AIIMS Paramedical Physics

Sample Paper – 7

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. The density of a cube is found by measuring its mass and the length of its side. If the maximum error in the measurement of mass is 2% and that in the length of a side is 1%, the maximum percentage error in the calculated density is:

(A) 3%

(B) 5%

(C) 6%

(D) 9%

Q2. A car moving at 20 m s^{-1} is brought to rest by applying brakes that produce a uniform retardation of 5 m s^{-2}. The distance travelled by the car before it stops is:

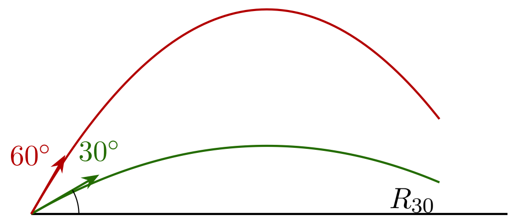
(A) 20 m

(B) 30 m

(C) 40 m

(D) 80 m

Q3. Two balls are projected from the ground with the same speed but at angles 30° and 60° to the horizontal, as shown. The ratio of their horizontal ranges $R_{30} : R_{60}$ is:



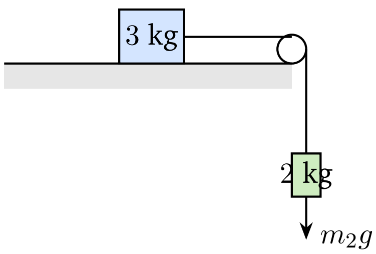
(A) $\sqrt{3} : 1$

(B) $3 : 1$

(C) $1 : \sqrt{3}$

(D) $1 : 1$

Q4. A block of mass 3 kg rests on a smooth horizontal table and is connected by a light string passing over a frictionless pulley at the table edge to a hanging mass of 2 kg, as shown. Taking $g = 10$ m s^{-2}, the acceleration of the system is:



(A) 4 m s^{-2}

(B) 2 m s^{-2}

(C) 5 m s^{-2}

(D) 6 m s^{-2}

Q5. A ball of mass 0.2 kg moving at 10 m s^{-1} strikes a wall normally and rebounds with the same speed. If the ball is in contact with the wall for 0.01 s, the average force exerted by the wall on the ball is:

(A) 200 N

(B) 400 N

(C) 100 N

(D) 800 N

Q6. The potential energy of a particle moving along the x-axis is $U(x) = x^2 - 4x + 5$ (in joules, with x in metres). The position of stable equilibrium is at:

(A) $x = 0$ m

(B) $x = 1$ m

(C) $x = 2$ m

(D) $x = 4$ m

Q7. A ball is dropped from a height of 1.0 m onto a hard floor and rebounds to a height of 0.64 m. The coefficient of restitution between the ball and the floor is:

(A) 0.8

(B) 0.64

(C) 0.4

(D) 0.9

Q8. A particle of mass 2 kg moves with a constant velocity of 3 m s^{-1} along a straight line whose perpendicular distance from a fixed point O is 4 m. The angular momentum of the particle about O is:

(A) 6 kg m^{2}s^{-1}

(B) 12 kg m^{2}s^{-1}

(C) 48 kg m^{2}s^{-1}

(D) 24 kg m^{2}s^{-1}

Q9. A geostationary satellite appears stationary relative to an observer on the Earth. This is possible only because its:

(A) orbital radius equals the radius of the Earth

(B) time period of revolution equals 24 hours and it orbits in the equatorial plane in the direction of Earth's rotation

(C) speed is equal to the escape velocity of the Earth

(D) orbit lies in a plane perpendicular to the equatorial plane

Q10. Water rises to a height of 8 cm in a capillary tube. If a second capillary tube of half the radius of the first is dipped in the same water, the height to which the water rises in it is:

(A) 16 cm

(B) 4 cm

(C) 8 cm

(D) 2 cm

Q11. A black body at absolute temperature T radiates energy at a rate P. If its absolute temperature is doubled (area unchanged), the rate at which it radiates energy becomes:

(A) $2P$

(B) $8P$

(C) $16P$

(D) $4P$

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

(A) v

(B) $2v$

(C) $4v$

(D) $\sqrt{2}\,v$

Q13. A particle executes simple harmonic motion of amplitude 0.05 m and angular frequency 10 rad s^{-1}. The magnitude of its maximum acceleration is:

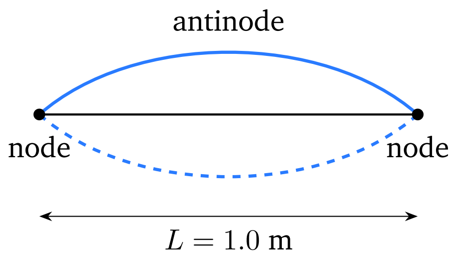
(A) 5 m s^{-2}

(B) 0.5 m s^{-2}

(C) 50 m s^{-2}

(D) 2.5 m s^{-2}

Q14. A string of length 1.0 m is fixed at both ends and vibrates in its fundamental mode as shown. If the speed of transverse waves on the string is 200 m s^{-1}, the fundamental frequency is:



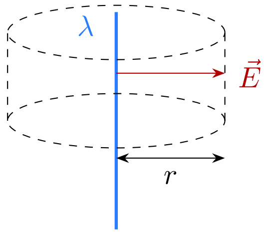
(A) 50 Hz

(B) 200 Hz

(C) 400 Hz

(D) 100 Hz

Q15. A long straight cylinder carries a uniform linear charge density λ along its axis. Using Gauss's law, the magnitude of the electric field at a perpendicular distance r from the axis (outside the cylinder) is:



(A) $\dfrac{\lambda}{4\pi\varepsilon_0 r^2}$

(B) $\dfrac{\lambda}{4\pi\varepsilon_0 r}$

(C) $\dfrac{\lambda}{2\pi\varepsilon_0 r}$

(D) $\dfrac{\lambda r}{2\pi\varepsilon_0}$

Q16. The capacitance of an isolated conducting sphere of radius 9 cm is (take $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ SI units):

(A) 10 pF

(B) 1 pF

(C) 90 pF

(D) 0.1 pF

Q17. Each plate of a parallel-plate capacitor carries a charge of magnitude Q and the uniform field between the plates is E. The electrostatic force of attraction on one plate is:

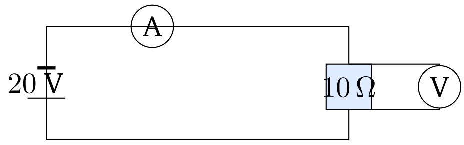
(A) QE

(B) $2QE$

(C) $\dfrac{QE}{4}$

(D) $\dfrac{QE}{2}$

Q18. In the circuit shown, an ideal ammeter (zero resistance) and an ideal voltmeter (infinite resistance) are connected with a $10\ \Omega$ resistor across a 20 V battery of negligible internal resistance. The readings of the ammeter and the voltmeter are:



(A) 1 A, 10 V

(B) 2 A, 20 V

(C) 2 A, 10 V

(D) 0.5 A, 20 V

Q19. A number of identical cells, each of EMF E and internal resistance r, are to drive current through an external resistance R. The current is maximum when the cells are arranged so that the combination of cells has an internal resistance equal to:

(A) twice the external resistance R

(B) zero

(C) the external resistance R

(D) half the external resistance R

Q20. A 100 W bulb and a 60 W bulb, both rated for 220 V, are connected in series across a 220 V supply. Which bulb glows brighter?

(A) the 60 W bulb, because it has the higher resistance

(B) the 100 W bulb, because it has the higher power rating

(C) both glow with equal brightness

(D) the 100 W bulb, because it has the higher resistance

Q21. A circular coil of 50 turns and radius 0.1 m carries a current of 2 A. The magnetic moment of the coil is approximately:

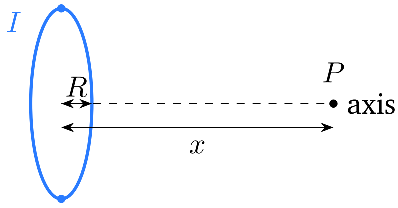
(A) 1.57 A m^2

(B) 3.14 A m^2

(C) 0.79 A m^2

(D) $6.28\ \text{A m}^2$

Q22. A circular loop of radius R carries a current I. The magnetic field at a point on its axis, at a distance x from the centre, is:



(A) $\dfrac{\mu_0 I R^2}{2x^3}$

(B) $\dfrac{\mu_0 I}{2R}$

(C) $\dfrac{\mu_0 I R^2}{2\left(R^2+x^2\right)^{3/2}}$

(D) $\dfrac{\mu_0 I R^2}{\left(R^2+x^2\right)^{1/2}}$

Q23. In an RL circuit with $R = 10\ \Omega$ and $L = 2$ H connected to a battery through a switch, the time constant of the growth of current after the switch is closed is:

(A) 20 s

(B) 5 s

(C) 0.5 s

(D) 0.2 s

Q24. In a series LCR circuit, the resistance is $3\ \Omega$, the inductive reactance is $X_L = 12\ \Omega$ and the capacitive reactance is $X_C = 8\ \Omega$. The impedance of the circuit is:

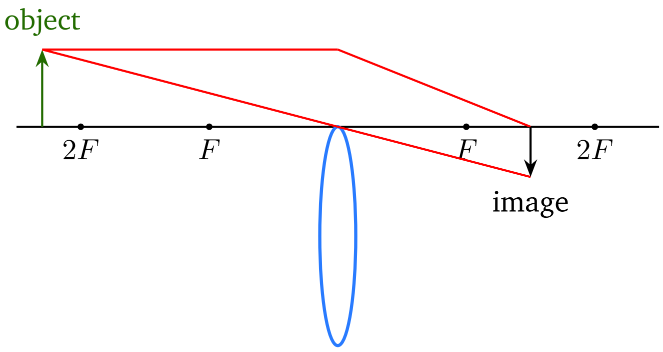
(A) $5\ \Omega$

(B) $7\ \Omega$

(C) $23\ \Omega$

(D) $13\ \Omega$

Q25. An object is placed beyond $2F$ in front of a convex lens, as shown. The image formed is:



(A) virtual, erect and magnified

(B) real, inverted and diminished

(C) real, inverted and of the same size

(D) virtual, erect and diminished

Q26. The core of an optical fibre has refractive index $\frac{3}{2}$ with respect to the surrounding cladding-equivalent air. The critical angle for total internal reflection at the core boundary satisfies:

(A) $\sin\theta_c = \frac{3}{2}$

(B) $\cos\theta_c = \frac{2}{3}$

(C) $\sin\theta_c = \frac{2}{3}$

(D) $\tan\theta_c = \frac{2}{3}$

Q27. In a Young's double-slit experiment, the intensities of light from the two slits are in the ratio $I_1 : I_2 = 4 : 1$. The ratio of the maximum to the minimum intensity in the interference pattern is:

(A) $4 : 1$

(B) $16 : 1$

(C) $5 : 3$

(D) $9 : 1$

Q28. In a photoelectric experiment, the frequency of the incident light is kept fixed (above threshold) while its intensity is doubled. The saturation photocurrent:

(A) doubles

(B) remains unchanged

(C) becomes four times

(D) is halved

Q29. A radioactive sample contains 4×10^{16} undecayed nuclei and has a decay constant of $\lambda = 2 \times 10^{-6}\ \text{s}^{-1}$. The activity of the sample is:

(A) 2×10^{10} decays s^{-1}

(B) 4×10^{10} decays s^{-1}

(C) 8×10^{10} decays s^{-1}

(D) 2×10^{22} decays s^{-1}

Q30. A light-emitting diode (LED) and a photodiode are both pn-junction devices. Which statement correctly describes their normal mode of operation?

(A) Both are operated under reverse bias

(B) An LED is operated under forward bias and emits light, while a photodiode is operated under reverse bias and detects light

(C) Both are operated under forward bias

(D) An LED detects light while a photodiode emits light

Detailed Solutions

Q1.

Solution

Concept — Propagation of errors: For a quantity formed by products and powers, the maximum fractional error is the sum of the fractional errors of each factor, each multiplied by the magnitude of its power.

Step 1 — Write density in terms of measured quantities: For a cube of side a, the volume is a^3, so the density is

$$\rho = \frac{m}{a^3}.$$

Step 2 — Apply the error rule: Mass appears to the power 1 and length to the power 3, so

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\,\frac{\Delta a}{a}.$$

Step 3 — Substitute the percentage errors:

$$\frac{\Delta\rho}{\rho} \times 100 = 2\% + 3 \times 1\% = 2\% + 3\% = 5\%.$$

Why other options are wrong:

- (A) 3% uses the length error only once instead of three times.
- (C) 6% multiplies the mass error by 3 as well.
- (D) 9% multiplies every error by 3.

Final Answer: maximum error $= 5\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 1

Q2.

Solution

Concept — Uniformly retarded motion: When a body decelerates uniformly to rest, the stopping distance follows from $v^2 = u^2 - 2as$ with final velocity $v = 0$.

Step 1 — List the data: $u = 20\ \text{m s}^{-1}$, $v = 0$, retardation $a = 5\ \text{m s}^{-2}$.

Step 2 — Apply the kinematic equation:

$$0 = u^2 - 2as \;\Rightarrow\; s = \frac{u^2}{2a}.$$

Step 3 — Substitute and evaluate:

$$s = \frac{(20)^2}{2 \times 5} = \frac{400}{10} = 40 \text{ m}.$$

Why other options are wrong:

- (A) 20 m and (B) 30 m come from arithmetic slips.
- (D) 80 m forgets the factor of 2 in the denominator.

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

Answer: (C) Go Back to Q 2

Q3.

Solution

Concept — Range of a projectile: For a given launch speed u, the horizontal range is $R = \frac{u^2 \sin 2\theta}{g}$. Angles that are complementary (θ and $90^\circ - \theta$) give the same range.

Step 1 — Write the two ranges:

$$R_{30} = \frac{u^2 \sin 60^\circ}{g}, \qquad R_{60} = \frac{u^2 \sin 120^\circ}{g}.$$

Step 2 — Compare the sine factors: Since $\sin 120^\circ = \sin 60^\circ$, both ranges have the same value.

Step 3 — Form the ratio:

$$R_{30} : R_{60} = \sin 60^\circ : \sin 120^\circ = 1 : 1.$$

Why other options are wrong:

- (A) $\sqrt{3} : 1$ and (C) $1 : \sqrt{3}$ compare the maximum heights, not the ranges.
- (B) $3 : 1$ squares the height ratio.

Final Answer: $R_{30} : R_{60} = 1 : 1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 3

Q4.

Solution

Concept — Connected bodies over a pulley: The hanging mass is pulled down by its weight and the system accelerates together. With a smooth table the only driving force is the weight of the hanging mass.

Step 1 — Write the equations of motion: Let a be the common acceleration and T the string tension. For the hanging mass m_2 and the table block m_1:

$$m_2 g - T = m_2 a, \qquad T = m_1 a.$$

Step 2 — Add the equations:

$$m_2 g = (m_1 + m_2)a \;\Rightarrow\; a = \frac{m_2 g}{m_1 + m_2}.$$

Step 3 — Substitute the values: $m_1 = 3$ kg, $m_2 = 2$ kg, $g = 10$ m s^{-2}.

$$a = \frac{2 \times 10}{3 + 2} = \frac{20}{5} = 4 \text{ m s}^{-2}.$$

Why other options are wrong:

- (B) 2 m s^{-2} uses the difference of the masses (an Atwood-type error).
- (C) 5 m s^{-2} divides by m_2 alone.
- (D) 6 m s^{-2} divides by m_1 alone.

Final Answer: $a = 4$ m s^{-2} $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 4

Q5.

Solution

Concept — Impulse–momentum theorem: The impulse delivered equals the change in momentum, $F_{avg}\,\Delta t = \Delta p$. For a rebound, the velocity reverses, so the speed change is from $+u$ to $-u$.

Step 1 — Find the change in momentum: Taking the incoming direction as positive,

$$\Delta p = m(-u) - m(+u) = -2mu.$$

The magnitude is $|\Delta p| = 2mu = 2 \times 0.2 \times 10 = 4\ \text{kg m s}^{-1}$.

Step 2 — Apply the impulse relation:

$$F_{avg} = \frac{|\Delta p|}{\Delta t} = \frac{4}{0.01}.$$

Step 3 — Evaluate:

$$F_{avg} = 400\ \text{N}.$$

Why other options are wrong:

- (A) 200 N uses mu instead of $2mu$ (forgets the reversal).
- (C) 100 N halves the momentum change as well.
- (D) 800 N doubles the impulse incorrectly.

Final Answer: $F_{avg} = 400\ \text{N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 5

Q6.

Solution

Concept — Equilibrium from a potential-energy curve: Equilibrium occurs where $\frac{dU}{dx} = 0$. It is stable if $\frac{d^2U}{dx^2} > 0$ (a minimum of U).

Step 1 — Differentiate the potential energy:

$$\frac{dU}{dx} = \frac{d}{dx}\left(x^2 - 4x + 5\right) = 2x - 4.$$

Step 2 — Set the derivative to zero:

$$2x - 4 = 0 \ \Rightarrow\ x = 2\ \text{m}.$$

Step 3 — Check stability:

$$\frac{d^2U}{dx^2} = 2 > 0,$$

so $x = 2$ m is a minimum of U, i.e. stable equilibrium.

Why other options are wrong:

- (A) $x = 0$ and (D) $x = 4$ are arbitrary points where $\frac{dU}{dx} \neq 0$.
- (B) $x = 1$ does not satisfy $2x - 4 = 0$.

Final Answer: stable equilibrium at $x = 2$ m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 6

Q7.

Solution

Concept — Coefficient of restitution by rebound height: For a ball dropped from height h and rebounding to height h', the coefficient of restitution is $e = \frac{v_{up}}{v_{down}} = \sqrt{\frac{h'}{h}}$.

Step 1 — Relate speeds to heights: The impact speed is $\sqrt{2gh}$ and the rebound speed is $\sqrt{2gh'}$, so

$$e = \frac{\sqrt{2gh'}}{\sqrt{2gh}} = \sqrt{\frac{h'}{h}}.$$

Step 2 — Substitute the heights:

$$e = \sqrt{\frac{0.64}{1.0}} = \sqrt{0.64}.$$

Step 3 — Evaluate:

$$e = 0.8.$$

Why other options are wrong:

- (B) 0.64 is the height ratio, not its square root.
- (C) 0.4 and (D) 0.9 do not match $\sqrt{0.64}$.

Final Answer: $e = 0.8 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 7

Q8.

Solution

Concept — Angular momentum of a particle: The angular momentum of a particle about a point is $L = m\,v\,d$, where d is the perpendicular distance of the line of motion from that point.

Step 1 — List the data: $m = 2$ kg, $v = 3$ m s^{-1}, $d = 4$ m.

Step 2 — Apply the formula:

$$L = m\,v\,d = 2 \times 3 \times 4.$$

Step 3 — Evaluate:

$$L = 24 \text{ kg m}^2\text{s}^{-1}.$$

Why other options are wrong:

- (A) 6 uses mv only, dropping the distance.
- (B) 12 uses half the distance.
- (C) 48 doubles the result.

Final Answer: $L = 24 \text{ kg m}^2\text{s}^{-1} \Rightarrow \boxed{\text{D}}$

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

Q9.

Solution

Concept — Geostationary satellite: A satellite stays fixed over a point on the Earth only if it orbits in the equatorial plane, in the same sense as Earth's rotation, with an orbital period exactly equal to one sidereal day (≈ 24 hours).

Step 1 — Match the angular speed: To appear stationary, the satellite's angular speed must equal Earth's, so the period $T = 24$ hours.

Step 2 — Fix the orbital plane and sense: The orbit must lie in the equatorial plane and go in the direction of Earth's spin; otherwise the satellite drifts across the sky.

Step 3 — Identify the correct statement: Option (B) states exactly these conditions.

Why other options are wrong:

- (A) the geostationary radius is about $6.6\,R_E$, not R_E.
- (C) escape velocity would let the satellite leave its orbit entirely.
- (D) a polar orbit cannot stay above a single point.

Final Answer: period 24 h, equatorial, prograde $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 9

Q10.

Solution

Concept — Capillary rise: The height to which a liquid rises in a capillary tube is $h = \dfrac{2T\cos\theta}{\rho g r}$, so for the same liquid h is inversely proportional to the tube radius r.

Step 1 — Write the inverse relation: For the same liquid and contact angle, $h\,r =$ constant, so

$$\frac{h_2}{h_1} = \frac{r_1}{r_2}.$$

Step 2 — Substitute the radius ratio: The second tube has half the radius, $r_2 = \frac{1}{2}r_1$, so $\dfrac{r_1}{r_2} = 2$.

$$h_2 = 2\,h_1 = 2 \times 8 \text{ cm}.$$

Step 3 — Evaluate:

$$h_2 = 16 \text{ cm}.$$

Why other options are wrong:

- (B) 4 cm and (D) 2 cm treat the rise as directly proportional to radius.
- (C) 8 cm ignores the change in radius altogether.

Final Answer: $h_2 = 16$ cm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 10

Q11.

Solution

Concept — Stefan–Boltzmann law: The power radiated by a black body is $P = \sigma A T^4$, so for a fixed area $P \propto T^4$.

Step 1 — Form the ratio: If the temperature changes from T to $2T$,

$$\frac{P'}{P} = \left(\frac{2T}{T}\right)^4 = 2^4.$$

Step 2 — Evaluate the factor:

$$\frac{P'}{P} = 16.$$

Step 3 — State the new power:

$$P' = 16P.$$

Why other options are wrong:

- (A) $2P$ treats $P \propto T$.
- (B) $8P$ treats $P \propto T^3$.
- (D) $4P$ treats $P \propto T^2$.

Final Answer: $P' = 16P \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 11

Q12.

Solution

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

Step 1 — Form the ratio: For the same gas,

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

Step 2 — Evaluate the square root:

$$\frac{v'}{v} = \sqrt{4} = 2.$$

Step 3 — State the new speed:

$$v' = 2v.$$

Why other options are wrong:

- (A) v ignores the temperature change.
- (C) $4v$ treats $v \propto T$.
- (D) $\sqrt{2}\,v$ would correspond to doubling T, not quadrupling it.

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

Answer: (B) Go Back to Q 12

Q13.

Solution

Concept — Maximum acceleration in SHM: In simple harmonic motion the acceleration is $a = -\omega^2 x$, so its magnitude is greatest at the extreme position, $a_{max} = \omega^2 A$.

Step 1 — List the data: amplitude $A = 0.05$ m, angular frequency $\omega = 10$ rad s^{-1}.

Step 2 — Apply the formula:

$$a_{max} = \omega^2 A = (10)^2 \times 0.05.$$

Step 3 — Evaluate:

$$a_{max} = 100 \times 0.05 = 5 \text{ m s}^{-2}.$$

Why other options are wrong:

- (B) 0.5 m s^{-2} uses ω instead of ω^2.
- (C) 50 m s^{-2} uses the wrong amplitude.
- (D) 2.5 m s^{-2} halves the amplitude.

Final Answer: $a_{max} = 5 \text{ m s}^{-2} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 13

Q14.

Solution

Concept — Standing wave on a string fixed at both ends: In the fundamental mode there is one antinode and a node at each fixed end, so the length equals half a wavelength, $L = \frac{\lambda}{2}$, and $f = \frac{v}{\lambda}$.

Step 1 — Find the wavelength:

$$\lambda = 2L = 2 \times 1.0 = 2.0 \text{ m}.$$

Step 2 — Apply the wave relation:

$$f = \frac{v}{\lambda} = \frac{200}{2.0}.$$

Step 3 — Evaluate:

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

Why other options are wrong:

- (A) 50 Hz takes $\lambda = 4L$ (a closed-pipe error).
- (B) 200 Hz takes $\lambda = L$.
- (C) 400 Hz is the second overtone, not the fundamental.

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

Answer: (D) Go Back to Q 14

Q15.

Solution

Concept — Gauss's law for a line/cylinder of charge: Choosing a coaxial cylindrical Gaussian surface of radius r and length ℓ, the field is radial and uniform on the curved surface, so $E\,(2\pi r\ell) = \frac{\lambda\ell}{\varepsilon_0}$.

Step 1 — Enclosed charge: A length ℓ of the cylinder encloses charge $q_{enc} = \lambda\ell$.

Step 2 — Apply Gauss's law: Only the curved surface (area $2\pi r\ell$) contributes flux,

$$E\,(2\pi r\ell) = \frac{\lambda\ell}{\varepsilon_0}.$$

Step 3 — Solve for E:

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}.$$

Why other options are wrong:

- (A) $\frac{\lambda}{4\pi\varepsilon_0 r^2}$ is a point-charge ($1/r^2$) form.
- (B) uses 4π instead of 2π.
- (D) has the wrong r dependence (rises with r).

Final Answer: $E = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 15

Q16.

Solution

Concept — Capacitance of an isolated sphere: An isolated conducting sphere of radius R has capacitance $C = 4\pi\varepsilon_0 R = \frac{R}{1/(4\pi\varepsilon_0)}$.

Step 1 — Convert the radius: $R = 9$ cm $= 0.09$ m.

Step 2 — Apply the formula:

$$C = \frac{R}{1/(4\pi\varepsilon_0)} = \frac{0.09}{9 \times 10^9}.$$

Step 3 — Evaluate:

$$C = 1 \times 10^{-11} \text{ F} = 10 \text{ pF}.$$

Why other options are wrong:

- (B) 1 pF drops a factor of ten in the conversion.
- (C) 90 pF keeps the radius in centimetres.
- (D) 0.1 pF misplaces the power of ten.

Final Answer: $C = 10$ pF $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 16

Q17.

Solution

Concept — Force between capacitor plates: A plate sits in the field produced by the *other* plate, which is $\frac{E}{2}$ (half the total field E between the plates). The force on a plate carrying charge Q is $F = Q \times \frac{E}{2}$.

Step 1 — Field due to one plate: The total field between the plates is E, made of equal contributions $\frac{E}{2}$ from each plate.

Step 2 — Force on a plate: A plate feels only the field of the other plate,

$$F = Q\,E_{\text{other}} = Q \cdot \frac{E}{2}.$$

Step 3 — State the result:

$$F = \frac{QE}{2}.$$

Why other options are wrong:

- (A) QE wrongly uses the full field (a plate does not act on itself).
- (B) $2QE$ doubles the field.
- (C) $\frac{QE}{4}$ halves the field twice.

Final Answer: $F = \frac{QE}{2} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 17

Q18.

Solution

Concept — Ideal meters in a circuit: An ideal ammeter has zero resistance (it does not change the current) and an ideal voltmeter has infinite resistance (it draws no current). So the only resistance in the loop is the $10\ \Omega$ resistor.

Step 1 — Find the current (ammeter reading): The ammeter is in series, carrying the full loop current,

$$I = \frac{V}{R} = \frac{20}{10} = 2\text{ A}.$$

Step 2 — Find the voltmeter reading: The voltmeter is across the $10\ \Omega$ resistor, which carries 2 A,

$$V_R = IR = 2 \times 10 = 20\text{ V}.$$

Step 3 — State both readings: ammeter $= 2$ A, voltmeter $= 20$ V.

Why other options are wrong:

- (A) 1 A, 10 V uses a wrong current.
- (C) 2 A, 10 V gets the current right but misreads the voltage.
- (D) 0.5 A, 20 V uses a wrong current.

Final Answer: 2 A, 20 V $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 18

Q19.

Solution

Concept — Grouping of cells (maximum-power/maximum-current matching): For a mixed grouping, the current through the external resistance is largest when the total internal resistance of the cell combination is made equal to the external resistance R (impedance matching).

Step 1 — Write the current: For a combination with EMF E_{tot} and internal resistance r_{tot},

$$I = \frac{E_{tot}}{R + r_{tot}}.$$

Step 2 — Optimise over the grouping: Rearranging the rows and columns of cells trades E_{tot} against r_{tot}; the standard mixed-grouping analysis shows the delivered current peaks when

$$r_{tot} = R.$$

Step 3 — State the condition: The internal resistance of the combination should equal the external resistance.

Why other options are wrong:

- (A) $2R$ and (D) $\frac{1}{2}R$ are not the matching condition.
- (B) zero internal resistance is not achievable by regrouping a fixed set of cells.

Final Answer: $r_{tot} = R \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 19

Q20.

Solution

Concept — Bulbs in series: In series the same current flows through both bulbs, so the brighter one is the bulb that dissipates more power, $P = I^2R$. The bulb with the larger resistance is brighter. A higher wattage rating means lower resistance, since $R = \dfrac{V^2}{P}$ at rated voltage.

Step 1 — Find each resistance: At 220 V,

$$R_{100} = \frac{220^2}{100}, \qquad R_{60} = \frac{220^2}{60}.$$

Since $60 < 100$, $R_{60} > R_{100}$.

Step 2 — Compare power in series: The common current I gives $P = I^2R$, so the larger-resistance bulb dissipates more,

$$P_{60} > P_{100} \quad \text{(in series)}.$$

Step 3 — Conclude: The 60 W bulb has the higher resistance and glows brighter.

Why other options are wrong:

- (B) the wattage rating applies only at rated voltage, not in this series circuit.
- (C) equal brightness would need equal resistances.
- (D) the 100 W bulb actually has the *lower* resistance.

Final Answer: the 60 W bulb glows brighter $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q 20

Q21.

Solution

Concept — Magnetic moment of a current loop: For a flat coil of N turns, each of area A, carrying current I, the magnetic moment is $\mu = NIA$, with $A = \pi R^2$.

Step 1 — Find the area of one turn:

$$A = \pi R^2 = \pi\,(0.1)^2 = \pi \times 0.01 = 0.01\pi\ \text{m}^2.$$

Step 2 — Apply the moment formula:

$$\mu = NIA = 50 \times 2 \times 0.01\pi.$$

Step 3 — Evaluate:

$$\mu = 100 \times 0.01\pi = \pi \text{ A m}^2 \approx 3.14 \text{ A m}^2.$$

Why other options are wrong:

- (A) 1.57 A m^2 uses half the current ($I = 1$ A).
- (C) 0.79 A m^2 uses one quarter of the current.
- (D) 6.28 A m^2 doubles the correct result.

Final Answer: $\mu = \pi \text{ A m}^2 \approx 3.14 \text{ A m}^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 21

Q22.

Solution

Concept — Field on the axis of a circular loop: The magnetic field at an axial point a distance x from the centre of a single-turn loop of radius R carrying current I is $B = \dfrac{\mu_0 I R^2}{2\,(R^2 + x^2)^{3/2}}$.

Step 1 — Recall the Biot–Savart result: Summing the axial components of dB around the loop gives

$$B = \frac{\mu_0 I R^2}{2\,(R^2 + x^2)^{3/2}}.$$

Step 2 — Check the centre limit: Setting $x = 0$,

$$B = \frac{\mu_0 I R^2}{2R^3} = \frac{\mu_0 I}{2R},$$

which is the known centre value, confirming the formula.

Step 3 — Identify the correct option: Option (C) is the general axial expression.

Why other options are wrong:

- (A) is the far-field ($x \gg R$) approximation, not the exact field.
- (B) is only the field at the centre ($x = 0$).
- (D) has the wrong power in the denominator.

Final Answer: $B = \dfrac{\mu_0 I R^2}{2\,(R^2 + x^2)^{3/2}} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 22

Q23.

Solution

Concept — Growth of current in an RL circuit: When a battery is switched on, the current grows as $I = I_0\left(1 - e^{-t/\tau}\right)$, where the time constant is $\tau = \dfrac{L}{R}$.

Step 1 — List the data: $L = 2$ H, $R = 10\ \Omega$.

Step 2 — Apply the time-constant formula:

$$\tau = \frac{L}{R} = \frac{2}{10}.$$

Step 3 — Evaluate:

$$\tau = 0.2 \text{ s}.$$

Why other options are wrong:

- (A) 20 s uses LR instead of L/R.
- (B) 5 s inverts the ratio (R/L).
- (C) 0.5 s comes from an arithmetic slip.

Final Answer: $\tau = 0.2 \text{ s} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 23

Q24.

Solution

Concept — Impedance of a series LCR circuit: The impedance is $Z = \sqrt{R^2 + (X_L - X_C)^2}$, where X_L and X_C are the inductive and capacitive reactances.

Step 1 — Find the net reactance:

$$X_L - X_C = 12 - 8 = 4\ \Omega.$$

Step 2 — Apply the impedance formula:

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{3^2 + 4^2}.$$

Step 3 — Evaluate:

$$Z = \sqrt{9 + 16} = \sqrt{25} = 5\ \Omega.$$

Why other options are wrong:

- (B) $7\ \Omega$ adds R and the net reactance arithmetically.
- (C) $23\ \Omega$ adds all three magnitudes.
- (D) $13\ \Omega$ uses $X_L + X_C$ instead of the difference.

Final Answer: $Z = 5\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q 24**

Q25.

Solution

Concept — Convex lens, object beyond $2F$: When the object lies beyond $2F$, a convex lens forms a real, inverted image between F and $2F$ on the other side, and the image is diminished (smaller than the object).

Step 1 — Locate the image: Using $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ with $|u| > 2f$, the image distance satisfies $f < |v| < 2f$, so the image lies between F and $2F$.

Step 2 — Determine nature and orientation: Real rays actually meet on the far side, giving a real image; the ray construction inverts it, so it is inverted.

Step 3 — Determine size: Since $|v| < |u|$, the magnification magnitude $\left|\frac{v}{u}\right| < 1$, so the image is diminished.

Why other options are wrong:

- (A) and (D) describe virtual erect images, which a convex lens forms only for objects inside F.
- (C) same-size image occurs only when the object is exactly at $2F$.

Final Answer: real, inverted, diminished $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q 25**

Q26.

Solution

Concept — Critical angle: Total internal reflection occurs when light travels from a denser to a rarer medium beyond the critical angle θ_c, given by $\sin\theta_c = \frac{1}{n}$, where n is the refractive index of the denser medium relative to the rarer one.

Step 1 — Identify the refractive index: The core (denser) has $n = \frac{3}{2}$ relative to the surrounding rarer medium.

Step 2 — Apply the critical-angle relation:

$$\sin\theta_c = \frac{1}{n} = \frac{1}{3/2}.$$

Step 3 — Simplify:

$$\sin\theta_c = \frac{2}{3}.$$

Why other options are wrong:

- (A) $\sin\theta_c = \frac{3}{2}$ exceeds 1 and is impossible.
- (B) and (D) use cosine or tangent, not the correct sine relation.

Final Answer: $\sin\theta_c = \frac{2}{3} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 26

Q27.

Solution

Concept — Intensity in two-slit interference: The extreme intensities are $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$ and $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$.

Step 1 — Take the amplitudes (square roots of intensity): With $I_1 : I_2 = 4 : 1$, the amplitudes are in the ratio $\sqrt{4} : \sqrt{1} = 2 : 1$.

Step 2 — Form the extreme intensities:

$$I_{max} \propto (2+1)^2 = 9, \qquad I_{min} \propto (2-1)^2 = 1.$$

Step 3 — Take the ratio:

$$\frac{I_{max}}{I_{min}} = \frac{9}{1} = 9 : 1.$$

Why other options are wrong:

- (A) $4:1$ uses the intensity ratio directly without combining amplitudes.
- (B) $16:1$ squares the intensity ratio.
- (C) $5:3$ adds intensities instead of amplitudes.

Final Answer: $I_{max} : I_{min} = 9 : 1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 27

Q28.

Solution

Concept — Saturation photocurrent and intensity: The saturation photocurrent is proportional to the number of photoelectrons emitted per second, which is proportional to the number of incident photons per second, i.e. to the light intensity (at fixed frequency).

Step 1 — Relate current to intensity:

$$I_{sat} \propto (\text{photons per second}) \propto (\text{intensity}).$$

Step 2 — Apply the change: Doubling the intensity doubles the number of incident photons per second, hence doubles the emitted photoelectrons per second.

Step 3 — State the result: The saturation photocurrent doubles. (The stopping potential, which depends on frequency, is unchanged.)

Why other options are wrong:

- (B) the current cannot stay unchanged when more photons arrive.
- (C) four times would need the square of intensity.
- (D) halving is the opposite of the actual effect.

Final Answer: the saturation photocurrent doubles $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 28

Q29.

Solution

Concept — Activity of a radioactive sample: The activity (number of disintegrations per second) is $A = \lambda N$, where λ is the decay constant and N is the number of undecayed nuclei.

Step 1 — List the data: $N = 4 \times 10^{16}$, $\lambda = 2 \times 10^{-6}\ \text{s}^{-1}$.

Step 2 — Apply the activity formula:

$$A = \lambda N = (2 \times 10^{-6}) \times (4 \times 10^{16}).$$

Step 3 — Evaluate:

$$A = 8 \times 10^{10}\ \text{decays s}^{-1}.$$

Why other options are wrong:

- (A) 2×10^{10} and (B) 4×10^{10} come from arithmetic slips in the mantissa.
- (D) 2×10^{22} multiplies the powers of ten incorrectly.

Final Answer: $A = 8 \times 10^{10}$ decays $\text{s}^{-1} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — LED and photodiode operation: An LED is a forward-biased pn-junction in which electron–hole recombination releases energy as light. A photodiode is a reverse-biased pn-junction in which incident light generates electron–hole pairs, producing a measurable photocurrent.

Step 1 — LED operation: Under forward bias, carriers are injected across the junction and recombine, emitting photons; LEDs are used as indicator lamps and in displays.

Step 2 — Photodiode operation: Under reverse bias, light absorbed in the depletion region creates carriers that increase the reverse current in proportion to the light intensity; photodiodes are used as light detectors.

Step 3 — Match to the option: Option (B) states exactly: LED forward biased and emits light, photodiode reverse biased and detects light.

Why other options are wrong:

- (A) an LED is not reverse biased in normal use.
- (C) a photodiode is not operated in forward bias for detection.
- (D) reverses the roles of the two devices.

Final Answer: LED forward-biased emitter, photodiode reverse-biased detector $\Rightarrow \boxed{B}$

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