AIIMS Paramedical Physics

Sample Paper – 6

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 (no negative marking).
- 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. In the equation $v = a + \dfrac{b}{t}$, where v is velocity and t is time, the equation is dimensionally consistent. The dimensional formulae of a and b are respectively:

(A) $[LT^{-1}]$ and $[LT^{-2}]$

(B) $[LT^{-1}]$ and $[L]$

(C) $[LT^{-2}]$ and $[LT^{-1}]$

(D) $[L]$ and $[LT^{-1}]$

Q2. A stone is thrown horizontally with a speed of $15\ \text{m s}^{-1}$ from the top of a cliff of height 20 m. Taking $g = 10\ \text{m s}^{-2}$, the horizontal distance from the foot of the cliff at which it lands is:

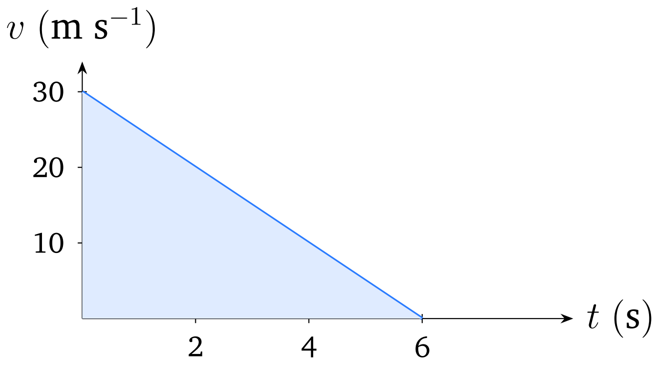
(A) 15 m

(B) 20 m

(C) 30 m

(D) 45 m

Q3. The velocity–time graph of a uniformly decelerating body is shown. The distance travelled by the body before it comes to rest is:



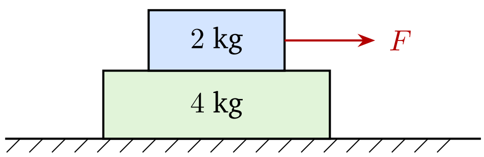
(A) 30 m

(B) 45 m

(C) 60 m

(D) 90 m

Q4. A block of mass 2 kg rests on top of a block of mass 4 kg, which itself rests on a smooth floor. The coefficient of friction between the two blocks is 0.4. The maximum horizontal force that can be applied to the upper block so that the two blocks move together is (take $g = 10$ m s^{-2}):



(A) 8 N

(B) 24 N

(C) 12 N

(D) 48 N

Q5. A body of mass 5 kg is suspended from a spring balance inside a lift. When the lift accelerates upward at 2 m s^{-2} (take $g = 10$ m s^{-2}), the reading of the spring balance is:

(A) 60 N

(B) 50 N

(C) 40 N

(D) 10 N

Q6. A bullet of mass 10 g is fired into a wooden block of mass 990 g suspended as a pendulum. After the bullet embeds, the block rises through a height of 20 cm. Taking $g = 10$ m s^{-2}, the initial speed of the bullet is:

(A) 100 m s^{-1}

(B) 150 m s^{-1}

(C) 50 m s^{-1}

(D) 200 m s^{-1}

Q7. A constant force of 50 N acts on a body initially at rest and moves it through 40 m in 4 s along the direction of the force. The average power developed during this interval is:

(A) 200 W

(B) 400 W

(C) 500 W

(D) 800 W

Q8. A flywheel of moment of inertia 0.5 kg m^2 rotates at an angular speed of 20 rad s^{-1}. Its rotational kinetic energy is:

(A) 100 J

(B) 200 J

(C) 50 J

(D) 400 J

Q9. A satellite revolves close to the surface of a planet of mean density ρ. The time period of revolution depends only on ρ and the gravitational constant G as $T = \sqrt{\frac{3\pi}{G\rho}}$. For a planet of density 5000 kg m^{-3} (take $G = \frac{20}{3} \times 10^{-11}$ SI units, $\pi^2 = 10$), the period is approximately:

(A) 4200 s

(B) 5300 s

(C) 6000 s

(D) 3600 s

Q10. A wire is stretched by a force F producing an elongation $\Delta L = 2$ mm. If the force applied is 200 N, the elastic potential energy stored in the wire is:

(A) 0.4 J

(B) 0.8 J

(C) 0.2 J

(D) 0.1 J

Q11. How much heat is required to convert 20 g of ice at 0°C into water at 30°C? (Take $L_f = 80$ cal g^{-1} and specific heat of water $= 1$ cal g^{-1} °C^{-1}.)

(A) 1600 cal

(B) 600 cal

(C) 1000 cal

(D) 2200 cal

Q12. An ideal gas at a constant pressure of 2×10^5 Pa expands from a volume of 1×10^{-3} m^3 to 3×10^{-3} m^3. The work done by the gas is:

(A) 400 J

(B) 200 J

(C) 600 J

(D) 800 J

Q13. A seconds pendulum (time period 2 s) is taken from the Earth to a planet where the acceleration due to gravity is one-fourth that on Earth. Its new time period is:

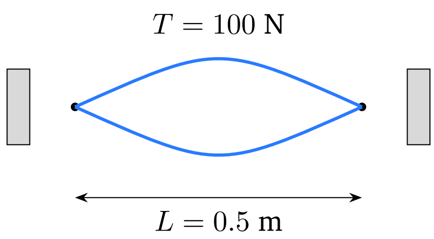
(A) 1 s

(B) 4 s

(C) 8 s

(D) 2 s

Q14. A sonometer wire of length 0.5 m has a mass per unit length of 0.01 kg m^{-1} and is stretched by a tension of 100 N. The fundamental frequency of vibration of the wire is:



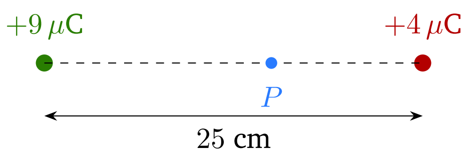
(A) 50 Hz

(B) 200 Hz

(C) 100 Hz

(D) 150 Hz

Q15. Two point charges $+9\ \mu$C and $+4\ \mu$C are placed 25 cm apart. The point on the line joining them where the resultant electric field is zero lies at a distance from the $+9\ \mu$C charge of:



(A) 15 cm

(B) 10 cm

(C) 12.5 cm

(D) 20 cm

Q16. A conducting spherical shell of radius 0.1 m carries a charge of 2×10^{-9} C. The electric potential at a point 0.05 m from the centre (i.e. inside the shell) is (take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ SI units):

(A) 360 V

(B) 180 V

(C) 90 V

(D) 0 V

Q17. A capacitor $C = 2\ \mu$F is charged through a resistor $R = 1$ MΩ by a battery of EMF 10 V. After one time constant ($t = \tau = RC$), the charge on the capacitor is (take $e^{-1} = 0.37$):

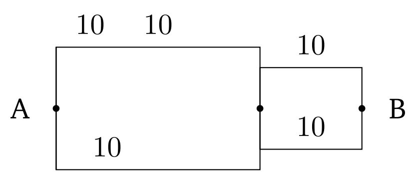
(A) 20 μC

(B) 7.4 μC

(C) 3.7 μC

(D) 12.6 μC

Q18. Five identical resistors each of $10\ \Omega$ are connected between A and B as shown: two are in series forming one branch, and this branch is in parallel with a single $10\ \Omega$ resistor; the result is then in series with the remaining two $10\ \Omega$ resistors (which are themselves in parallel). The equivalent resistance between A and B is:



(A) $11.7\ \Omega$

(B) $15\ \Omega$

(C) $11.\overline{6}\ \Omega$

(D) $20\ \Omega$

Q19. A battery of EMF 12 V and internal resistance $1\ \Omega$ is being charged by an external source that drives a current of 2 A through it (into the positive terminal). The terminal voltage across the battery during charging is:

(A) 14 V

(B) 10 V

(C) 12 V

(D) 24 V

Q20. An electric heater is rated 1000 W at 250 V. The minimum current rating of the fuse that should be used in its circuit is:

(A) 2 A

(B) 4 A

(C) 5 A

(D) 10 A

Q21. A straight wire of length 0.2 m carries a current of 5 A and is placed perpendicular to a uniform magnetic field of 0.3 T. The magnitude of the force on the wire is:

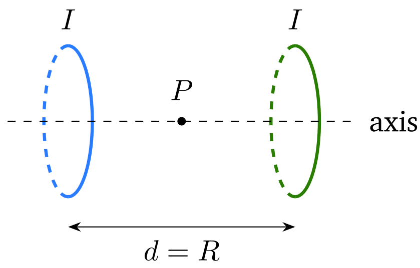
(A) 0.15 N

(B) 0.45 N

(C) 0.60 N

(D) 0.30 N

Q22. Two identical coaxial circular coils, each of N turns, radius R and carrying current I, are arranged as a Helmholtz pair. At the midpoint on the common axis each coil produces a field B_0 along the axis. The total magnetic field at the midpoint is:



(A) B_0

(B) $\frac{B_0}{2}$

(C) $2B_0$

(D) $4B_0$

Q23. The current through an inductor of inductance 0.4 H is 5 A. The energy stored in the magnetic field of the inductor is:

(A) 5 J

(B) 10 J

(C) 2 J

(D) 1 J

Q24. In a series AC circuit the voltage leads the current by a phase angle of $60°$. If the rms current is 2 A, the wattless component of the current is:

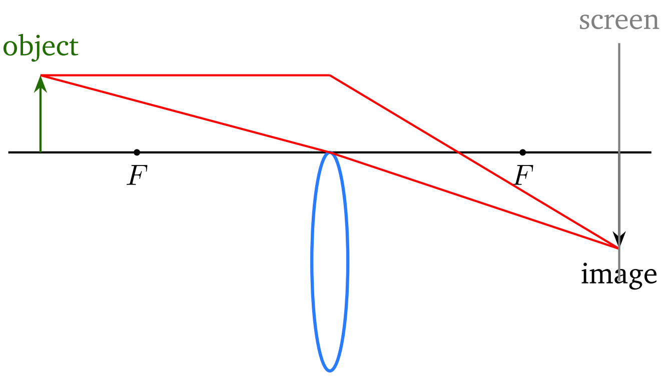
(A) 1 A

(B) 2 A

(C) 0 A

(D) $\sqrt{3}$ A

Q25. An object is placed 15 cm in front of a convex lens of focal length 10 cm, and a sharp image is formed on a screen. The magnification of the image is:



(A) -1

(B) -2

(C) -3

(D) $+2$

Q26. An astronomical telescope in normal adjustment has an objective of focal length 100 cm and an eyepiece of focal length 5 cm. Its magnifying power is:

(A) 5

(B) 10

(C) 20

(D) 25

Q27. Plane-polarized light of intensity I_0 passes through an analyser whose transmission axis is at 60° to the plane of polarization of the incident light. The intensity of the transmitted light is:

(A) $\frac{I_0}{2}$

(B) $\frac{I_0}{4}$

(C) $\frac{3I_0}{4}$

(D) I_0

Q28. An electron is accelerated from rest through a potential difference of 150 V. Its de Broglie wavelength is approximately:

(A) 0.1 nm

(B) 0.5 nm

(C) 0.05 nm

(D) 0.1 nm $(= 1\ \text{Å})$

Q29. The radius of a nucleus is given by $R = R_0 A^{1/3}$, where $R_0 = 1.2$ fm and A is the mass number. The nuclear mass density is best described as:

(A) independent of A (nearly constant for all nuclei)

(B) proportional to A

(C) proportional to $A^{1/3}$

(D) proportional to $A^{2/3}$

Q30. In the forward characteristic of a junction diode, the current increases from 10 mA to 30 mA when the applied voltage changes from 0.70 V to 0.72 V. The dynamic (a.c.) resistance of the diode in this region is:

(A) $0.5\ \Omega$

(B) $1\ \Omega$

(C) $2\ \Omega$

(D) $20\ \Omega$

Detailed Solutions

Q1.

Solution

Concept — Principle of dimensional homogeneity: In any physically correct equation, every additive term must carry the same dimensions as the quantity on the left-hand side.

Step 1 — Match the term a: The left side v has dimensions $[LT^{-1}]$. Since a is added directly to v, it must have the same dimensions.

$$[a] = [LT^{-1}].$$

Step 2 — Match the term $\frac{b}{t}$: The whole term $\frac{b}{t}$ must also equal $[LT^{-1}]$.

$$\frac{[b]}{[T]} = [LT^{-1}].$$

Step 3 — Solve for b:

$$[b] = [LT^{-1}] \times [T] = [L].$$

Why other options are wrong:

- (A) gives b the dimensions of acceleration, which would make b/t have dimensions $[LT^{-3}]$.
- (C) and (D) assign the wrong dimensions to a.

Final Answer: $[a] = [LT^{-1}],\ [b] = [L] \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 1

Q2.

Solution

Concept — Horizontal projectile from a height: The horizontal and vertical motions are independent. The time of flight is fixed by the fall through the height h, and the horizontal range is the horizontal speed times that time.

Step 1 — Find the time of fall: The vertical drop is $h = \frac{1}{2}gt^2$, so

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{10}} = \sqrt{4} = 2 \text{ s}.$$

Step 2 — Horizontal distance:

$$x = ut = 15 \times 2.$$

Step 3 — Evaluate:

$$x = 30 \text{ m}.$$

Why other options are wrong:

- (A) and (B) use a wrong time of flight.
- (D) 45 m takes $t = 3$ s, which corresponds to a greater fall height.

Final Answer: $x = 30$ m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 2

Q3.

Solution

Concept — Distance from a v–t graph: For a uniformly decelerating body, the distance until it stops is the area of the triangle bounded by the line and the time axis.

Step 1 — Read the graph: The body starts at $v = 30$ m s^{-1} and decreases linearly to 0 at $t = 6$ s. So the triangle has base 6 s and height 30 m s^{-1}.

Step 2 — Area of the triangle:

$$\text{Distance} = \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 6 \times 30.$$

Step 3 — Evaluate:

$$\text{Distance} = \frac{1}{2} \times 180 = 90 \text{ m}.$$

Why other options are wrong:

- (A) and (B) take only part of the triangle or use a wrong base.

- (C) 60 m uses base 4 s instead of 6 s.

Final Answer: Distance $= 90$ m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 3

Q4.

Solution

Concept — Block on block, friction-limited: The force F is applied to the upper block. The lower block is dragged only by the friction acting on it from the upper block. The largest common acceleration is set by the maximum static friction available at the interface.

Step 1 — Maximum friction on the lower block: The normal force between the blocks is the weight of the upper block, $N = m_1 g = 2 \times 10 = 20$ N. The maximum friction is

$$f_{\text{max}} = \mu N = 0.4 \times 20 = 8 \text{ N}.$$

Step 2 — Acceleration set by the lower block: This friction is the only horizontal force on the 4 kg block, so the greatest common acceleration is

$$a = \frac{f_{\text{max}}}{m_2} = \frac{8}{4} = 2 \text{ m s}^{-2}.$$

Step 3 — Force on the upper block at this acceleration: For the whole system (mass 6 kg) on a smooth floor,

$$F = (m_1 + m_2)\, a = 6 \times 2 = 12 \text{ N}.$$

Why other options are wrong:

- (A) 8 N is the friction force, not the applied force.
- (B) and (D) ignore that the floor is smooth or mis-assign the masses.

Final Answer: $F_{\text{max}} = 12$ N $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 4

Q5.

Solution

Concept — Apparent weight in an accelerating lift: The spring balance reads the tension, which equals the apparent weight $m(g+a)$ when the lift accelerates upward.

Step 1 — Write the force equation: For upward acceleration,

$$T = m(g+a).$$

Step 2 — Substitute the data: $m = 5$ kg, $g = 10$ m s^{-2}, $a = 2$ m s^{-2}.

$$T = 5 \times (10+2).$$

Step 3 — Evaluate:

$$T = 5 \times 12 = 60 \text{ N}.$$

Why other options are wrong:

- (B) 50 N is the reading when the lift is at rest or moves uniformly.
- (C) 40 N corresponds to downward acceleration.
- (D) 10 N has no physical basis here.

Final Answer: $T = 60$ N $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 5

Q6.

Solution

Concept — Ballistic pendulum: The collision is perfectly inelastic, so momentum is conserved during impact. After impact the combined mass rises, converting kinetic energy into potential energy.

Step 1 — Speed of the block just after impact: Energy conservation for the rise gives

$$V = \sqrt{2gh} = \sqrt{2 \times 10 \times 0.20} = \sqrt{4} = 2 \text{ m s}^{-1}.$$

Step 2 — Conserve momentum during the impact: The bullet ($m = 0.010$ kg) embeds in the block ($M = 0.990$ kg), so the combined mass is 1.000 kg.

$$m\,v = (m+M)\,V.$$

Step 3 — Solve for the bullet speed:

$$v = \frac{(m+M)V}{m} = \frac{1.000 \times 2}{0.010} = 200 \text{ m s}^{-1}.$$

Why other options are wrong:

- (A) 100 m s^{-1} uses the wrong mass ratio.
- (B) and (C) come from arithmetic slips in V or the mass ratio.

Final Answer: $v = 200 \text{ m s}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 6

Q7.

Solution

Concept — Average power: Average power is the total work done divided by the time taken, $P_{\text{avg}} = \frac{W}{t}$, where $W = F\,d$ for a constant force along the displacement.

Step 1 — Work done by the force:

$$W = F\,d = 50 \times 40 = 2000 \text{ J}.$$

Step 2 — Divide by the time:

$$P_{\text{avg}} = \frac{W}{t} = \frac{2000}{4}.$$

Step 3 — Evaluate:

$$P_{\text{avg}} = 500 \text{ W}.$$

Why other options are wrong:

- (A) and (B) use a wrong work or time value.
- (D) 800 W multiplies force by distance over a wrong interval.

Final Answer: $P_{\text{avg}} = 500 \text{ W} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 7

Q8.

Solution

Concept — Rotational kinetic energy: A body rotating with moment of inertia I at angular speed ω has rotational kinetic energy $KE = \frac{1}{2}I\omega^2$.

Step 1 — List the data: $I = 0.5$ kg m^2, $\omega = 20$ rad s^{-1}.

Step 2 — Apply the formula:

$$KE = \frac{1}{2}I\omega^2 = \frac{1}{2} \times 0.5 \times (20)^2.$$

Step 3 — Evaluate:

$$KE = \frac{1}{2} \times 0.5 \times 400 = 100 \text{ J}.$$

Why other options are wrong:

- (B) 200 J drops the $\frac{1}{2}$ factor.
- (C) 50 J uses ω instead of ω^2 in part.
- (D) 400 J omits both $\frac{1}{2}$ and I scaling.

Final Answer: $KE = 100 \text{ J} \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q 8**

Q9.

Solution

Concept — Period of a close-orbit satellite: For a satellite skimming a planet of density ρ, the orbital period depends only on ρ and G through $T = \sqrt{\frac{3\pi}{G\rho}}$.

Step 1 — Substitute the data: $\rho = 5000$ kg m^{-3}, $G = \frac{20}{3} \times 10^{-11}$.

$$G\rho = \frac{20}{3} \times 10^{-11} \times 5000 = \frac{100000}{3} \times 10^{-11} = \frac{1}{3} \times 10^{-6}.$$

Step 2 — Form the ratio inside the root:

$$\frac{3\pi}{G\rho} = \frac{3\pi}{\frac{1}{3} \times 10^{-6}} = 9\pi \times 10^6.$$

Step 3 — Take the square root (use $\pi^2 = 10$, so $\pi \approx 3.16$):

$$T = \sqrt{9\pi \times 10^6} = 3\sqrt{\pi} \times 10^3 = 3 \times 1.78 \times 10^3 \approx 5.3 \times 10^3 \text{ s}.$$

Why other options are wrong:

- (A) and (D) use a wrong value of the constant product $G\rho$.
- (C) 6000 s rounds too coarsely from the square root.

Final Answer: $T \approx 5300$ s $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 9

Q10.

Solution

Concept — Elastic PE in a stretched wire: The work stored in a wire stretched within its elastic limit is $U = \frac{1}{2}F\,\Delta L$ (the area under the force–extension line).

Step 1 — Convert the extension: $\Delta L = 2$ mm $= 2 \times 10^{-3}$ m.

Step 2 — Apply the formula:

$$U = \frac{1}{2}F\,\Delta L = \frac{1}{2} \times 200 \times (2 \times 10^{-3}).$$

Step 3 — Evaluate:

$$U = \frac{1}{2} \times 200 \times 2 \times 10^{-3} = 0.2 \text{ J}.$$

Why other options are wrong:

- (A) 0.4 J drops the $\frac{1}{2}$ factor.
- (B) 0.8 J omits the factor and mis-converts units.
- (D) 0.1 J halves the extension wrongly.

Final Answer: $U = 0.2$ J $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Calorimetry (two stages): First the ice must melt at $0°$C (latent heat of fusion), then the resulting water must be warmed from $0°$C to $30°$C.

Step 1 — Heat to melt the ice:

$$Q_1 = mL_f = 20 \times 80 = 1600 \text{ cal}.$$

Step 2 — Heat to warm the water:

$$Q_2 = mc\,\Delta T = 20 \times 1 \times 30 = 600 \text{ cal}.$$

Step 3 — Total heat:

$$Q = Q_1 + Q_2 = 1600 + 600 = 2200 \text{ cal}.$$

Why other options are wrong:

- (A) 1600 cal counts only the melting stage.
- (B) 600 cal counts only the warming stage.
- (C) 1000 cal uses a wrong mass or temperature change.

Final Answer: $Q = 2200$ cal $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 11

Q12.

Solution

Concept — Work in an isobaric process: At constant pressure the work done by a gas is $W = P\,\Delta V = P(V_2 - V_1)$.

Step 1 — Find the volume change:

$$\Delta V = V_2 - V_1 = (3 - 1) \times 10^{-3} = 2 \times 10^{-3} \text{ m}^3.$$

Step 2 — Apply the formula:

$$W = P\,\Delta V = 2 \times 10^5 \times 2 \times 10^{-3}.$$

Step 3 — Evaluate:

$$W = 4 \times 10^2 = 400 \text{ J}.$$

Why other options are wrong:

- (B) 200 J uses only one volume value.
- (C) and (D) come from wrong powers of ten in the multiplication.

Final Answer: $W = 400 \text{ J} \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 12

Q13.

Solution

Concept — Pendulum period and gravity: The period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$, so $T \propto \frac{1}{\sqrt{g}}$ at fixed length.

Step 1 — Form the ratio:

$$\frac{T_2}{T_1} = \sqrt{\frac{g_1}{g_2}}.$$

Step 2 — Substitute $g_2 = \frac{1}{4}g_1$:

$$\frac{T_2}{T_1} = \sqrt{\frac{g_1}{\frac{1}{4}g_1}} = \sqrt{4} = 2.$$

Step 3 — New period:

$$T_2 = 2 \times T_1 = 2 \times 2 = 4 \text{ s}.$$

Why other options are wrong:

- (A) 1 s assumes g increases.
- (C) 8 s uses $T \propto 1/g$ instead of $1/\sqrt{g}$.
- (D) 2 s ignores the change in g.

Final Answer: $T_2 = 4 \text{ s} \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 13

Q14.

Solution

Concept — Fundamental frequency of a sonometer wire: A stretched string of length L, tension T and linear mass density μ vibrates in its fundamental mode at $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$.

Step 1 — Compute the wave speed factor:

$$\sqrt{\frac{T}{\mu}} = \sqrt{\frac{100}{0.01}} = \sqrt{10000} = 100 \text{ m s}^{-1}.$$

Step 2 — Apply the frequency formula:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{1}{2 \times 0.5} \times 100.$$

Step 3 — Evaluate:

$$f = \frac{100}{1} = 100 \text{ Hz}.$$

Why other options are wrong:

- (A) 50 Hz uses $f = \frac{1}{4L}\sqrt{T/\mu}$ (wrong factor).
- (B) 200 Hz is the second harmonic.
- (D) 150 Hz has no consistent derivation.

Final Answer: $f = 100$ Hz $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Null point between two like charges: Between two positive charges there is a point where the two fields cancel. Setting the field magnitudes equal locates it.

Step 1 — Set up the balance: Let P lie at distance x from the $+9\,\mu$C charge, so it is $(25 - x)$ cm from the $+4\,\mu$C charge.

$$\frac{k(9\mu)}{x^2} = \frac{k(4\mu)}{(25 - x)^2}.$$

Step 2 — Simplify and take the square root:

$$\frac{9}{x^2} = \frac{4}{(25-x)^2} \Rightarrow \frac{3}{x} = \frac{2}{25-x}.$$

Step 3 — Solve for x:

$$3(25-x) = 2x \Rightarrow 75 - 3x = 2x \Rightarrow 75 = 5x \Rightarrow x = 15 \text{ cm}.$$

Why other options are wrong:

- (B) 10 cm places the point closer to the larger charge, where its field dominates.
- (C) and (D) do not satisfy the inverse-square balance.

Final Answer: $x = 15$ cm from the $+9\,\mu$C charge $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q 15**

Q16.

Solution

Concept — Potential of a charged conducting shell: Inside a charged conducting shell the potential is constant and equal to its surface value $V = \frac{kQ}{R}$, where R is the shell radius.

Step 1 — Recognise the inside region: The point at 0.05 m lies inside the shell of radius 0.1 m, so the potential equals the surface potential (use $R = 0.1$ m, not 0.05 m).

Step 2 — Apply the formula:

$$V = \frac{kQ}{R} = \frac{9 \times 10^9 \times 2 \times 10^{-9}}{0.1}.$$

Step 3 — Evaluate:

$$V = \frac{18}{0.1} = 180 \text{ V}.$$

Why other options are wrong:

- (A) 360 V wrongly uses $r = 0.05$ m as if the field formula applied inside.
- (D) 0 V confuses zero *field* inside with zero potential; the potential is constant but nonzero.

Final Answer: $V = 180$ V $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 16

Q17.

Solution

Concept — Charging of a capacitor: The charge grows as $q(t) = Q_0\left(1 - e^{-t/\tau}\right)$, where $Q_0 = CV$ is the final charge and $\tau = RC$.

Step 1 — Final (maximum) charge:

$$Q_0 = CV = (2 \times 10^{-6}) \times 10 = 20\ \mu\text{C}.$$

Step 2 — Evaluate at $t = \tau$:

$$q = Q_0\left(1 - e^{-1}\right) = 20\,(1 - 0.37)\,.$$

Step 3 — Compute:

$$q = 20 \times 0.63 = 12.6\ \mu\text{C}.$$

Why other options are wrong:

- (A) $20\ \mu$C is the fully charged value, reached only after a long time.
- (B) $7.4\ \mu$C uses $Q_0 e^{-1}$ (the discharging form).
- (C) $3.7\ \mu$C mis-scales the exponential.

Final Answer: $q = 12.6\ \mu$C $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 17

Q18.

Solution

Concept — Series and parallel resistors: Resistors in series add directly; resistors in parallel combine as $\dfrac{1}{R_p} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$. We reduce the network in stages.

Step 1 — The first parallel group ($20\ \Omega \parallel 10\ \Omega$): Two $10\ \Omega$ resistors in series give $20\ \Omega$. In parallel with a single $10\ \Omega$:

$$R_1 = \frac{20 \times 10}{20 + 10} = \frac{200}{30} = \frac{20}{3}\ \Omega.$$

Step 2 — The second parallel group ($10\ \Omega \parallel 10\ \Omega$):

$$R_2 = \frac{10 \times 10}{10 + 10} = \frac{100}{20} = 5\ \Omega.$$

Step 3 — Add the two groups in series:

$$R_{AB} = R_1 + R_2 = \frac{20}{3} + 5 = \frac{20 + 15}{3} = \frac{35}{3} \approx 11.\bar{6}\ \Omega.$$

Why other options are wrong:

- (A) $11.7\ \Omega$ is a rounded value but not the exact fraction asked.
- (B) $15\ \Omega$ and (D) $20\ \Omega$ mishandle the parallel reductions.

Final Answer: $R_{AB} = \frac{35}{3} = 11.\bar{6}\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 18

Q19.

Solution

Concept — Terminal voltage during charging: When a battery is being charged, current is forced into its positive terminal, so the terminal voltage exceeds the EMF: $V = E + Ir$.

Step 1 — Identify the sign: During charging the internal resistance drop adds to the EMF (unlike discharging, where it subtracts).

Step 2 — Substitute the data: $E = 12$ V, $I = 2$ A, $r = 1\ \Omega$.

$$V = E + Ir = 12 + (2 \times 1).$$

Step 3 — Evaluate:

$$V = 12 + 2 = 14\ \text{V}.$$

Why other options are wrong:

- (B) 10 V subtracts the drop, which applies to discharging, not charging.
- (C) 12 V ignores the internal resistance.
- (D) 24 V doubles the EMF without basis.

Final Answer: $V = 14\ \text{V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 19

Q20.

Solution

Concept — Current rating of a fuse: A fuse must carry at least the operating current of the appliance, found from $P = VI$, so $I = \dfrac{P}{V}$.

Step 1 — Apply the power relation:

$$I = \frac{P}{V} = \frac{1000}{250}.$$

Step 2 — Evaluate:

$$I = 4 \text{ A}.$$

Step 3 — Interpret: The fuse must be rated to carry at least 4 A, so a 4 A (or slightly higher) fuse is required.

Why other options are wrong:

- (A) 2 A would blow under normal operation.
- (C) and (D) use wrong values of P or V.

Final Answer: $I = 4 \text{ A} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 20

Q21.

Solution

Concept — Force on a current-carrying conductor: A straight wire of length L carrying current I in a field B at angle θ feels a force $F = BIL\sin\theta$. For $\theta = 90°$, $F = BIL$.

Step 1 — List the data: $B = 0.3$ T, $I = 5$ A, $L = 0.2$ m, $\theta = 90°$ so $\sin\theta = 1$.

Step 2 — Apply the formula:

$$F = BIL = 0.3 \times 5 \times 0.2.$$

Step 3 — Evaluate:

$$F = 0.30 \text{ N}.$$

Why other options are wrong:

- (A) 0.15 N halves the result wrongly.
- (B) 0.45 N uses a wrong length.
- (C) 0.60 N doubles the field or current.

Final Answer: $F = 0.30$ N $\Rightarrow$ D

Answer: (D) Go Back to Q 21

Q22.

Solution

Concept — Helmholtz coil pair: In a Helmholtz arrangement the two coils carry current in the same sense, so their axial fields at the central midpoint add in the same direction.

Step 1 — Field from each coil: Each coil contributes an axial field B_0 at the midpoint, both pointing the same way.

Step 2 — Superpose the two fields: Since the fields are parallel,

$$B_{\text{total}} = B_0 + B_0.$$

Step 3 — Result:

$$B_{\text{total}} = 2B_0.$$

Why other options are wrong:

- (A) B_0 counts only one coil.
- (B) $\frac{B_0}{2}$ would require opposing currents that partly cancel.
- (D) $4B_0$ over-counts the contributions.

Final Answer: $B_{\text{total}} = 2B_0 \Rightarrow$ C

Answer: (C) Go Back to Q 22

Q23.

Solution

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

Step 1 — List the data: $L = 0.4$ H, $I = 5$ A.

Step 2 — Apply the formula:

$$U = \frac{1}{2}LI^2 = \frac{1}{2} \times 0.4 \times (5)^2.$$

Step 3 — Evaluate:

$$U = \frac{1}{2} \times 0.4 \times 25 = 5 \text{ J}.$$

Why other options are wrong:

- (B) 10 J drops the $\frac{1}{2}$ factor.
- (C) 2 J uses I instead of I^2.
- (D) 1 J mis-scales the inductance.

Final Answer: $U = 5$ J $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) **Go Back to Q 23**

Q24.

Solution

Concept — Wattless current: The component of current that does no average work is the "wattless" component $I \sin\phi$, perpendicular to the voltage. (The in-phase, power-carrying component is $I\cos\phi$.)

Step 1 — Identify the phase angle: $\phi = 60^\circ$, so $\sin\phi = \dfrac{\sqrt{3}}{2}$.

Step 2 — Wattless component:

$$I_{\text{wattless}} = I\sin\phi = 2 \times \frac{\sqrt{3}}{2}.$$

Step 3 — Evaluate:

$$I_{\text{wattless}} = \sqrt{3} \text{ A} \approx 1.73 \text{ A}.$$

Why other options are wrong:

- (A) 1 A is the in-phase (power) component $I\cos 60°$.
- (B) 2 A is the total current.
- (C) 0 A would require a purely resistive circuit ($\phi = 0$).

Final Answer: $I_{\text{wattless}} = \sqrt{3}\text{ A} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 24

Q25.

Solution

Concept — Lens formula and magnification: For a thin lens, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, and the linear magnification is $m = \frac{v}{u}$ (using the sign convention with u negative for a real object).

Step 1 — Apply the lens formula: $u = -15$ cm, $f = +10$ cm.

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} + \frac{1}{-15}.$$

Step 2 — Combine the fractions:

$$\frac{1}{v} = \frac{3-2}{30} = \frac{1}{30} \quad \Rightarrow \quad v = +30\text{ cm}.$$

Step 3 — Magnification:

$$m = \frac{v}{u} = \frac{30}{-15} = -2.$$

Why other options are wrong:

- (A) -1 and (C) -3 use a wrong image distance.
- (D) $+2$ has the wrong sign; a real image from a convex lens is inverted ($m < 0$).

Final Answer: $m = -2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 25

Q26.

Solution

Concept — Magnifying power of a telescope: An astronomical telescope in normal adjustment has magnifying power $M = \frac{f_o}{f_e}$, the ratio of objective to eyepiece focal lengths.

Step 1 — List the data: $f_o = 100$ cm, $f_e = 5$ cm.

Step 2 — Apply the formula:

$$M = \frac{f_o}{f_e} = \frac{100}{5}.$$

Step 3 — Evaluate:

$$M = 20.$$

Why other options are wrong:

- (A) 5 and (B) 10 use wrong ratios.
- (D) 25 would require $f_e = 4$ cm.

Final Answer: $M = 20 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 26

Q27.

Solution

Concept — Malus's law: When plane-polarized light of intensity I_0 passes through an analyser at angle θ to its plane of polarization, the transmitted intensity is $I = I_0 \cos^2\theta$.

Step 1 — Identify the angle: $\theta = 60^\circ$, so $\cos 60^\circ = \frac{1}{2}$.

Step 2 — Apply Malus's law:

$$I = I_0 \cos^2 60^\circ = I_0 \left(\frac{1}{2}\right)^2.$$

Step 3 — Evaluate:

$$I = I_0 \times \frac{1}{4} = \frac{I_0}{4}.$$

Why other options are wrong:

- (A) $\dfrac{I_0}{2}$ is the average for unpolarized light through one polaroid, not this case.
- (C) $\dfrac{3I_0}{4}$ uses $\sin^2\theta$ instead of $\cos^2\theta$.
- (D) I_0 assumes $\theta = 0$.

Final Answer: $I = \dfrac{I_0}{4} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 27

Q28.

Solution

Concept — de Broglie wavelength of an accelerated electron: An electron accelerated through a potential difference V has wavelength $\lambda = \dfrac{1.227}{\sqrt{V}}$ nm (with V in volts).

Step 1 — Substitute $V = 150$ V:

$$\lambda = \frac{1.227}{\sqrt{150}} \text{ nm}.$$

Step 2 — Evaluate the square root:

$$\sqrt{150} \approx 12.25.$$

Step 3 — Compute:

$$\lambda = \frac{1.227}{12.25} \approx 0.10 \text{ nm} = 1 \text{ Å}.$$

Why other options are wrong:

- (B) 0.5 nm and (C) 0.05 nm use a wrong accelerating voltage.
- (A) gives the right number but option (D) states it explicitly as 1 Å, the standard textbook result for 150 V.

Final Answer: $\lambda \approx 0.1 \text{ nm} = 1 \text{ Å} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 28

Q29.

Solution

Concept — Nuclear density: The nuclear radius is $R = R_0 A^{1/3}$, so the volume $V = \frac{4}{3}\pi R^3 \propto A$. Since nuclear mass $\propto A$, the density (mass/volume) is independent of A.

Step 1 — Express the volume:

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A.$$

Step 2 — Express the mass: With nucleon mass m, the nuclear mass is $M = Am$.

Step 3 — Form the density:

$$\rho = \frac{M}{V} = \frac{Am}{\frac{4}{3}\pi R_0^3 A} = \frac{m}{\frac{4}{3}\pi R_0^3}.$$

The factor A cancels, so ρ is the same for all nuclei.

Why other options are wrong:

- (B), (C), (D) all retain a dependence on A, but A cancels exactly between mass and volume.

Final Answer: Nuclear density is independent of $A \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 29

Q30.

Solution

Concept — Dynamic resistance of a diode: The a.c. (dynamic) resistance over a small region of the forward characteristic is the ratio of the change in voltage to the change in current, $r_d = \dfrac{\Delta V}{\Delta I}$.

Step 1 — Find the changes:

$$\Delta V = 0.72 - 0.70 = 0.02 \text{ V}, \qquad \Delta I = 30 - 10 = 20 \text{ mA} = 20 \times 10^{-3} \text{ A}.$$

Step 2 — Apply the formula:

$$r_d = \frac{\Delta V}{\Delta I} = \frac{0.02}{20 \times 10^{-3}}.$$

Step 3 — Evaluate:

$$r_d = \frac{0.02}{0.02} = 1\ \Omega.$$

Why other options are wrong:

- (A) $0.5\ \Omega$ and (C) $2\ \Omega$ mis-handle the current conversion.
- (D) $20\ \Omega$ forgets to convert mA to A.

Final Answer: $r_d = 1\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q 30**

Answer Key

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