AIIMS Paramedical Physics

Sample Paper – 2

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. A penalty of $-\frac{1}{3}$ **mark** is deducted for each incorrect answer; unattempted questions carry **0** marks.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 NCERT Physics**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. Two forces of magnitudes 8 N and 6 N act at a point and the angle between them is $90°$. What is the magnitude of their resultant?

(A) 2 N

(B) 7 N

(C) 10 N

(D) 14 N

Q2. A boat can travel at 5 m s^{-1} in still water. It crosses a river 200 m wide that flows at 3 m s^{-1}. If the boatman heads the boat straight across (to take the shortest time), how long does the crossing take?

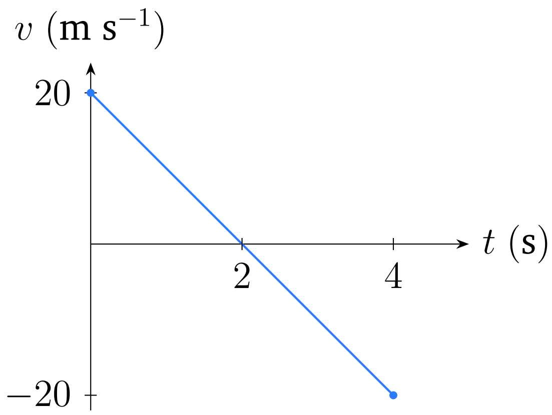
(A) 25 s

(B) 40 s

(C) 50 s

(D) 67 s

Q3. The velocity–time graph below describes a ball thrown vertically upward (taking upward as positive). Using the graph, the maximum height reached by the ball above the point of projection is



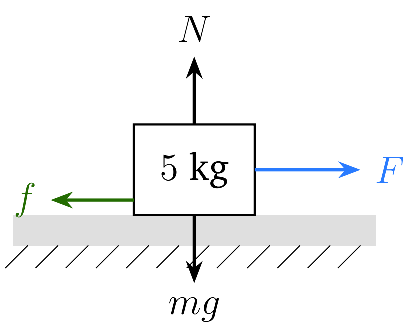
(A) 20 m

(B) 40 m

(C) 10 m

(D) 80 m

Q4. A block of mass 5 kg rests on a rough horizontal floor for which the coefficient of static friction is $\mu_s = 0.4$. Take $g = 10$ m s^{-2}. The minimum horizontal force needed to just set the block moving is



(A) 10 N

(B) 20 N

(C) 25 N

(D) 50 N

Q5. A person of mass 60 kg stands on a weighing machine inside a lift. The lift accelerates downward at 2 m s^{-2}. Taking $g = 10 \text{ m s}^{-2}$, the reading of the machine (apparent weight) is

(A) 720 N

(B) 600 N

(C) 120 N

(D) 480 N

Q6. A spring of force constant 200 N m^{-1} is compressed by 0.1 m and used to launch a block of mass 0.4 kg along a frictionless horizontal surface. The speed acquired by the block is

(A) 1 m s^{-1}

(B) 1.5 m s^{-1}

(C) $\sqrt{5} \text{ m s}^{-1}$

(D) 5 m s^{-1}

Q7. A ball of mass 2 kg moving at 6 m s^{-1} makes a head-on elastic collision with a stationary ball of mass 4 kg. The velocity of the 2 kg ball just after the collision is

(A) -2 m s^{-1}

(B) $+2 \text{ m s}^{-1}$

(C) $+4 \text{ m s}^{-1}$

(D) 0 m s^{-1}

Q8. A disc rotating about its central axis at angular speed ω has moment of inertia I. A second identical disc (same I) at rest is gently dropped coaxially onto it, and the two rotate together. The common angular speed is

(A) 2ω

(B) $\frac{\omega}{2}$

(C) ω

(D) $\frac{\omega}{4}$

Q9. The escape velocity from the surface of the Earth is 11.2 km s^{-1}. For a planet having the same density as Earth but twice its radius, the escape velocity would be approximately

(A) 5.6 km s^{-1}

(B) 11.2 km s^{-1}

(C) 15.8 km s^{-1}

(D) 22.4 km s^{-1}

Q10. A small spherical raindrop of radius r falls through air with terminal velocity v. A second drop of radius $2r$ of the same liquid falls through the same air. Its terminal velocity is

(A) v

(B) $2v$

(C) $4v$

(D) $8v$

Q11. A metal rod of length 0.5 m and uniform cross-sectional area 4×10^{-4} m^2 has its ends maintained at $100°$C and $0°$C. If the thermal conductivity of the metal is 50 W m^{-1} K^{-1}, the rate of heat flow through the rod in steady state is

(A) 4 W

(B) 8 W

(C) 2 W

(D) 1 W

Q12. The root-mean-square speed of the molecules of an ideal gas at temperature T is v. If the absolute temperature is raised to $4T$, the new rms speed becomes

(A) v

(B) $2v$

(C) $4v$

(D) $\frac{v}{2}$

Q13. The time period of a simple pendulum is 2 s. To make its time period 4 s (at the same place), its length should be

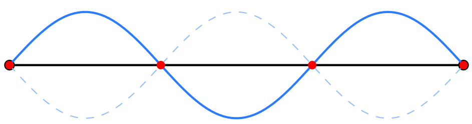
(A) doubled

(B) halved

(C) kept the same

(D) made four times the original

Q14. A string fixed at both ends vibrates in the standing-wave pattern shown below. The length of the string is 1.2 m and the wave speed on it is 120 m s^{-1}. The frequency of this mode of vibration is



fixed–fixed, three loops

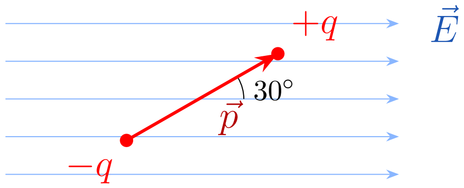
(A) 50 Hz

(B) 100 Hz

(C) 150 Hz

(D) 200 Hz

Q15. An electric dipole of dipole moment $p = 4 \times 10^{-9}$ C m is placed in a uniform electric field $E = 5 \times 10^{4}$ N C^{-1} such that the dipole axis makes an angle of 30° with the field, as shown. The torque acting on the dipole is



(A) 1.0×10^{-4} N m

(B) 2.0×10^{-4} N m

(C) $\sqrt{3} \times 10^{-4}$ N m

(D) 0.5×10^{-4} N m

Q16. A solid conducting sphere of radius 10 cm carries a total charge of 2×10^{-9} C. Taking $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^{2}C^{-2}, the electric field at a point 5 cm from the centre (inside the sphere) is

(A) 720 N C^{-1}

(B) 0

(C) 1800 N C^{-1}

(D) 180 N C^{-1}

Q17. A parallel-plate capacitor has capacitance 6 μF with air between its plates. When a slab of dielectric constant $K = 4$ completely fills the gap (plate separation and area unchanged), the new capacitance is

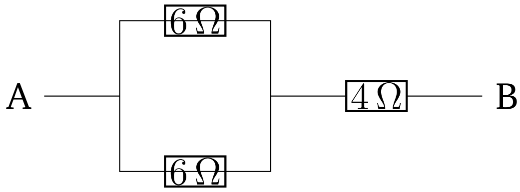
(A) 1.5 μF

(B) 6 μF

(C) 10 μF

(D) 24 μF

Q18. In the network shown, the two 6 Ω resistors are in parallel and that combination is in series with the 4 Ω resistor. The equivalent resistance between terminals A and B is



(A) $16\ \Omega$

(B) $12\ \Omega$

(C) $7\ \Omega$

(D) $3\ \Omega$

Q19. In a metre-bridge experiment, the unknown resistance X is in the left gap and a known resistance $R = 30\ \Omega$ is in the right gap. The balance point (null point) is found at 40 cm from the left end. The value of X is

(A) $45\ \Omega$

(B) $30\ \Omega$

(C) $40\ \Omega$

(D) $20\ \Omega$

Q20. Two identical electric bulbs each rated for the same supply are first connected in series and then in parallel across the same source. The ratio of the total power consumed in series to that in parallel is

(A) $1 : 4$

(B) $4 : 1$

(C) $1 : 2$

(D) $1 : 1$

Q21. Two long straight parallel wires, 0.2 m apart, each carry a current of 10 A in the same direction. Taking $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}, the force per unit length between them is

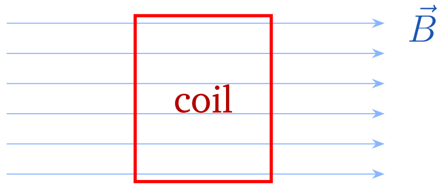
(A) 5×10^{-5} N m^{-1}, repulsive

(B) 1×10^{-4} N m^{-1}, attractive

(C) 1×10^{-4} N m^{-1}, repulsive

(D) 2×10^{-4} N m^{-1}, attractive

Q22. A rectangular coil of 50 turns and area 2×10^{-3} m^2 carries a current of 0.4 A. It is placed in a uniform magnetic field of 0.1 T with the plane of the coil parallel to the field, as shown. The torque on the coil is



plane || field

(A) 1×10^{-3} N m

(B) 2×10^{-3} N m

(C) 4×10^{-3} N m

(D) 8×10^{-3} N m

Q23. A current of 4 A flows through a coil of self-inductance 0.5 H. The energy stored in the magnetic field of the coil is

(A) 1 J

(B) 2 J

(C) 8 J

(D) 4 J

Q24. A series LCR circuit has $L = 2$ H and $C = 8$ μF. The angular frequency at which the circuit is in resonance is

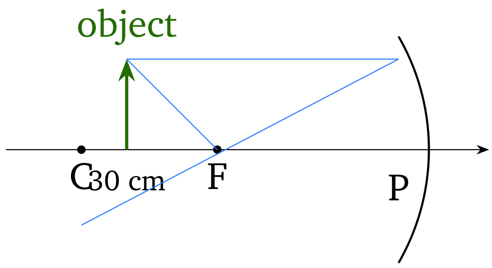
(A) 250 rad s^{-1}

(B) 500 rad s^{-1}

(C) 125 rad s^{-1}

(D) 1000 rad s^{-1}

Q25. An object is placed 30 cm in front of a concave mirror of focal length 20 cm. Using the ray diagram below, the image distance from the mirror is



(A) −30 cm

(B) −60 cm

(C) −12 cm

(D) +60 cm

Q26. The objective and eyepiece of a compound microscope produce linear magnifications of 5 and 8 respectively. The total magnifying power of the microscope is

(A) 13

(B) 3

(C) 40

(D) 1.6

Q27. Light is incident from air onto the surface of a transparent medium of refractive index $\sqrt{3}$. The angle of incidence at which the reflected light is completely plane polarised (Brewster's angle) is

(A) 60°

(B) 30°

(C) 45°

(D) 90°

Q28. A particle of mass 2×10^{-30} kg moves with a speed of 5×10^{6} m s^{-1}. Taking Planck's constant $h = 6.6 \times 10^{-34}$ J s, its de Broglie wavelength is

(A) 3.3×10^{-11} m

(B) 6.6×10^{-11} m

(C) 1.3×10^{-10} m

(D) 6.6×10^{-10} m

Q29. A radioactive sample has a half-life of 5 years. The fraction of the original nuclei that remain undecayed after 15 years is

(A) $\frac{1}{2}$

(B) $\frac{1}{4}$

(C) $\frac{1}{8}$

(D) $\frac{1}{16}$

Q30. A Zener diode of breakdown voltage 6 V is used as a voltage regulator. It is connected in reverse bias across a load through a series resistor, and the unregulated input is 10 V. If the series resistance is 200 Ω and the load draws 10 mA, the current flowing through the Zener diode is

(A) 20 mA

(B) 30 mA

(C) 5 mA

(D) 10 mA

Detailed Solutions

Q1.

Solution

Concept — Resultant of two perpendicular vectors: When two vectors of magnitudes A and B act at 90°, the magnitude of their resultant is $R = \sqrt{A^2 + B^2}$.

Step 1 — Identify the magnitudes: Here $A = 8$ N and $B = 6$ N, with the angle between them $\theta = 90^\circ$.

Step 2 — Apply the formula:

$$R = \sqrt{8^2 + 6^2} = \sqrt{64 + 36}.$$

Step 3 — Simplify:

$$R = \sqrt{100} = 10 \text{ N}.$$

Why other options are wrong:

- 2 N: that is $|A - B|$, the resultant only when the vectors are anti-parallel (180°).
- 14 N: that is $A + B$, the resultant only when the vectors are parallel (0°).
- 7 N: not obtained from any standard combination here.

Final Answer: $R = 10 \text{ N} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 1

Q2.

Solution

Concept — Shortest-time crossing: For the shortest time to cross a river, the boat is headed straight across (perpendicular to the bank). The time depends only on the width and the boat's own speed across the stream; the current merely drifts the boat downstream.

Step 1 — Component used for crossing: Heading straight across, the full boat speed $v_b = 5 \text{ m s}^{-1}$ is directed across the river.

Step 2 — Compute the time:

$$t = \frac{\text{width}}{v_b} = \frac{200}{5}.$$

Step 3 — Simplify:

$$t = 40 \text{ s}.$$

Why other options are wrong:

- 50 s: comes from using the resultant ground speed $\sqrt{5^2 + 3^2} = \sqrt{34}$ incorrectly, or from $200/4$ (using $\sqrt{5^2 - 3^2} = 4$, the shortest-path case, not shortest time).
- 25 s: uses $200/8$, adding speeds wrongly.
- 67 s: uses $200/3$, the current speed, which is irrelevant to crossing time.

Final Answer: $t = 40$ s $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 2

Q3.

Solution

Concept — Area under a v–t graph: The displacement equals the area between the velocity curve and the time axis. The maximum height is reached when $v = 0$, i.e. at the instant the line crosses the time axis.

Step 1 — Read the graph: The velocity starts at $+20$ m s^{-1} at $t = 0$ and reaches 0 at $t = 2$ s (the upward journey).

Step 2 — Area for the upward trip: The shape is a triangle with base 2 s and height 20 m s^{-1}:

$$H = \tfrac{1}{2} \times \text{base} \times \text{height} = \tfrac{1}{2} \times 2 \times 20.$$

Step 3 — Simplify:

$$H = 20 \text{ m}.$$

Why other options are wrong:

- 40 m: uses base 4 s (whole trip) instead of the up-journey only; that area is zero net.
- 10 m: forgets the factor or halves wrongly.
- 80 m: multiplies without the $\frac{1}{2}$ factor and uses the full time.

Final Answer: Maximum height $= 20$ m $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 3

Q4.

Solution

Concept — Limiting static friction: A block on a horizontal floor begins to move when the applied horizontal force just exceeds the maximum static friction $f_{\max} = \mu_s N$. On a horizontal surface with no vertical applied force, $N = mg$.

Step 1 — Normal reaction:

$$N = mg = 5 \times 10 = 50 \text{ N}.$$

Step 2 — Maximum static friction:

$$f_{\max} = \mu_s N = 0.4 \times 50.$$

Step 3 — Minimum force to move: The block just starts moving when $F = f_{\max}$:

$$F = 20 \text{ N}.$$

Why other options are wrong:

- 10 N: uses $\mu_s mg$ with g halved or μ_s misread.
- 25 N: half of mg, ignores μ_s.
- 50 N: equals mg, but friction is only a fraction μ_s of this.

Final Answer: $F = 20 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 4

Q5.

Solution

Concept — Apparent weight in a lift: The weighing machine reads the normal reaction N. For a lift accelerating downward with acceleration a, Newton's second law gives $mg - N = ma$, so $N = m(g - a)$.

Step 1 — Substitute values: $m = 60$ kg, $g = 10$ m s^{-2}, $a = 2$ m s^{-2} (downward):

$$N = 60 \times (10 - 2).$$

Step 2 — Simplify:

$$N = 60 \times 8 = 480 \text{ N}.$$

Why other options are wrong:

- 600 N: the true weight mg, valid only when the lift is at rest or moving uniformly.
- 720 N: $m(g+a)$, the value for upward acceleration.
- 120 N: $m \times a$, only the inertial part, not the reaction.

Final Answer: Reading $= 480$ N $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 5

Q6.

Solution

Concept — Conservation of mechanical energy: On a frictionless surface, the elastic potential energy stored in the compressed spring converts entirely into the kinetic energy of the block: $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$.

Step 1 — Spring potential energy:

$$U = \tfrac{1}{2}kx^2 = \tfrac{1}{2} \times 200 \times (0.1)^2 = \tfrac{1}{2} \times 200 \times 0.01 = 1 \text{ J}.$$

Step 2 — Equate to kinetic energy:

$$\tfrac{1}{2}mv^2 = 1 \;\Rightarrow\; \tfrac{1}{2} \times 0.4 \times v^2 = 1.$$

Step 3 — Solve for v:

$$0.2\,v^2 = 1 \;\Rightarrow\; v^2 = \frac{1}{0.2} = 5 \;\Rightarrow\; v = \sqrt{5} \text{ m s}^{-1} \approx 2.24 \text{ m s}^{-1}.$$

Why other options are wrong:

- 5 m s^{-1}: this equals v^2, not v; forgetting the square root.
- 1 m s^{-1}: uses $U = mv$ instead of $\frac{1}{2}mv^2$.
- 1.5 m s^{-1}: arbitrary, not from energy conservation.

Final Answer: $v = \sqrt{5} \approx 2.24$ m s^{-1} $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 6

Q7.

Solution

Concept — 1D elastic collision: For a mass m_1 moving at u_1 hitting a stationary mass m_2, the final velocity of m_1 is

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2} u_1.$$

Step 1 — Substitute values: $m_1 = 2$ kg, $m_2 = 4$ kg, $u_1 = 6 \text{ m s}^{-1}$:

$$v_1 = \frac{2-4}{2+4} \times 6 = \frac{-2}{6} \times 6.$$

Step 2 — Simplify:

$$v_1 = -2 \text{ m s}^{-1}.$$

The negative sign means the lighter ball rebounds (moves opposite to its original direction), which is expected when it strikes a heavier ball.

Why other options are wrong:

- $+2 \text{ m s}^{-1}$: correct magnitude but wrong sign; a lighter ball cannot continue forward after an elastic hit on a heavier one.
- $+4 \text{ m s}^{-1}$: this is the velocity of the struck heavier ball (v_2), not of m_1.
- 0 m s^{-1}: would require equal masses.

Final Answer: $v_1 = -2 \text{ m s}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 7

Q8.

Solution

Concept — Conservation of angular momentum: No external torque acts during the gentle coupling, so total angular momentum is conserved: $L_i = L_f$.

Step 1 — Initial angular momentum: Only the first disc spins:

$$L_i = I\omega.$$

Step 2 — Final angular momentum: Both discs spin together with moment of inertia $I + I = 2I$ at common speed ω':

$$L_f = 2I\,\omega'.$$

Step 3 — Equate and solve:

$$I\omega = 2I\,\omega' \;\Rightarrow\; \omega' = \frac{\omega}{2}.$$

Why other options are wrong:

- 2ω: would violate conservation; adding mass cannot speed up the rotation.
- ω: ignores the doubling of moment of inertia.
- $\frac{\omega}{4}$: comes from doubling I twice, an error.

Final Answer: $\omega' = \frac{\omega}{2} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 8

Q9.

Solution

Concept — Escape velocity and density: Escape velocity is $v_e = \sqrt{\frac{2GM}{R}}$. Writing the mass in terms of density ρ, $M = \frac{4}{3}\pi R^3\rho$, gives $v_e = R\sqrt{\frac{8\pi G\rho}{3}}$. So for fixed density, $v_e \propto R$.

Step 1 — Use the proportionality: Same density, radius doubled:

$$\frac{v_e'}{v_e} = \frac{R'}{R} = 2.$$

Step 2 — Compute:

$$v_e' = 2 \times 11.2 = 22.4\ \text{km s}^{-1}.$$

Why other options are wrong:

- 11.2 km s^{-1}: assumes no change, ignoring the larger radius.
- 15.8 km s^{-1}: this is $11.2\sqrt{2}$, the result if only M scaled as R (wrong scaling).
- 5.6 km s^{-1}: halves the value, the opposite of the correct trend.

Final Answer: $v_e' = 22.4\ \text{km s}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 9

Q10.

Solution

Concept — Terminal velocity (Stokes' law): For a sphere falling through a viscous fluid, the terminal velocity is $v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$, so $v_t \propto r^2$ when the liquid and fluid are unchanged.

Step 1 — Use the proportionality: Radius increases from r to $2r$:

$$\frac{v_2}{v} = \left(\frac{2r}{r}\right)^2 = 4.$$

Step 2 — Compute:

$$v_2 = 4v.$$

Why other options are wrong:

- $2v$: assumes $v_t \propto r$ instead of r^2.
- $8v$: assumes $v_t \propto r^3$ (mass scaling), but drag balances differently.
- v: ignores the size change entirely.

Final Answer: $v_2 = 4v \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Steady-state conduction: The rate of heat flow along a rod is $\frac{Q}{t} = \frac{kA\,\Delta T}{L}$, where k is thermal conductivity, A the area, ΔT the temperature difference, and L the length.

Step 1 — List the values: $k = 50$ W m^{-1}K^{-1}, $A = 4 \times 10^{-4}$ m^2, $\Delta T = 100 - 0 = 100$ K, $L = 0.5$ m.

Step 2 — Substitute:

$$\frac{Q}{t} = \frac{50 \times (4 \times 10^{-4}) \times 100}{0.5}.$$

Step 3 — Simplify:

$$\frac{Q}{t} = \frac{50 \times 4 \times 10^{-4} \times 100}{0.5} = \frac{2}{0.5} = 4 \text{ W}.$$

Why other options are wrong:

- 8 W: forgets to divide by $L = 0.5$ correctly (multiplies instead).
- 2 W: leaves out the factor from ΔT or L.
- 1 W: divides by an extra factor.

Final Answer: $\frac{Q}{t} = 4 \text{ W} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — RMS speed and temperature: The rms speed of an ideal gas is $v_{rms} = \sqrt{\frac{3RT}{M}}$, so $v_{rms} \propto \sqrt{T}$.

Step 1 — Use the proportionality: Temperature changes from T to $4T$:

$$\frac{v'}{v} = \sqrt{\frac{4T}{T}} = \sqrt{4} = 2.$$

Step 2 — Compute:

$$v' = 2v.$$

Why other options are wrong:

- $4v$: wrongly takes $v_{rms} \propto T$ instead of $\sqrt{T}$.
- v: ignores the temperature change.
- $\frac{v}{2}$: corresponds to lowering the temperature, the opposite trend.

Final Answer: $v' = 2v \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 12

Q13.

Solution

Concept — Simple pendulum: The time period is $T = 2\pi\sqrt{\frac{L}{g}}$, so $T \propto \sqrt{L}$ at a fixed place.

Step 1 — Set up the ratio: To double the period (2 s $\to 4$ s):

$$\frac{T_2}{T_1} = \sqrt{\frac{L_2}{L_1}} = \frac{4}{2} = 2.$$

Step 2 — Solve for the length:

$$\frac{L_2}{L_1} = 2^2 = 4 \;\Rightarrow\; L_2 = 4L_1.$$

The length must be made four times the original.

Why other options are wrong:

- doubled: doubling L multiplies T by $\sqrt{2}$, not 2.
- halved: halving L shortens the period.
- kept the same: the period would not change.

Final Answer: Length made four times the original $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 13

Q14.

Solution

Concept — Harmonics of a fixed-fixed string: A string fixed at both ends supports standing waves with $L = n\frac{\lambda}{2}$. The number of loops equals the harmonic number n; the frequency is $f = \frac{v}{\lambda} = \frac{nv}{2L}$.

Step 1 — Identify the mode: The figure shows three loops, so $n = 3$ (third harmonic).

Step 2 — Find the wavelength:

$$L = \frac{3\lambda}{2} \;\Rightarrow\; \lambda = \frac{2L}{3} = \frac{2 \times 1.2}{3} = 0.8 \text{ m}.$$

Step 3 — Find the frequency:

$$f = \frac{v}{\lambda} = \frac{120}{0.8} = 150 \text{ Hz}.$$

Why other options are wrong:

- 50 Hz: the fundamental ($n = 1$), not the shown mode.
- 100 Hz: the second harmonic ($n = 2$, two loops).
- 200 Hz: the fourth harmonic ($n = 4$, four loops).

Final Answer: $f = 150 \text{ Hz} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Torque on a dipole: An electric dipole of moment p in a uniform field E experiences a torque $\tau = pE\sin\theta$, where θ is the angle between $\vec{p}$ and $\vec{E}$.

Step 1 — List the values: $p = 4 \times 10^{-9}$ C m, $E = 5 \times 10^{4}$ N C^{-1}, $\theta = 30°$, $\sin 30° = \frac{1}{2}$.

Step 2 — Substitute:

$$\tau = pE\sin\theta = (4 \times 10^{-9})(5 \times 10^{4}) \times \tfrac{1}{2}.$$

Step 3 — Simplify:

$$\tau = (20 \times 10^{-5}) \times \tfrac{1}{2} = 10 \times 10^{-5} = 1.0 \times 10^{-4} \text{ N m}.$$

Why other options are wrong:

- 2.0×10^{-4} N m: uses $\sin 90° = 1$, the maximum-torque case.
- $\sqrt{3} \times 10^{-4}$ N m: uses $\sin 60°$ instead of $\sin 30°$.
- 0.5×10^{-4} N m: uses an extra factor of $\frac{1}{2}$.

Final Answer: $\tau = 1.0 \times 10^{-4} \text{ N m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 15

Q16.

Solution

Concept — Field inside a charged conductor: For a charged conducting sphere, all the charge resides on the surface. By Gauss's law, the electric field at any point inside the conductor is zero.

Step 1 — Locate the point: The point is 5 cm from the centre, which is inside the sphere of radius 10 cm.

Step 2 — Apply Gauss's law: A Gaussian sphere of radius 5 cm encloses no charge (all charge is on the 10 cm surface), so

$$E = 0.$$

Why other options are wrong:

- 720 N C^{-1}: comes from the field at the surface ($r = 10$ cm), not inside.
- 1800 N C^{-1}: uses $r = 10$ cm in a wrong formula or treats the charge as a point at 5 cm.
- 180 N C^{-1}: an arbitrary mid-value; the interior field is exactly zero.

Final Answer: $E = 0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 16

Q17.

Solution

Concept — Dielectric in a capacitor: Filling the gap of a parallel-plate capacitor with a dielectric of constant K multiplies the capacitance by K: $C' = KC_0$.

Step 1 — List the values: $C_0 = 6\ \mu$F, $K = 4$.

Step 2 — Compute:

$$C' = KC_0 = 4 \times 6 = 24\ \mu\text{F}.$$

Why other options are wrong:

- $1.5\ \mu$F: divides by K instead of multiplying.
- $6\ \mu$F: ignores the dielectric.
- $10\ \mu$F: adds K instead of multiplying.

Final Answer: $C' = 24\ \mu\text{F} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 17

Q18.

Solution

Concept — Series and parallel resistors: Equal resistors R in parallel give $R/2$. Series resistances simply add.

Step 1 — Combine the two $6\ \Omega$ in parallel:

$$R_p = \frac{6 \times 6}{6 + 6} = \frac{36}{12} = 3\ \Omega.$$

Step 2 — Add the series $4\ \Omega$:

$$R_{AB} = R_p + 4 = 3 + 4 = 7\ \Omega.$$

Why other options are wrong:

- $16\ \Omega$: adds all three in series $(6 + 6 + 4)$, ignoring the parallel connection.
- $12\ \Omega$: treats the two $6\ \Omega$ as series (12) and drops the $4\ \Omega$.
- $3\ \Omega$: stops at the parallel pair and forgets the series $4\ \Omega$.

Final Answer: $R_{AB} = 7\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 18

Q19.

Solution

Concept — Metre bridge balance: At the null point, $\frac{X}{R} = \frac{l}{100 - l}$, where l is the balance length from the left end and X is in the left gap.

Step 1 — List the values: $R = 30\ \Omega$, $l = 40$ cm, so $100 - l = 60$ cm.

Step 2 — Apply the relation:

$$X = R \times \frac{l}{100 - l} = 30 \times \frac{40}{60}.$$

Step 3 — Simplify:

$$X = 30 \times \frac{2}{3} = 20\ \Omega.$$

Why other options are wrong:

- $45\ \Omega$: inverts the ratio, using $\frac{60}{40}$.
- $30\ \Omega$: assumes balance at the centre (50 cm).
- $40\ \Omega$: confuses the length value with resistance.

Final Answer: $X = 20\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 19

Q20.

Solution

Concept — Power of identical resistors: Each bulb has fixed resistance R. Across the same source voltage V, the total power is $P = \frac{V^2}{R_{eq}}$, so smaller equivalent resistance means larger power.

Step 1 — Series equivalent: Two bulbs in series: $R_{series} = 2R$, so

$$P_{series} = \frac{V^2}{2R}.$$

Step 2 — Parallel equivalent: Two bulbs in parallel: $R_{parallel} = \frac{R}{2}$, so

$$P_{parallel} = \frac{V^2}{R/2} = \frac{2V^2}{R}.$$

Step 3 — Take the ratio:

$$\frac{P_{series}}{P_{parallel}} = \frac{V^2/2R}{2V^2/R} = \frac{1}{4}.$$

Why other options are wrong:

- $4:1$: inverts the ratio; parallel actually consumes more power.
- $1:2$ and $1:1$: do not follow from $P \propto 1/R_{eq}$ with the factor-of-4 change.

Final Answer: $P_{series} : P_{parallel} = 1:4 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 20

Q21.

Solution

Concept — Force between parallel currents: Two long parallel wires carrying currents I_1 and I_2 separated by distance d exert a force per unit length $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$. Currents in the same direction attract.

Step 1 — List the values: $I_1 = I_2 = 10$ A, $d = 0.2$ m, $\mu_0 = 4\pi \times 10^{-7}$.

Step 2 — Substitute:

$$\frac{F}{L} = \frac{(4\pi \times 10^{-7})(10)(10)}{2\pi \times 0.2}.$$

Step 3 — Simplify:

$$\frac{F}{L} = \frac{4\pi \times 10^{-7} \times 100}{0.4\pi} = \frac{400\pi \times 10^{-7}}{0.4\pi} = 1000 \times 10^{-7} = 1 \times 10^{-4}\ \text{N m}^{-1}.$$

Same-direction currents attract, so the force is attractive.

Why other options are wrong:

- 1×10^{-4} repulsive: same magnitude but wrong nature; same-direction currents attract.
- 5×10^{-5} repulsive: wrong magnitude (off by a factor of 2) and wrong nature.
- 2×10^{-4} attractive: uses $d = 0.1$ m instead of 0.2 m.

Final Answer: $\frac{F}{L} = 1 \times 10^{-4}$ N m^{-1}, attractive $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) **Go Back to Q 21**

Q22.

Solution

Concept — Torque on a current loop: A coil of N turns, area A, carrying current I in a field B has torque $\tau = NIAB \sin\theta$, where θ is the angle between the field and the coil's normal. When the plane of the coil is parallel to the field, the normal is perpendicular to B, so $\theta = 90^\circ$ and $\sin\theta = 1$ (maximum torque).

Step 1 — List the values: $N = 50$, $A = 2 \times 10^{-3}$ m^2, $I = 0.4$ A, $B = 0.1$ T, $\sin\theta = 1$.

Step 2 — Substitute:

$$\tau = NIAB = 50 \times 0.4 \times (2 \times 10^{-3}) \times 0.1.$$

Step 3 — Simplify:

$$\tau = 50 \times 0.4 \times 0.1 \times 2 \times 10^{-3} = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3}\ \text{N m}.$$

Why other options are wrong:

- 2×10^{-3} N m: drops a factor of 2 (e.g. misreads the area).
- 1×10^{-3} N m: uses the plane perpendicular to the field ($\sin\theta = 0$ region) wrongly.
- 8×10^{-3} N m: doubles the current or area.

Final Answer: $\tau = 4 \times 10^{-3}$ N m $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 22

Q23.

Solution

Concept — Energy stored in an inductor: The magnetic energy stored in an inductor carrying current I is $U = \frac{1}{2}LI^2$.

Step 1 — List the values: $L = 0.5$ H, $I = 4$ A.

Step 2 — Substitute:

$$U = \frac{1}{2} \times 0.5 \times (4)^2 = \frac{1}{2} \times 0.5 \times 16.$$

Step 3 — Simplify:

$$U = \frac{1}{2} \times 8 = 4\ \text{J}.$$

Why other options are wrong:

- 8 J: forgets the factor $\frac{1}{2}$.
- 2 J: uses I instead of I^2 partly.
- 1 J: uses $\frac{1}{2}LI$ without squaring the current.

Final Answer: $U = 4$ J $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 23

Q24.

Solution

Concept — Resonance in a series LCR circuit: At resonance the inductive and capacitive reactances cancel, and the resonant angular frequency is $\omega_0 = \frac{1}{\sqrt{LC}}$.

Step 1 — List the values: $L = 2$ H, $C = 8 \times 10^{-6}$ F.

Step 2 — Compute the product LC:

$$LC = 2 \times 8 \times 10^{-6} = 16 \times 10^{-6}.$$

Step 3 — Take the reciprocal square root:

$$\omega_0 = \frac{1}{\sqrt{16 \times 10^{-6}}} = \frac{1}{4 \times 10^{-3}} = 250 \text{ rad s}^{-1}.$$

Why other options are wrong:

- 500 rad s^{-1}: uses $\sqrt{LC} = 2 \times 10^{-3}$, dropping a factor of 2.
- 125 rad s^{-1}: doubles $\sqrt{LC}$ instead.
- 1000 rad s^{-1}: ignores the factor of L.

Final Answer: $\omega_0 = 250 \text{ rad s}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 24

Q25.

Solution

Concept — Mirror formula: For a mirror, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$. Using the sign convention, a concave mirror has $f < 0$ and a real object has $u < 0$.

Step 1 — Assign signs: $f = -20$ cm, $u = -30$ cm.

Step 2 — Substitute into the mirror formula:

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-20} - \frac{1}{-30} = -\frac{1}{20} + \frac{1}{30}.$$

Step 3 — Combine the fractions:

$$\frac{1}{v} = \frac{-3+2}{60} = -\frac{1}{60} \Rightarrow v = -60 \text{ cm}.$$

The image is real and forms 60 cm in front of the mirror.

Why other options are wrong:

- -30 cm: would place the image at the object; that is not the solution of the formula.
- -12 cm: comes from adding the reciprocals with wrong signs.
- $+60$ cm: a virtual image (behind the mirror), which does not occur for an object beyond f in a concave mirror.

Final Answer: $v = -60$ cm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 25

Q26.

Solution

Concept — Magnification of a compound microscope: The total magnifying power is the product of the magnifications of the objective and the eyepiece: $M = m_o \times m_e$.

Step 1 — List the values: $m_o = 5$, $m_e = 8$.

Step 2 — Multiply:

$$M = 5 \times 8 = 40.$$

Why other options are wrong:

- 13: adds the magnifications instead of multiplying.
- 3: subtracts them.
- 1.6: divides them.

Final Answer: $M = 40 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 26

Q27.

Solution

Concept — Brewster's law: The angle of incidence at which reflected light is fully plane polarised satisfies $\tan\theta_B = n$, where n is the refractive index of the medium.

Step 1 — Apply Brewster's law: $n = \sqrt{3}$, so

$$\tan\theta_B = \sqrt{3}.$$

Step 2 — Solve for θ_B:

$$\theta_B = \tan^{-1}(\sqrt{3}) = 60^\circ.$$

Why other options are wrong:

- 30°: $\tan 30^\circ = 1/\sqrt{3}$, which corresponds to $n = 1/\sqrt{3} < 1$, impossible for a denser medium.
- 45°: $\tan 45^\circ = 1$, the value for $n = 1$ (no refraction contrast).
- 90°: grazing incidence, not Brewster's angle.

Final Answer: $\theta_B = 60^\circ \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 27

Q28.

Solution

Concept — de Broglie wavelength: A particle of momentum $p = mv$ has wavelength $\lambda = \frac{h}{mv}$.

Step 1 — List the values: $h = 6.6\times10^{-34}$ J s, $m = 2\times10^{-30}$ kg, $v = 5\times10^{6}$ m s^{-1}.

Step 2 — Compute the momentum:

$$mv = (2\times10^{-30})(5\times10^{6}) = 10\times10^{-24} = 1\times10^{-23}\ \text{kg m s}^{-1}.$$

Step 3 — Compute the wavelength:

$$\lambda = \frac{6.6\times10^{-34}}{1\times10^{-23}} = 6.6\times10^{-11}\ \text{m}.$$

Why other options are wrong:

- 3.3×10^{-11} m: divides h by twice the momentum.
- 1.3×10^{-10} m: doubles the wavelength (momentum halved).
- 6.6×10^{-10} m: a power-of-ten slip (10^{-24} used for mv).

Final Answer: $\lambda = 6.6 \times 10^{-11}$ m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 28

Q29.

Solution

Concept — Radioactive decay: After n half-lives, the undecayed fraction is $\left(\frac{1}{2}\right)^n$, where $n = \frac{t}{T_{1/2}}$.

Step 1 — Find the number of half-lives:

$$n = \frac{t}{T_{1/2}} = \frac{15}{5} = 3.$$

Step 2 — Compute the remaining fraction:

$$\left(\frac{1}{2}\right)^3 = \frac{1}{8}.$$

Why other options are wrong:

- $\frac{1}{2}$: after one half-life (5 years) only.
- $\frac{1}{4}$: after two half-lives (10 years).
- $\frac{1}{16}$: after four half-lives (20 years).

Final Answer: Remaining fraction $= \frac{1}{8} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — Zener voltage regulator: A Zener diode in reverse breakdown holds the load voltage at its breakdown value V_Z. The series resistor carries the total current; by Kirchhoff's current law the Zener current is the series current minus the load current.

Step 1 — Voltage across the series resistor: The Zener clamps the output at $V_Z = 6$ V, so the drop across the $200\ \Omega$ resistor is

$$V_R = V_{in} - V_Z = 10 - 6 = 4 \text{ V}.$$

Step 2 — Series (total) current:

$$I_s = \frac{V_R}{R} = \frac{4}{200} = 0.02 \text{ A} = 20 \text{ mA}.$$

Step 3 — Zener current: The load draws 10 mA, so

$$I_Z = I_s - I_{load} = 20 - 10 = 10 \text{ mA}.$$

Why other options are wrong:

- 20 mA: the total series current, not the Zener share alone.
- 30 mA: adds the load current instead of subtracting it.
- 5 mA: uses a wrong resistor drop.

Final Answer: $I_Z = 10 \text{ mA} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 30

Answer Key

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