \frac{(2\Omega)(3\Omega)}{2\Omega + 3\Omega}$$

Step 5: Calculate the equivalent resistance.

$$R_{eq} = \frac{6\Omega^2}{5\Omega}$$

$$R_{eq} = \frac{6}{5}\Omega$$

$$R_{eq} = 1.2\Omega$$

Step 6: Compare with the given options.

The equivalent resistance is 1.2Ω .

Options B, C, and D are incorrect.

Final Answer: 1.2Ω

Answer: (A)

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Q31.

Solution

Concept: In Simple Harmonic Motion (SHM), we analyze the relationship between displacement, velocity, and acceleration. We need to determine the phase difference between displacement and acceleration.

Solution: Step 1: Express displacement in SHM.

Let the displacement be $x(t) = A \cos(\omega t)$, where A is amplitude and ω is angular frequency.

Step 2: Find velocity and acceleration.

$$\text{Velocity } v(t) = \frac{dx}{dt} = -A\omega \sin(\omega t).$$

$$\text{Acceleration } a(t) = \frac{dv}{dt} = -A\omega^2 \cos(\omega t).$$

Step 3: Relate acceleration to displacement.

We can see that $a(t) = -\omega^2(A \cos(\omega t))$, which means $a(t) = -\omega^2 x(t)$.

Step 4: Determine the phase difference.

The equation $a(t) = -\omega^2 x(t)$ shows that acceleration is always in the opposite direction to displacement. This indicates a phase difference of π radians (or 180°).

Alternatively, using $a(t) = A\omega^2 \cos(\omega t + \pi)$, we compare it to $x(t) = A \cos(\omega t)$, showing a phase difference of π .

Step 5: Select the correct option.

The phase difference between displacement and acceleration in SHM is π .

Final Answer:

Answer: (C)

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Q32.

Solution

Concept: Young's modulus is a measure of the stiffness of an elastic material. It quantifies the resistance of a material to elastic deformation under tensile or compressive stress.

Solution: Step 1: Recall the definition of stress.

Stress (σ) is defined as the force (F) applied per unit cross-sectional area (A) of a material.

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

Step 2: Recall the definition of strain.

Strain (ϵ) is the measure of deformation representing the extent of deformation of the material. For tensile or compressive stress, it is defined as the ratio of the change in length (ΔL) to the original length (L_0).

$$\epsilon = \frac{\Delta L}{L_0}$$

Step 3: State the definition of Young's modulus.

Young's modulus (Y) is the ratio of stress to strain in the elastic region of deformation. It is a measure of a material's resistance to stretching or compressing.

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

Step 4: Substitute the definitions of stress and strain.

$$Y = \frac{F/A}{\Delta L/L_0}$$

Step 5: Evaluate the options based on the definition.

- Stress to strain: This is the direct definition of Young's modulus.
- Strain to stress: This is the reciprocal of Young's modulus.
- Force to area: This is the definition of stress.
- Pressure to volume: Pressure is related to stress, but volume change is related to bulk modulus.

Step 6: Select the correct ratio.

Young's modulus is the ratio of stress to strain.

Final Answer: *Stresstostrain*

Answer: (A)

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Q33.

Solution

Concept: The potential energy of a satellite in orbit is determined by its gravitational interaction with the central body. For objects in bound orbits (like planets around stars or satellites around planets), this potential energy is negative.

Solution: Step 1: Recall the formula for gravitational potential energy.

The gravitational potential energy (U) of a system of two masses, M (central body) and m (satellite), separated by a distance r , is given by:

$$U(r) = -\frac{GMm}{r}$$

where G is the gravitational constant.

Step 2: Analyze the sign of the potential energy.

In this formula, G , M , m , and r are all positive quantities. Therefore, the potential energy $U(r)$ is always negative.

Step 3: Consider the context of a satellite in circular orbit.

A satellite in a circular orbit is bound to the central body by gravity. This bound state corresponds to a negative total energy (kinetic energy + potential energy). Since kinetic energy is always positive, the potential energy must be negative to make the total energy negative.

Step 4: Evaluate the options.

- Positive: Incorrect, as the formula yields a negative value.
- Negative: Correct, as per the formula and the concept of bound orbits.
- Zero: Potential energy is zero only at an infinite distance from the central body, not in orbit.
- Infinite: This is not the value of potential energy in orbit.

Final Answer: *Negative*

Answer: (B)

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Q34.

Solution

Concept: The de Broglie hypothesis states that all matter exhibits wave-like properties. The de Broglie wavelength associated with a particle is inversely proportional to its momentum.

Solution: Step 1: Recall de Broglie's hypothesis.

Louis de Broglie proposed that all matter has wave-like properties. He hypothesized that a particle with momentum p has an associated wavelength λ , given by:

$$\lambda = \frac{h}{p}$$

where h is Planck's constant.

Step 2: Express momentum in terms of mass and velocity.

Momentum (p) is defined as the product of mass (m) and velocity (v):

$$p = mv$$

Step 3: Substitute the expression for momentum into the de Broglie wavelength equation.

$$\lambda = \frac{h}{mv}$$

Step 4: Analyze the dependence of wavelength on other quantities.

From the formula $\lambda = \frac{h}{p}$, it is clear that the de Broglie wavelength depends on the momentum (p) of the particle.

From the formula $\lambda = \frac{h}{mv}$, it depends on mass (m) and velocity (v).

Step 5: Evaluate the given options.

- Mass only: Incorrect, as velocity also plays a role.
- Velocity only: Incorrect, as mass also plays a role.
- Momentum: Correct, as the de Broglie wavelength is directly and inversely proportional to momentum.
- Charge: Charge is a property of particles, but it does not directly determine the de Broglie wavelength.

Final Answer: *Momentum*

Answer: (C)

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Q35.

Solution

Concept: The efficiency of a transformer depends on its core material's ability to manage magnetic flux. Soft iron is preferred for transformer cores due to specific magnetic properties.

Solution: Step 1: Function of a transformer core.

The core channels magnetic flux from the primary to the secondary coil, enabling voltage transformation via electromagnetic induction.

Step 2: Desired properties for the core.

For efficiency, the core should:

- Easily magnetize and demagnetize (low hysteresis loss).
- Effectively support and concentrate magnetic field lines.

Step 3: Analyze magnetic properties.

- Permeability: A measure of how easily a material supports a magnetic field. High permeability is crucial for efficient flux channeling.
- Retentivity: Ability to retain magnetism. High retentivity leads to high hysteresis loss, which is undesirable.
- Coercivity: Resistance to demagnetization. High coercivity indicates a "hard" magnetic material, unsuitable for transformers.

Step 4: Evaluate options.

- High retentivity: Undesirable.
- Low permeability: Undesirable.
- High permeability: Desirable for efficient flux transfer and low magnetizing force.
- Large coercivity: Undesirable.

Step 5: Conclusion.

Soft iron has high permeability and low retentivity/coercivity, making it ideal for transformer cores. High permeability is the key property listed.

Final Answer: *High permeability*

Answer: (C)

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Q36.

Solution

Concept: A vector quantity is a physical quantity that has both magnitude and direction, while a scalar quantity has only magnitude. We need to identify which of the given quantities are vectors.

Solution: Step 1: Define vector and scalar quantities.

- Vector quantity: Has both magnitude and direction (e.g., displacement, velocity, force).
- Scalar quantity: Has only magnitude (e.g., mass, distance, speed, work).

Step 2: Analyze each given quantity.

- Velocity: Velocity describes the rate of change of displacement, which includes both speed (magnitude) and direction. Therefore, velocity is a vector.
- Work: Work done by a force is given by $W = \vec{F} \cdot \vec{d}$. The dot product of two vectors results in a scalar quantity. Work has magnitude but no inherent direction associated with it. Therefore, work is a scalar.
- Momentum: Linear momentum is defined as $p = mv$. It has both magnitude (mass \times speed) and direction (same as velocity). Therefore, momentum is a vector.
- Torque: Torque is the rotational equivalent of force. It is defined as $\vec{\tau} = \vec{r} \times \vec{F}$. It has both magnitude and a direction (often described by the right-hand rule). Therefore, torque is a vector.

Step 3: Identify the vector quantities from the analysis.

Velocity, Momentum, and Torque are vector quantities. Work is a scalar quantity.

Step 4: Select the options that are vectors.

Velocity, Momentum, and Torque are vectors.

Final Answer: *Velocity, Momentum, Torque*

Answer: (A,C,D)

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Q37.

Solution

Concept: In Simple Harmonic Motion (SHM), we analyze the relationships between displacement, velocity, acceleration, and energy at different points of the oscillation (mean and extreme positions).

Solution: Step 1: Express SHM equations.

Assume displacement $x(t) = A \cos(\omega t)$.

- Velocity: $v(t) = -A\omega \sin(\omega t)$.
- Acceleration: $a(t) = -A\omega^2 \cos(\omega t)$.
- Potential Energy: $U(t) = \frac{1}{2}kx(t)^2 = \frac{1}{2}mA^2\omega^2 \cos^2(\omega t)$.
- Total Energy: $E = \frac{1}{2}mA^2\omega^2$ (constant).

Step 2: Analyze each statement.

- (A) Velocity is maximum at the mean position: At the mean position ($x = 0$), $\cos(\omega t) = 0$ and $\sin(\omega t) = \pm 1$. Velocity $v = \pm A\omega$, which is maximum. Correct.
- (B) Acceleration is zero at the extreme position: At extreme positions ($x = \pm A$), $\cos(\omega t) = \pm 1$. Acceleration $a = \mp A\omega^2$, which is maximum. Acceleration is zero at the mean position. Incorrect.
- (C) Total energy remains constant: The total energy $E = \frac{1}{2}mA^2\omega^2$ is constant. Correct.
- (D) Potential energy is maximum at the extreme position: At extreme positions ($x = \pm A$), $U = \frac{1}{2}kA^2$ (maximum). At the mean position, $U = 0$. Correct.

Step 3: Identify correct statements.

Statements A, C, and D are correct.

Final Answer:

Velocity is maximum at mean position
Total energy remains constant
Potential energy is maximum at extreme position

Answer: (A,C,D)

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Q38.

Solution

Concept: Electromagnetic waves are waves that do not require a medium for propagation and can travel through a vacuum. They are produced by oscillating electric and magnetic fields.

Solution: Step 1: Understand the nature of electromagnetic waves.

Electromagnetic waves are generated by oscillating electric charges and consist of oscillating electric and magnetic fields. A key characteristic is that they do not require a medium to propagate and can travel through a vacuum.

Step 2: Consider the options provided.

- X-rays: X-rays are a form of electromagnetic radiation. They travel through a vacuum.
- Radio waves: Radio waves are also a form of electromagnetic radiation. They travel through a vacuum.
- Sound waves: Sound waves are mechanical waves. They require a medium (like air, water, or solids) to propagate and cannot travel through a vacuum.
- Microwaves: Microwaves are a type of electromagnetic radiation. They travel through a vacuum.

Step 3: Identify which of the listed waves are electromagnetic and can travel through vacuum. X-rays, radio waves, and microwaves are all types of electromagnetic waves and can propagate through a vacuum. Sound waves are mechanical waves and require a medium.

Step 4: Select the correct options.

X-rays, radio waves, and microwaves can travel through vacuum.

Final Answer: *X – rays, Radiowaves, Microwaves*

Answer: (A,B,D)

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Q39.

Solution

Concept: Einstein's explanation of the photoelectric effect involves photons, threshold frequency, and the energy balance during electron emission. We analyze how frequency and intensity affect the process.

Solution: Step 1: Einstein's photoelectric equation: $hf = \phi + K_{max}$.

- h : Planck's constant.

- f : Frequency of incident light.

- ϕ : Work function (minimum energy to eject an electron).

- K_{max} : Maximum kinetic energy of emitted electron.

Step 2: Evaluate each statement.

- (A) Threshold frequency exists: Photoemission occurs only if $hf \geq \phi$. This implies a minimum frequency $f_0 = \phi/h$ (threshold frequency) below which no emission occurs, regardless of light intensity. Correct.

- (B) Emission depends on frequency: Emission is dependent on f being greater than or equal to f_0 . If $f < f_0$, no emission occurs. Correct.

- (C) Emission is instantaneous: When light with $f \geq f_0$ strikes the surface, energy transfer from photon to electron is immediate, leading to instantaneous emission. Correct.

- (D) Intensity affects stopping potential: Stopping potential V_s is related to K_{max} by $eV_s = K_{max} = hf - \phi$. V_s depends on f and ϕ , not intensity. Intensity affects the *number* of emitted electrons (photocurrent), not their energy. Incorrect.

Step 3: Identify correct statements.

A, B, and C are correct.

Final Answer:

Threshold frequency exists
Emission depends on frequency
Emission is instantaneous

Answer: (A,B,C)

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Q40.

Solution

Concept: A p-n junction diode's behavior is determined by the depletion region and the applied bias.

Solution: Step 1: Understand forward and reverse bias.

- Forward bias: Positive terminal to p-type, negative to n-type. Reduces potential barrier, shrinks depletion region, allows easy current flow.
- Reverse bias: Negative terminal to p-type, positive to n-type. Increases potential barrier, widens depletion region, blocks current flow.

Step 2: Evaluate the statements.

- (A) Forward bias decreases depletion layer: Correct. Forward bias shrinks the depletion region.
- (B) Reverse bias increases depletion layer: Correct. Reverse bias widens the depletion region.
- (C) Current flows easily in reverse bias: Incorrect. Current is blocked in reverse bias.
- (D) A diode can act as a rectifier: Correct. Its one-way conduction property makes it a rectifier.

Step 3: Identify the correct statements.

A, B, and D are correct.

Final Answer:

Forward bias decreases depletion layer
Reverse bias increases depletion layer
A diode can act as a rectifier

Answer: (A,B,D)

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Answer Key

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

