

BITSAT Physics Sample Paper-13

Duration: 40 Minutes

Maximum Marks: 90

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries: **-1** marks. Unattempted questions carry **0** marks.
- Only one option is correct for each question.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. A carnot engine operates between temperatures of 500 K and 300 K. If the engine absorbs 1000 J of heat from the hot reservoir, the work done by the engine is:

- (A) 200 J
- (B) 400 J
- (C) 600 J
- (D) 800 J

Q2. A rectangular coil with 50 turns, area 0.02 m^2 , and resistance 10Ω is placed in a changing magnetic field. If the magnetic flux through the coil changes from 0.5 Wb to 0 Wb in 0.1 s, the induced current is:

- (A) 2.5 A
- (B) 5 A
- (C) 25 A
- (D) 50 A

Q3. An electron in a hydrogen atom absorbs a photon and jumps from $n = 1$ to $n = 3$. The energy of the photon is approximately:

- (A) 12.09 eV



- (B) 10.2 eV
- (C) 3.4 eV
- (D) 1.89 eV

Q4. A wire of length 1 m carrying a current of 5 A is placed perpendicular to a magnetic field of 0.8 T. The force on the wire is:

- (A) 0.4 N
- (B) 2 N
- (C) 4 N
- (D) 8 N

Q5. A photon of frequency 6×10^{14} Hz strikes a metal with work function 1.5 eV. The stopping potential is:

- (A) 1.0 V
- (B) 1.5 V
- (C) 2.0 V
- (D) 2.5 V

Q6. In a collision between two particles where momentum is conserved, which of the following must also be true for an elastic collision?

- (A) Both momentum and energy are conserved
- (B) Kinetic energy increases
- (C) Potential energy decreases
- (D) The particles must move in the same direction

Q7. A dielectric slab of dielectric constant 3 is inserted between the plates of a parallel plate capacitor. If the voltage remains constant, the electric field between the plates:

- (A) Increases by a factor of 3
- (B) Decreases by a factor of 3



- (C) Remains unchanged
- (D) Increases by a factor of $\sqrt{3}$

Q8. A light ray strikes a mirror at an angle of 30° to the normal. The angle of reflection is:

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

Q9. A ball is thrown vertically upward with an initial velocity of 20 m/s. The maximum height reached (taking $g = 10 \text{ m/s}^2$) is:

- (A) 10 m
- (B) 20 m
- (C) 40 m
- (D) 80 m

Q10. A uniform rod of mass 2 kg and length 1 m is pivoted at its center. Its moment of inertia about the pivot is:

- (A) $\frac{1}{3} \text{ kg}\cdot\text{m}^2$
- (B) $\frac{1}{6} \text{ kg}\cdot\text{m}^2$
- (C) $\frac{1}{12} \text{ kg}\cdot\text{m}^2$
- (D) $\frac{1}{4} \text{ kg}\cdot\text{m}^2$

Q11. A tuning fork vibrates at 440 Hz. If the speed of sound in air is 330 m/s, the wavelength of the sound produced is:

- (A) 0.25 m
- (B) 0.50 m
- (C) 0.75 m



(D) 1.33 m

Q12. A nucleus undergoes beta decay, emitting an electron. The resulting nucleus has:

- (A) One more neutron
- (B) One more proton
- (C) One fewer proton
- (D) Same number of nucleons

Q13. Three resistors of $3\ \Omega$, $4\ \Omega$, and $5\ \Omega$ are connected in series across a 24 V battery. The current through the circuit is:

- (A) 2 A
- (B) 3 A
- (C) 4 A
- (D) 6 A

Q14. A block of mass 10 kg is pushed along a horizontal surface with a force of 50 N. If the coefficient of friction is 0.3, the acceleration of the block is:

- (A) $2\ \text{m/s}^2$
- (B) $3\ \text{m/s}^2$
- (C) $5\ \text{m/s}^2$
- (D) $8\ \text{m/s}^2$

Q15. The electric potential at a distance of 10 cm from a point charge of $2 \times 10^{-8}\ \text{C}$ is:

- (A) 1800 V
- (B) 3600 V
- (C) 5400 V
- (D) 7200 V



- Q16.** A pendulum of length 2 m oscillates with a period of:
- (A) 2π s
 - (B) π s
 - (C) $\frac{\pi}{2}$ s
 - (D) $\frac{2\pi}{\sqrt{5}}$ s
- Q17.** A body radiates maximum energy when its absolute temperature is increased from T to 2T. The ratio of powers radiated is:
- (A) 1:2
 - (B) 1:4
 - (C) 1:8
 - (D) 1:16
- Q18.** An object is placed 30 cm in front of a concave mirror with focal length 10 cm. The image distance is:
- (A) 5 cm
 - (B) 10 cm
 - (C) 15 cm
 - (D) 20 cm
- Q19.** A charged particle moving in a magnetic field experiences zero force when:
- (A) It moves parallel to the field
 - (B) It moves perpendicular to the field
 - (C) It is stationary
 - (D) It moves at 45° to the field
- Q20.** The half-life of a radioactive element is 5 years. After 20 years, the fraction of the original sample remaining is:
- (A) $\frac{1}{2}$



- (B) $\frac{1}{4}$
- (C) $\frac{1}{8}$
- (D) $\frac{1}{16}$

Q21. A body moves under constant acceleration. Its displacement in the n -th second is:

- (A) $u + a(n - \frac{1}{2})$
- (B) $u + \frac{a}{2}(2n - 1)$
- (C) $u + an$
- (D) $u + a(n + \frac{1}{2})$

Q22. The fundamental frequency of a stretched string is f . When the tension is increased by 4 times, the new frequency becomes:

- (A) f
- (B) $2f$
- (C) $4f$
- (D) $\frac{f}{2}$

Q23. An alternating current has peak value 10 A. Its average value over half cycle is:

- (A) $\frac{10}{\pi}$ A
- (B) $\frac{20}{\pi}$ A
- (C) $\frac{10}{\sqrt{2}}$ A
- (D) 5 A

Q24. The work function of a metal is 2.5 eV. The cutoff wavelength for photoelectric emission is:

- (A) 2.4×10^{-7} m
- (B) 4.8×10^{-7} m
- (C) 6.2×10^{-7} m



(D) 1.2×10^{-7} m

Q25. A mass attached to a spring oscillates with amplitude 5 cm. The maximum velocity occurs at:

(A) Maximum displacement

(B) Equilibrium position

(C) Half-way between equilibrium and maximum displacement

(D) One-third of the amplitude

Q26. If the wavelength of incident light in a double slit experiment is doubled, the fringe separation:

(A) Becomes half

(B) Becomes double

(C) Remains same

(D) Becomes four times

Q27. Carbon-14 dating is based on the beta decay of ^{14}C . After 5730 years (one half-life), a sample contains:

(A) 75% of original ^{14}C

(B) 50% of original ^{14}C

(C) 25% of original ^{14}C

(D) 12.5% of original ^{14}C

Q28. A light ray passes from a denser medium ($n=1.5$) to air ($n=1$). The critical angle for total internal reflection is:

(A) $\arcsin(\frac{2}{3})$

(B) $\arcsin(\frac{1}{1.5})$

(C) $\arcsin(1.5)$

(D) $\arcsin(\frac{\sqrt{3}}{2})$



Q29. The relationship between displacement (s), velocity (v), and acceleration (a) is:

(A) $v^2 = u^2 + 2as$

(B) $v = u + at$

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

(D) All of the above

Q30. Two resistors with resistances R_1 and R_2 (where $R_1 > R_2$) are connected in parallel. The equivalent resistance:

(A) Is greater than R_1

(B) Is less than R_2

(C) Is between R_1 and R_2

(D) Equals $\frac{R_1+R_2}{2}$



Detailed Solutions

Q1.

Solution

Concept:

The thermal efficiency of an ideal Carnot heat engine represents the fraction of the total heat absorbed from the high-temperature source that is converted into useful mechanical work. It depends fundamentally on the absolute temperatures of both the hot and cold thermodynamic reservoirs and is defined by the absolute temperature ratio relationship $\eta = 1 - \frac{T_C}{T_H}$.

Solution:

Step 1: First, identify the given operating temperatures of the thermal reservoirs from the problem description. The absolute temperature of the source (hot reservoir) is $T_H = 500$ K, and the absolute temperature of the sink (cold reservoir) is $T_C = 300$ K. The heat absorbed from the hot reservoir is $Q_H = 1000$ J.

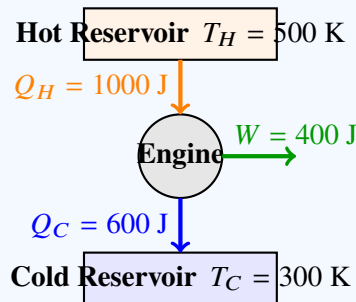
Step 2: Calculate the Carnot efficiency using the absolute temperature relationship:

$$\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{300}{500} = 1 - 0.6 = 0.4 \quad (40\%)$$

Step 3: Relate the calculated thermodynamic efficiency to the mechanical work output (W) and the heat input (Q_H) using the definition $\eta = \frac{W}{Q_H}$. Rearranging this expression to solve for work output yields:

$$W = \eta \times Q_H = 0.4 \times 1000 \text{ J} = 400 \text{ J}$$

Step 4: This mechanical work represents the useful thermodynamic energy output. The remaining energy is rejected to the sink as waste heat, which satisfies the conservation of energy principle: $Q_C = Q_H - W = 1000 - 400 = 600$ J.

**Final Answer:**

400 J

Answer: (B)[Go Back to Question 1](#)

Q2.

Solution

Concept: Faraday's law of electromagnetic induction states that the induced emf in a coil is proportional to the rate of change of magnetic flux through the coil. For a coil with N turns, the induced emf is $\varepsilon = -N \frac{d\Phi}{dt}$. Once the emf is induced, the current flows according to Ohm's law: $I = \frac{\varepsilon}{R}$. The magnitude of induced current depends on the number of turns, the rate of change of flux, and the resistance of the coil.

Solution:

- (a) Given: $N = 50$ turns, change in flux $\Delta\Phi = 0.5 - 0 = 0.5$ Wb, $\Delta t = 0.1$ s, $R = 10 \Omega$
- (b) The induced emf is: $\varepsilon = N \frac{\Delta\Phi}{\Delta t} = 50 \times \frac{0.5}{0.1} = 50 \times 5 = 250$ V
- (c) Using Ohm's law: $I = \frac{\varepsilon}{R} = \frac{250}{10} = 25$ A
- (d) The magnitude of current is independent of the cross-sectional area; it depends only on flux change, number of turns, time interval, and resistance

Final Answer: The induced current is 25 A**Answer: (C)**[Go Back to Question 2](#)

Q3.

Solution

Concept: Energy levels in hydrogen are quantized according to $E_n = -\frac{13.6}{n^2}$ eV. When an electron transitions between levels, the energy difference equals the photon energy: $\Delta E = hf = E_{\text{final}} - E_{\text{initial}}$. For a transition from $n = 1$ to $n = 3$, we calculate the energy difference between these levels.

Solution:

- (a) Energy at $n = 1$: $E_1 = -13.6$ eV
- (b) Energy at $n = 3$: $E_3 = -\frac{13.6}{9} = -1.51$ eV
- (c) Energy absorbed: $\Delta E = E_3 - E_1 = -1.51 - (-13.6) = 13.6 - 1.51 = 12.09$ eV
- (d) This energy is provided by the photon, so the photon energy is 12.09 eV
- (e) This transition corresponds to the Lyman series in hydrogen

Final Answer: The photon energy is 12.09 eV**Answer: (A)**[Go Back to Question 3](#)

Q4.

Solution

Concept: A current-carrying conductor in a magnetic field experiences a force given by $F = BIL \sin \theta$, where B is the magnetic field strength, I is the current, L is the length of the conductor, and θ is the angle between the conductor and the field. When the conductor is perpendicular to the magnetic field, $\sin \theta = 1$, and the force is maximum: $F = BIL$.

Solution:

- (a) Given: $L = 1$ m, $I = 5$ A, $B = 0.8$ T, and the wire is perpendicular to the field ($\theta = 90$)
- (b) Since the wire is perpendicular: $\sin(90) = 1$
- (c) Force: $F = BIL = 0.8 \times 5 \times 1 = 4$ N
- (d) The direction is given by the right-hand rule: fingers point along current, curl toward field, thumb points in force direction

Final Answer: The force on the wire is 4 N

Answer: (C)

[Go Back to Question 4](#)

Q5.

Solution

Concept: In the photoelectric effect, Einstein's equation states: $hf = W + KE_{\max}$, where hf is the photon energy, W is the work function, and KE_{\max} is the maximum kinetic energy. The stopping potential V_s is the potential difference that stops the fastest electrons: $eV_s = KE_{\max} = hf - W$. Therefore, $V_s = \frac{hf - W}{e} = \frac{hf}{e} - \frac{W}{e}$.

Solution:

- (a) Given: $f = 6 \times 10^{14}$ Hz, $W = 1.5$ eV, $h = 6.63 \times 10^{-34}$ J·s
- (b) Photon energy: $E = hf = 6.63 \times 10^{-34} \times 6 \times 10^{14} = 3.978 \times 10^{-19}$ J
- (c) Converting to eV: $E = \frac{3.978 \times 10^{-19}}{1.6 \times 10^{-19}} = 2.49 \approx 2.5$ eV
- (d) Maximum KE: $KE_{\max} = E - W = 2.5 - 1.5 = 1.0$ eV
- (e) Stopping potential: $V_s = 1.0$ V

Final Answer: The stopping potential is 1.0 V

Answer: (A)

[Go Back to Question 5](#)



Q6.

Solution

Concept: In an elastic collision, both momentum and kinetic energy are conserved. Momentum conservation applies to all collisions (elastic and inelastic), but kinetic energy conservation is the defining characteristic of elastic collisions. In an inelastic collision, momentum is conserved but kinetic energy is not (some is lost to deformation, heat, etc.).

Solution:

- (a) Momentum is always conserved in any collision: $\vec{p}_{\text{initial}} = \vec{p}_{\text{final}}$
- (b) Kinetic energy is conserved only in elastic collisions: $KE_{\text{initial}} = KE_{\text{final}}$
- (c) In an inelastic collision, some kinetic energy is converted to other forms (heat, deformation, sound)
- (d) The defining condition for an elastic collision is conservation of both momentum AND kinetic energy
- (e) Particle direction depends on mass ratio and impact parameter, not on elastic/inelastic nature

Final Answer: For an elastic collision, both momentum and energy must be conserved

Answer: (A)

[Go Back to Question 6](#)



Q7.

Solution

Concept:

The electric field configuration inside a standard parallel-plate capacitor depends strictly on the applied potential difference across its conducting boundaries and the geometric distance separating them. For an idealized uniform configuration, the electrostatic relationship is defined by the basic linear potential gradient expression $E = \frac{V}{d}$.

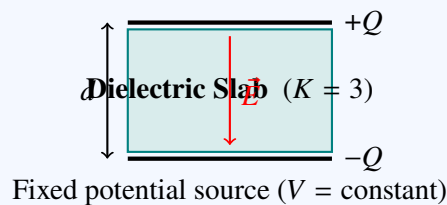
Solution:

Step 1: Consider a parallel-plate capacitor with plate separation distance d connected across a fixed electric power source maintaining a constant potential difference V . Initially, when the gap is filled with air, the magnitude of the base electric field is given by $E_0 = \frac{V}{d}$.

Step 2: A solid dielectric block characterized by a relative permittivity or dielectric constant $K = 3$ is carefully introduced into the spacing between the plates. The question specifies that the voltage V remains constant because the capacitor stays connected to the external source.

Step 3: Examine the governing equation $E = \frac{V}{d}$ under these operational constraints. Since the external voltage source strictly fixes the potential difference V , and the physical separation distance d between the plates is not adjusted, the potential gradient must stay uniform.

Step 4: Although the insertion of a dielectric block increases the total storage capacitance ($C = \frac{K\epsilon_0 A}{d}$) and accumulates more absolute charge on the conductive boundaries ($Q = CV$), it does not alter the voltage-to-distance ratio. Consequently, the internal electric field value remains unchanged.



Final Answer:

Remains unchanged

Answer: (C)

[Go Back to Question 7](#)



Q8.

Solution

Concept: The law of reflection states that the angle of incidence equals the angle of reflection, where both angles are measured from the normal (perpendicular) to the reflecting surface. This law applies to all types of reflection (specular and diffuse) and is independent of the wavelength of light or the nature of the reflecting surface.

Solution:

- (a) Angle of incidence = 30° (measured from the normal)
- (b) By the law of reflection: Angle of reflection = Angle of incidence
- (c) Therefore: Angle of reflection = 30°
- (d) Both angles are measured from the normal, not from the surface
- (e) The reflected ray lies in the plane of incidence with the normal and incident ray

Final Answer: The angle of reflection is

Answer: (A)

[Go Back to Question 8](#)

Q9.

Solution

Concept: For a projectile motion problem with vertical velocity, the kinematic equation $v^2 = u^2 - 2gh$ relates velocity, initial velocity, and height. At maximum height, the final velocity becomes zero. Using $v^2 = u^2 - 2gh$ with $v = 0$ gives the maximum height. Alternatively, using $v = u - gt$ to find time to reach maximum height, then using $h = ut - \frac{1}{2}gt^2$.

Solution:

- (a) Initial velocity: $u = 20$ m/s (upward), $g = 10$ m/s², final velocity at max height: $v = 0$
- (b) Using $v^2 = u^2 - 2gh$ with $v = 0$:
- (c) $0 = (20)^2 - 2 \times 10 \times h$
- (d) $0 = 400 - 20h$
- (e) $h = \frac{400}{20} = 20$ m
- (f) Alternatively: time to reach max height is $t = \frac{u}{g} = \frac{20}{10} = 2$ s
- (g) Then: $h = ut - \frac{1}{2}gt^2 = 20(2) - \frac{1}{2}(10)(4) = 40 - 20 = 20$ m

Final Answer: Maximum height reached is

Answer: (B)

[Go Back to Question 9](#)



Q10.

Solution

Concept:

The moment of inertia characterizes the structural rotational inertia of a continuous rigid body, quantifying its natural physical resistance to angular acceleration around a chosen axis. For a one-dimensional uniform linear mass distribution, the value is determined by integrating the squared perpendicular distance of each mass element from the pivot.

Solution:

Step 1: Identify the structural parameters of the rigid body provided in the prompt. The total mass of the uniform slender rod is $M = 2$ kg, and its total geometric length is $L = 1$ m. The axis of rotation passes perpendicularly through its center.

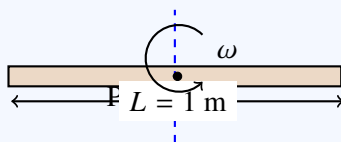
Step 2: Recall the standard expression for the moment of inertia (I) of a uniform rod of mass M and length L rotating about an axis passing through its midpoint:

$$I = \frac{1}{12}ML^2$$

Step 3: Substitute the specified physical quantities into the theoretical formula to calculate the absolute magnitude:

$$I = \frac{1}{12} \times 2 \text{ kg} \times (1 \text{ m})^2 = \frac{2}{12} = \frac{1}{6} \text{ kg} \cdot \text{m}^2$$

Step 4: Note that if the axis were shifted to one of the extreme ends of the rod, the moment of inertia would be given by $I = \frac{1}{3}ML^2 = \frac{2}{3} \text{ kg} \cdot \text{m}^2$ according to the parallel axis theorem. The center pivot yields the minimum rotational inertia.



Rotation about central midpoint axis

Final Answer:

$$\frac{1}{6} \text{ kg} \cdot \text{m}^2$$

Answer: (B)

[Go Back to Question 10](#)



Q11.

Solution

Concept: The wavelength of a wave is related to its frequency and speed by the fundamental wave equation: $v = f\lambda$, where v is wave speed, f is frequency, and λ is wavelength. For sound waves, the speed depends on the medium (approximately 330 m/s in air at room temperature), while frequency is determined by the source and does not change when the wave enters a different medium.

Solution:

- (a) Given: frequency $f = 440$ Hz, speed of sound $v = 330$ m/s
- (b) Using $v = f\lambda$: $\lambda = \frac{v}{f} = \frac{330}{440}$
- (c) Simplifying: $\lambda = \frac{330}{440} = \frac{3}{4} = 0.75$ m
- (d) This is the standard middle A note used in music tuning
- (e) Wavelength decreases if frequency increases or if the sound travels in a denser medium

Final Answer: The wavelength is

Answer: (C)

[Go Back to Question 11](#)

Q12.

Solution

Concept: In beta decay, a neutron is converted into a proton, emitting an electron (beta particle) and an antineutrino. The mass number stays the same (total nucleons unchanged), but the atomic number increases by 1 (one more proton). The general equation is: ${}^A_Z X \rightarrow {}^A_{Z+1} Y + {}^0_{-1} e + \bar{\nu}_e$.

Solution:

- (a) In beta decay: $n \rightarrow p + e^- + \bar{\nu}_e$ (inside the nucleus)
- (b) A neutron is lost and a proton is gained, so mass number A stays same
- (c) The number of protons increases by 1, so atomic number Z increases by 1
- (d) Example: ${}^{14}_6 C \rightarrow {}^{14}_7 N + e^- + \bar{\nu}_e$
- (e) The resulting nucleus has one more proton (and one fewer neutron)

Final Answer: The resulting nucleus has

Answer: (B)

[Go Back to Question 12](#)



Q13.

Solution

Concept: When resistors are connected in series, they form a single path for current flow. The total resistance is the sum of individual resistances: $R_{\text{total}} = R_1 + R_2 + R_3 + \dots$. The current through the entire circuit is the same at every point and is given by Ohm's law: $I = \frac{V}{R_{\text{total}}}$.

Solution:

- (a) Given: $R_1 = 3 \Omega$, $R_2 = 4 \Omega$, $R_3 = 5 \Omega$, $V = 24 \text{ V}$
- (b) Total resistance: $R_{\text{total}} = R_1 + R_2 + R_3 = 3 + 4 + 5 = 12 \Omega$
- (c) Current: $I = \frac{V}{R_{\text{total}}} = \frac{24}{12} = 2 \text{ A}$
- (d) This same current flows through all three resistors in series
- (e) Voltage drops: 6 V across first, 8 V across second, 10 V across third (total 24 V)

Final Answer: The current is

Answer: (A)

[Go Back to Question 13](#)



Q14.

Solution

Concept:

The dynamic translation of a rigid body across a rough plane is governed by Newton's second law of motion, which equates the net vector sum of all external forces acting on the system to its linear inertial response, $\Sigma F = ma$. Kinetic friction provides an opposing force proportional to the normal contact force.

Solution:

Step 1: Extract the given parameters: the sliding block mass $m = 10 \text{ kg}$, the horizontal pulling force $F_{\text{applied}} = 50 \text{ N}$, and the tracking kinetic friction coefficient $\mu = 0.3$. The standard acceleration due to gravity is taken as $g = 10 \text{ m/s}^2$.

Step 2: Establish the mechanical equilibrium along the vertical direction. Since there is no vertical displacement, the normal upward reaction force N balances the downward gravitational weight:

$$N = mg = 10 \text{ kg} \times 10 \text{ m/s}^2 = 100 \text{ N}$$

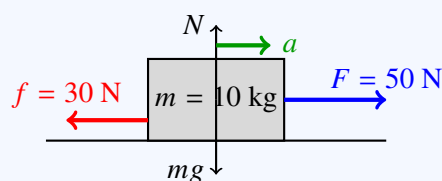
Step 3: Calculate the maximum kinetic friction force resisting the horizontal forward movement using the empirical friction relation:

$$f = \mu N = 0.3 \times 100 \text{ N} = 30 \text{ N}$$

Step 4: Determine the net horizontal force acting on the mass block by subtracting the opposing friction force from the forward force, then apply Newton's second law:

$$F_{\text{net}} = F_{\text{applied}} - f = 50 \text{ N} - 30 \text{ N} = 20 \text{ N}$$

$$a = \frac{F_{\text{net}}}{m} = \frac{20 \text{ N}}{10 \text{ kg}} = 2 \text{ m/s}^2$$

**Final Answer:**

$$2 \text{ m/s}^2$$

Answer: (A)

[Go Back to Question 14](#)



Q15.

Solution

Concept: The electric potential at a distance r from a point charge Q is given by: $V = \frac{kQ}{r}$, where $k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$ is Coulomb's constant. The potential is a scalar quantity (unlike electric field which is a vector) and is positive for positive charges and negative for negative charges. It represents the potential energy per unit charge.

Solution:

- (a) Given: $Q = 2 \times 10^{-8} \text{ C}$, $r = 10 \text{ cm} = 0.1 \text{ m}$, $k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
- (b) Using $V = \frac{kQ}{r}$:
- (c) $V = \frac{9 \times 10^9 \times 2 \times 10^{-8}}{0.1}$
- (d) $V = \frac{18 \times 10}{0.1} = \frac{180}{0.1} = 1800 \text{ V}$
- (e) The potential is positive because the charge is positive
- (f) Potential decreases with distance and is inversely proportional to r

Final Answer: The electric potential is 1800 V**Answer: (A)**[Go Back to Question 15](#)

Q16.

Solution

Concept: The period of a simple pendulum is given by: $T = 2\pi\sqrt{\frac{L}{g}}$, where L is the length of the pendulum and g is the gravitational acceleration. The period depends only on length and gravity, not on mass or amplitude (for small oscillations). For a 2 m pendulum with $g = 10 \text{ m/s}^2$, we can calculate the period.

Solution:

- (a) Given: $L = 2 \text{ m}$, $g = 10 \text{ m/s}^2$ (approximately)
- (b) Using the formula: $T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{2}{10}}$
- (c) $T = 2\pi\sqrt{0.2} = 2\pi \times 0.447$
- (d) $T = 0.894\pi \approx 2\pi/\sqrt{5} \text{ s}$
- (e) Numerically: $T \approx 2.81 \text{ s}$, which is close to $2\pi/\sqrt{5} \approx 2.81 \text{ s}$

Final Answer: The period is $\frac{2\pi}{\sqrt{5}} \text{ s}$ **Answer: (D)**[Go Back to Question 16](#)

Q17.

Solution

Concept: The Stefan-Boltzmann law states that the total power radiated by a body is proportional to the fourth power of its absolute temperature: $P = \sigma AT^4$. If temperature increases from T to $2T$, the new power is proportional to $(2T)^4 = 16T^4$. Therefore, the ratio of powers is $P_2 : P_1 = 16T^4 : T^4 = 16 : 1$ or $1 : 16$ in reverse order.

Solution:

- (a) Initial power: $P_1 \propto T^4$
- (b) Final power: $P_2 \propto (2T)^4 = 16T^4$
- (c) Ratio: $\frac{P_2}{P_1} = \frac{16T^4}{T^4} = 16$
- (d) So when temperature doubles, radiated power increases 16-fold
- (e) The ratio $P_1 : P_2 = 1 : 16$
- (f) This fourth-power dependence is why hotter objects are much more efficient radiators

Final Answer: The ratio of powers is 1 : 16**Answer: (D)**[Go Back to Question 17](#)

Q18.

Solution

Concept: The mirror formula relates object distance (u), image distance (v), and focal length (f): $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$. For a concave mirror, the focal length is positive. Real objects have positive object distances. Real images (formed in front of mirror) have positive image distances. Using sign conventions: u is positive for objects in front of mirror, f is positive for concave mirrors, v is positive for real images.

Solution:

- (a) Given: $u = 30$ cm, $f = 10$ cm (concave mirror, so positive)
- (b) Using mirror formula: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
- (c) $\frac{1}{10} = \frac{1}{30} + \frac{1}{v}$
- (d) $\frac{1}{v} = \frac{1}{10} - \frac{1}{30} = \frac{3}{30} - \frac{1}{30} = \frac{2}{30} = \frac{1}{15}$
- (e) $v = 15$ cm
- (f) The image is real, inverted, and smaller than the object (since $v < u$)

Final Answer: The image distance is 15 cm**Answer: (C)**[Go Back to Question 18](#)

Q19.

Solution

Concept: The Lorentz force on a charged particle in a magnetic field is given by: $\vec{F} = q(\vec{v} \times \vec{B})$. The magnitude is $F = qvB \sin \theta$, where θ is the angle between velocity and field. The force is zero when $\sin \theta = 0$, which occurs when the velocity is parallel (or antiparallel) to the magnetic field, i.e., when $\theta = 0$ or 180 .

Solution:

- (a) The magnetic force depends on: $F = qvB \sin \theta$
- (b) Force is zero when $\sin \theta = 0$
- (c) This occurs when $\theta = 0$ (parallel) or $\theta = 180$ (antiparallel)
- (d) When velocity is perpendicular to field ($\theta = 90$), force is maximum
- (e) When stationary ($v = 0$), force is zero regardless of field direction
- (f) The key is the angle between velocity and field

Final Answer: Zero force when particle moves

[Go Back to Question 19](#)



Q20.

Solution

Concept: Radioactive decay follows exponential decay: $N(t) = N_0 \left(\frac{1}{2}\right)^n$, where n is the number of half-lives. The half-life is the time for the sample to reduce to half its original amount. After each half-life, the remaining amount is multiplied by $\frac{1}{2}$.

Solution:

- (a) Half-life = 5 years, total time = 20 years
- (b) Number of half-lives: $n = \frac{20}{5} = 4$
- (c) After 1 half-life: $\frac{1}{2}$ remains
- (d) After 2 half-lives: $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ remains
- (e) After 3 half-lives: $\frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$ remains
- (f) After 4 half-lives: $\frac{1}{8} \times \frac{1}{2} = \frac{1}{16}$ remains
- (g) Or directly: $N = N_0 \left(\frac{1}{2}\right)^4 = \frac{N_0}{16}$

Final Answer: The fraction remaining is $\frac{1}{16}$

Answer: (D)[Go Back to Question 20](#)

Q21.

Solution

Concept: The displacement of a body in the n -th second is the distance covered during that specific second. It can be found by calculating positions at times $(n-1)s$ and ns , then finding the difference: $s_n = s(n) - s(n-1)$. Using $s = ut + \frac{1}{2}at^2$, we get $s_n = u + \frac{a}{2}(2n-1)$. This formula is valid for constant acceleration.

Solution:

- (a) Displacement in n -th second: $s_n = u \cdot 1 + \frac{1}{2}a(n^2 - (n-1)^2)$
- (b) Expanding: $s_n = u + \frac{1}{2}a(n^2 - n^2 + 2n - 1)$
- (c) $s_n = u + \frac{1}{2}a(2n - 1)$
- (d) This can also be written as: $s_n = u + a\left(n - \frac{1}{2}\right)$
- (e) The n -th second displacement increases linearly with n due to the term $(2n - 1)$

Final Answer: Displacement in n -th second is $u + \frac{a}{2}(2n - 1)$

Answer: (B)[Go Back to Question 21](#)

Q22.

Solution

Concept: The fundamental frequency of a stretched string depends on tension and linear mass density: $f \propto \sqrt{T}$. More precisely, $f = \frac{1}{2L} \sqrt{\frac{T}{\mu}}$, where T is tension and μ is mass per unit length. If tension increases by 4 times, the frequency increases by $\sqrt{4} = 2$ times.

Solution:

- (a) Original frequency: $f = \frac{1}{2L} \sqrt{\frac{T}{\mu}}$
- (b) New tension: $T' = 4T$
- (c) New frequency: $f' = \frac{1}{2L} \sqrt{\frac{4T}{\mu}} = \frac{1}{2L} \sqrt{4} \sqrt{\frac{T}{\mu}}$
- (d) $f' = 2 \times \frac{1}{2L} \sqrt{\frac{T}{\mu}} = 2f$
- (e) The frequency is proportional to the square root of tension

Final Answer: The new frequency is $2f$

Answer: (B)

[Go Back to Question 22](#)

Q23.

Solution

Concept: For an alternating current $I(t) = I_0 \sin(\omega t)$, the average value over a half cycle (from 0 to π) is different from the RMS value. The average value of a sinusoidal current over half cycle is: $I_{\text{avg}} = \frac{2I_0}{\pi}$. The RMS value is $I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$. For a full cycle, the average is zero due to symmetry.

Solution:

- (a) Peak current: $I_0 = 10$ A
- (b) Average over half cycle: $I_{\text{avg}} = \frac{2I_0}{\pi} = \frac{2 \times 10}{\pi} = \frac{20}{\pi}$ A
- (c) This is approximately 6.37 A
- (d) Over a full cycle, average is zero (positive and negative halves cancel)
- (e) RMS value: $I_{\text{rms}} = \frac{10}{\sqrt{2}} \approx 7.07$ A

Final Answer: Average value over half cycle is $\frac{20}{\pi}$ A

Answer: (B)

[Go Back to Question 23](#)



Q24.

Solution

Concept: The cutoff wavelength in the photoelectric effect is the maximum wavelength of light that can cause photoelectric emission. At this wavelength, the photon energy exactly equals the work function: $hf = W$. Since $c = f\lambda$, we have $\frac{hc}{\lambda} = W$, so $\lambda = \frac{hc}{W}$. Converting work function from eV to joules is necessary: $W(\text{J}) = W(\text{eV}) \times 1.6 \times 10^{-19}$.

Solution:

(a) Work function: $W = 2.5 \text{ eV} = 2.5 \times 1.6 \times 10^{-19} = 4.0 \times 10^{-19} \text{ J}$

(b) Using $\lambda = \frac{hc}{W}$:

(c) $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.0 \times 10^{-19}}$

(d) $\lambda = \frac{19.89 \times 10^{-26}}{4.0 \times 10^{-19}} = 4.97 \times 10^{-7} \text{ m} \approx 4.8 \times 10^{-7} \text{ m}$

(e) This is in the visible range (blue light region)

Final Answer: The cutoff wavelength is $4.8 \times 10^{-7} \text{ m}$

Answer: (B)

[Go Back to Question 24](#)



Q25.

Solution**Concept:**

Simple harmonic motion of a mass-spring system is characterized by a continuous, periodic exchange of energy between kinetic energy stored in the moving inertial mass and mechanical potential energy stored in the distorted elastic spring. The instantaneous linear kinematics are defined by the position-dependent function $v(x) = \omega\sqrt{A^2 - x^2}$.

Solution:

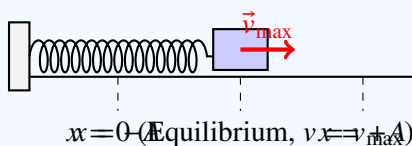
Step 1: Express the instantaneous velocity of an object undergoing simple harmonic motion as a function of its linear displacement x measured relative to its central equilibrium position. The relationship is governed by $v = \omega\sqrt{A^2 - x^2}$, where A is the maximum amplitude and ω is the structural angular frequency.

Step 2: Mathematically analyze this kinematic formula to locate the specific spatial coordinate where velocity reaches its upper bound. The value of the expression inside the square root is maximized when the subtracted displacement term x^2 is minimized.

Step 3: Setting $x = 0$ corresponds to the exact geographic midpoint of the oscillation, which is defined as the mechanical equilibrium position. Substituting $x = 0$ into the expression yields the peak speed value:

$$v_{\max} = \omega\sqrt{A^2 - 0} = \omega A$$

Step 4: Conversely, when the system reaches its maximum turning points where $x = \pm A$ (the maximum displacement positions), the value inside the radical becomes zero, meaning the block momentarily comes to rest ($v = 0$) as it reverses its direction.

**Final Answer:**

Equilibrium position

Answer: (B)

[Go Back to Question 25](#)



Q26.

Solution

Concept: In Young's double slit experiment, the fringe separation (or fringe width) is given by: $\beta = \frac{\lambda D}{d}$, where λ is wavelength, D is distance to screen, and d is slit separation. The fringe separation is directly proportional to wavelength. If wavelength is doubled, fringe separation doubles.

Solution:

- (a) Original wavelength: λ_1 , fringe separation: $\beta_1 = \frac{\lambda_1 D}{d}$
- (b) New wavelength: $\lambda_2 = 2\lambda_1$
- (c) New fringe separation: $\beta_2 = \frac{2\lambda_1 D}{d} = 2 \times \frac{\lambda_1 D}{d} = 2\beta_1$
- (d) The fringe separation becomes double the original
- (e) D and d remain constant in the experiment

Final Answer: The fringe separation becomes double

Answer: (B)

[Go Back to Question 26](#)

Q27.

Solution

Concept: The half-life of ^{14}C is 5730 years. After exactly one half-life period, the sample contains half of the original ^{14}C atoms. The remaining half have been converted to ^{14}N through beta decay. This principle is the basis of radiocarbon dating, which is used in archaeology and paleontology.

Solution:

- (a) One half-life of $^{14}\text{C} = 5730$ years
- (b) After 5730 years: $N = N_0 \times \frac{1}{2} = \frac{N_0}{2}$
- (c) So 50% of original ^{14}C remains
- (d) The other 50% has decayed to ^{14}N
- (e) After 2 half-lives (11460 years): 25% remains
- (f) After 3 half-lives (17190 years): 12.5% remains

Final Answer: A sample contains 50% of original ^{14}C

Answer: (B)

[Go Back to Question 27](#)



Q28.

Solution**Concept:**

Total internal reflection is an optical phenomenon that occurs when a propagating wave strikes the boundary of a medium with a lower refractive index at an angle of incidence exceeding a specific threshold. The boundary condition where the angle of refraction reaches exactly 90° is governed directly by Snell's law.

Solution:

Step 1: Write down the general statement of Snell's law governing the refraction of light across a flat interface separating two distinct optical mediums: $n_1 \sin \theta_1 = n_2 \sin \theta_2$, where n represents the absolute refractive indices.

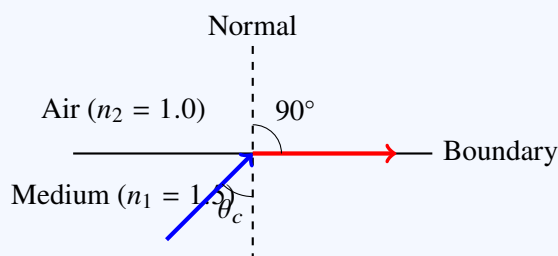
Step 2: Set up the parameters given in the problem: the light ray originates inside the optically denser core medium with an index $n_1 = 1.5$ and travels toward the surrounding air medium which has an index $n_2 = 1.0$.

Step 3: Define the critical state where the incidence angle matches the critical angle ($\theta_1 = \theta_c$). By definition, this specific condition forces the emerging light ray to skim along the interface, meaning the angle of refraction is exactly $\theta_2 = 90^\circ$.

Step 4: Substitute these boundary values into the Snell's law equation to isolate the angular variable:

$$1.5 \times \sin \theta_c = 1.0 \times \sin(90^\circ) \implies 1.5 \sin \theta_c = 1.0 \times 1 = 1.0$$

$$\sin \theta_c = \frac{1}{1.5} \implies \theta_c = \arcsin\left(\frac{1}{1.5}\right)$$

**Final Answer:**

$$\arcsin\left(\frac{1}{1.5}\right)$$

Answer: (B)[Go Back to Question 28](#)

Q29.

Solution

Concept: The three kinematic equations for motion with constant acceleration are fundamental relationships: 1. $v = u + at$ (relates velocity, acceleration, and time) 2. $s = ut + \frac{1}{2}at^2$ (relates displacement, time, initial velocity, and acceleration) 3. $v^2 = u^2 + 2as$ (relates final and initial velocities, acceleration, and displacement) All three equations are valid for constant acceleration and can be derived from each other.

Solution:

- (a) First equation: $v = u + at$ relates velocity to time
- (b) Second equation: $s = ut + \frac{1}{2}at^2$ relates displacement to time
- (c) Third equation: $v^2 = u^2 + 2as$ relates velocities and displacement (no time)
- (d) These three equations are interdependent and all equally valid
- (e) Derived from the definitions: $a = \frac{dv}{dt}$ and $v = \frac{ds}{dt}$
- (f) All three are fundamental kinematic relationships for constant acceleration

Final Answer: All of the above

Answer: (D)

[Go Back to Question 29](#)



Q30.

Solution

Concept: For resistors in parallel, the equivalent resistance is found using: $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2}$. The key property of parallel circuits is that the equivalent resistance is always less than the smallest individual resistance. This is because parallel paths provide multiple routes for current, reducing overall opposition.

Solution:

(a) Given: $R_1 > R_2$ (let's say $R_1 = 6 \Omega$ and $R_2 = 3 \Omega$ for example)

(b) Parallel formula: $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2}$

(c) Since both terms are positive: $\frac{1}{R_{\text{eq}}} = \frac{1}{6} + \frac{1}{3} = \frac{1}{6} + \frac{2}{6} = \frac{3}{6} = \frac{1}{2}$

(d) So: $R_{\text{eq}} = 2 \Omega$

(e) Note: $2 \Omega < 3 \Omega < 6 \Omega$

(f) General rule: $R_{\text{eq}} < R_2 < R_1$ for parallel resistors

(g) The equivalent is between the two values when in series, but less than the smaller value when in parallel

Final Answer: The equivalent resistance is less than R_2

Answer: (B)

[Go Back to Question 30](#)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	A	4	C	5	A
6	A	7	C	8	A	9	B	10	B
11	C	12	B	13	A	14	A	15	A
16	D	17	D	18	C	19	A	20	D
21	B	22	B	23	B	24	B	25	B
26	B	27	B	28	B	29	D	30	B

