AIIMS Paramedical Physics

Sample Paper – 9

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. A force $\vec{F} = (3\,\hat{\imath})$ N acts at the point $\vec{r} = (2\,\hat{\jmath})$ m measured from a pivot. The torque $\vec{\tau} = \vec{r} \times \vec{F}$ about the pivot has magnitude and direction

(A) 6 N m, along $+\hat{k}$

(B) 5 N m, along $-\hat{k}$

(C) 6 N m, along $-\hat{k}$

(D) 6 N m, along $+\hat{\imath}$

Q2. Two cars travel along a straight road in the same direction. Car A moves at a constant 20 m s^{-1} and car B at a constant 30 m s^{-1}. At the instant B is 100 m behind A, the time taken by B to completely overtake (draw level with) A is

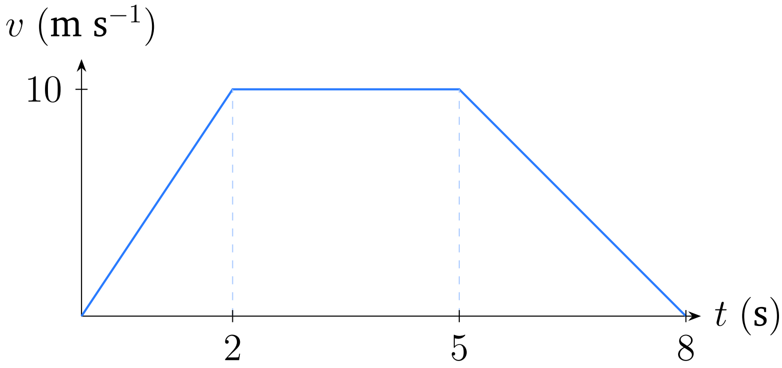
(A) 5 s

(B) 10 s

(C) 20 s

(D) 2 s

Q3. The speed–time graph below describes a particle's motion. Using the area under the graph, the total distance travelled by the particle in the 8 s shown is



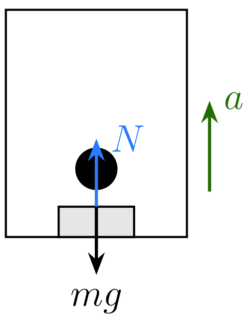
(A) 40 m

(B) 50 m

(C) 80 m

(D) 55 m

Q4. A person of mass 60 kg stands on a weighing scale inside a lift that accelerates *upward* at 2 m s^{-2}. Taking $g = 10$ m s^{-2}, the apparent weight (normal reaction N) registered by the scale is



(A) 720 N

(B) 600 N

(C) 480 N

(D) 120 N

Q5. A block is released from rest on a smooth (frictionless) fixed wedge whose inclined face makes an angle of $30°$ with the horizontal. Taking $g = 10$ m s^{-2}, the acceleration of the block down the incline is

(A) 10 m s^{-2}

(B) 8.66 m s^{-2}

(C) 5 m s^{-2}

(D) 2.5 m s^{-2}

Q6. A small ball is tied to a string of length 0.4 m and whirled in a vertical circle. Taking $g = 10$ m s^{-2}, the minimum speed the ball must have at the highest point of the circle so that the string stays taut is

(A) 4 m s^{-1}

(B) 1.6 m s^{-1}

(C) 8 m s^{-1}

(D) 2 m s^{-1}

Q7. A constant force of 50 N acts on a body moving in the direction of the force. At the instant the body's speed is 12 m s^{-1}, the instantaneous power delivered by the force ($P = Fv$) is

(A) 600 W

(B) 300 W

(C) 62 W

(D) 150 W

Q8. Two equal and opposite parallel forces of magnitude 5 N each act on a rigid body, their lines of action separated by a perpendicular distance of 0.4 m. The torque (moment) of this couple is

(A) 1 N m

(B) 2 N m

(C) 0 N m

(D) 4 N m

Q9. Two point masses of 4 kg and 6 kg are held 0.2 m apart. Taking $G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2}, the gravitational potential energy of this two-mass system, $U = -\dfrac{Gm_1m_2}{r}$, is

(A) -4.0×10^{-9} J

(B) $+8.0 \times 10^{-9}$ J

(C) -8.0×10^{-9} J

(D) -1.6×10^{-8} J

Q10. In a hydraulic lift the small piston has an area of 5 cm^2 and the large piston an area of 250 cm^2. If a force of 40 N is applied to the small piston, by Pascal's law the force exerted on the large piston is

(A) 200 N

(B) 800 N

(C) 1250 N

(D) 2000 N

Q11. A black body radiates most intensely at a wavelength of 1.45 μm. Using Wien's displacement law with $b = 2.9 \times 10^{-3}$ m K, the temperature of the body is

(A) 2000 K

(B) 1450 K

(C) 4000 K

(D) 1000 K

Q12. An ideal gas is taken round a closed rectangular cycle on a P–V diagram. The pressure varies between 1×10^5 Pa and 3×10^5 Pa, and the volume between 2×10^{-3} m^3 and 5×10^{-3} m^3. The net work done by the gas per cycle (the area enclosed) is

(A) 300 J

(B) 600 J

(C) 1200 J

(D) 150 J

Q13. A particle executes SHM with period $T = 12$ s, starting from its mean position at $t = 0$ with displacement $x = A\sin(\omega t)$. The time it first takes to reach a displacement equal to half the amplitude ($x = A/2$) is

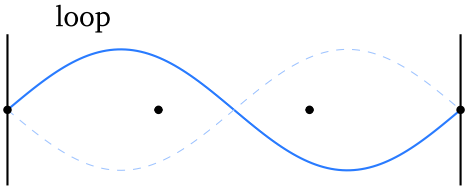
(A) 2 s

(B) 3 s

(C) 1 s

(D) 4 s

Q14. A string of linear mass density $\mu = 2.5 \times 10^{-3}$ kg m^{-1} is stretched under a tension of $T = 90$ N, as shown by the standing-wave pattern it supports. The speed of a transverse wave on the string, $v = \sqrt{T/\mu}$, is



stretched string, tension T

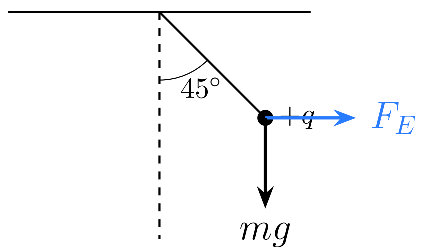
(A) 36 m s^{-1}

(B) 90 m s^{-1}

(C) 150 m s^{-1}

(D) 190 m s^{-1}

Q15. A small charged ball of mass m hangs from a light thread in a region of uniform horizontal electric field, the thread making an angle of $45°$ with the vertical at equilibrium, as shown. If the horizontal electric force on the ball is F_E and its weight is mg, then the relation between them is



(A) $F_E = mg$

(B) $F_E = \dfrac{mg}{\sqrt{2}}$

(C) $F_E = \sqrt{2}\,mg$

(D) $F_E = \dfrac{mg}{2}$

Q16. The electric field in a certain region of free space has magnitude $E = 2 \times 10^4$ V m^{-1}. Taking $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}, the energy stored per unit volume of the field, $u = \frac{1}{2}\varepsilon_0 E^2$, is approximately

(A) 3.5×10^{-3} J m^{-3}

(B) 8.85×10^{-4} J m^{-3}

(C) 3.5×10^{-4} J m^{-3}

(D) 1.77×10^{-3} J m^{-3}

Q17. A parallel-plate capacitor of plate area A and separation d has its space filled by two dielectric slabs, each occupying half the plate area, with dielectric constants $K_1 = 2$ and $K_2 = 4$. The two halves act as capacitors in parallel. If the air capacitance of the full plate would be C_0, the new capacitance is

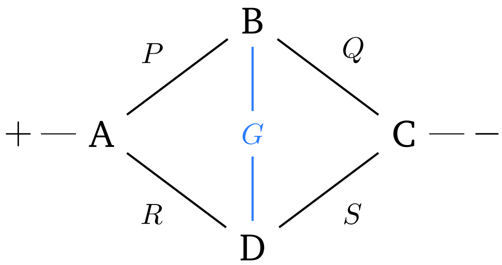
(A) $6C_0$

(B) $\dfrac{8}{3}C_0$

(C) $3C_0$

(D) $2C_0$

Q18. In the Wheatstone bridge shown, a galvanometer G connects the mid-points. Three arms are $P = 10\ \Omega$, $Q = 20\ \Omega$ and $R = 15\ \Omega$. For the galvanometer to show *zero* deflection (balanced bridge, $\frac{P}{Q} = \frac{R}{S}$), the fourth arm S must be



(A) $7.5\ \Omega$

(B) $30\ \Omega$

(C) $22.5\ \Omega$

(D) $10\ \Omega$

Q19. At a junction in a circuit, currents of 3 A and 5 A flow *into* the node, while a current of 4 A flows *out*. By Kirchhoff's junction rule, the remaining current in the fourth wire, and its direction, is

(A) 4 A into the node

(B) 2 A into the node

(C) 4 A out of the node

(D) 12 A out of the node

Q20. Two identical bulbs, each rated to dissipate power P when connected alone across a supply, are now connected in series across the same supply. The total power dissipated by the pair is

(A) $2P$

(B) $4P$

(C) P

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

Q21. A galvanometer of resistance $G = 90\ \Omega$ gives full-scale deflection for a current of $I_g = 10$ mA. To convert it into an ammeter reading up to $I = 1$ A, the shunt resistance $S = \dfrac{I_g G}{I - I_g}$ to be connected in parallel is

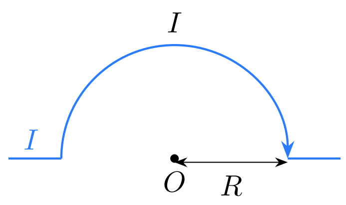
(A) $0.909\ \Omega$

(B) $9\ \Omega$

(C) $0.9\ \Omega$

(D) $90\ \Omega$

Q22. A wire carrying current $I = 2$ A is bent into a semicircle of radius $R = 0.1$ m, as shown. Taking $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1} and using $B = \dfrac{\mu_0 I}{4R}$, the magnitude of the magnetic field at the centre O is



(A) 1.26×10^{-5} T

(B) 6.28×10^{-6} T

(C) 2.51×10^{-5} T

(D) 3.14×10^{-6} T

Q23. When the current in one coil changes at the rate of 20 A s^{-1}, an emf of 4 mV is induced in a neighbouring coil. The mutual inductance between the two coils, $M = \dfrac{|\varepsilon|}{|dI/dt|}$, is

(A) 80 mH

(B) 5 mH

(C) 0.2 mH

(D) 2 mH

Q24. An ideal LC circuit has $L = 2$ mH and $C = 5$ μF. The angular frequency of the free oscillations, $\omega = \dfrac{1}{\sqrt{LC}}$, is

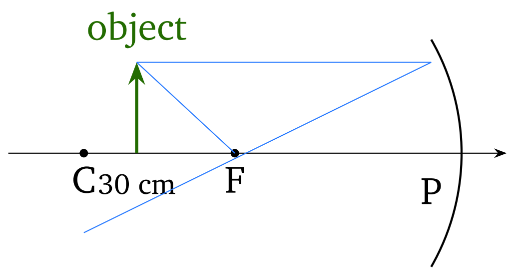
(A) 10^6 rad s^{-1}

(B) 10^4 rad s^{-1}

(C) 2×10^4 rad s^{-1}

(D) 10^5 rad s^{-1}

Q25. An object is placed 30 cm in front of a concave mirror of focal length 20 cm, as shown. Using the mirror formula $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$ (with the sign convention $u = -30$ cm, $f = -20$ cm), the image distance is



(A) -60 cm (real, inverted)

(B) $+60$ cm (virtual, erect)

(C) -12 cm (real, inverted)

(D) -20 cm (real, inverted)

Q26. Light passes through a thin prism. The refractive index of the prism material is 1.52 for violet light and 1.50 for red light. Since violet has the *larger* refractive index, on emerging from the prism

(A) red light is deviated more than violet

(B) violet light is deviated more than red

(C) both colours are deviated equally

(D) neither colour is deviated

Q27. The limit of resolution of a telescope of objective aperture D for light of wavelength λ is $\Delta\theta = \dfrac{1.22\,\lambda}{D}$. If the aperture D of the objective is doubled (with λ unchanged), the resolving power of the telescope

(A) is halved

(B) stays the same

(C) is doubled

(D) becomes four times

Q28. A monochromatic source emits light of energy 4×10^{-19} J per photon at a total radiated power of 8 W. The number of photons emitted by the source per second is

(A) 2×10^{18}

(B) 4×10^{19}

(C) 0.5×10^{19}

(D) 2×10^{19}

Q29. For the Lyman series of hydrogen, the series limit corresponds to a transition from $n = \infty$ to $n = 1$, so $\dfrac{1}{\lambda} = R\left(\dfrac{1}{1^2} - \dfrac{1}{\infty^2}\right) = R$. Taking $R = 1.1 \times 10^7$ m^{-1}, the series-limit wavelength is approximately

(A) 91 nm

(B) 364 nm

(C) 122 nm

(D) 46 nm

Q30. In a half-wave rectifier the secondary of the transformer supplies a peak alternating voltage of $V_0 = 220$ V to a single diode. During the half cycle when the diode is reverse-biased, the maximum reverse voltage (peak inverse voltage, PIV) that the diode must withstand is

(A) 110 V

(B) 220 V

(C) 440 V

(D) 311 V

Detailed Solutions

Q1.

Solution

Concept — Cross product for torque: The torque is $\vec{\tau} = \vec{r} \times \vec{F}$. Its magnitude is $rF\sin\theta$ and its direction is given by the right-hand rule applied to the order $\vec{r}$ then $\vec{F}$.

Step 1 — Write the vectors: Here $\vec{r} = 2\,\hat{\jmath}$ and $\vec{F} = 3\,\hat{\imath}$.

Step 2 — Evaluate the cross product:

$$\vec{\tau} = (2\,\hat{\jmath}) \times (3\,\hat{\imath}) = 6\,(\hat{\jmath} \times \hat{\imath}).$$

Step 3 — Use the unit-vector rule: Since $\hat{\jmath} \times \hat{\imath} = -\hat{k}$,

$$\vec{\tau} = 6\,(-\hat{k}) = -6\,\hat{k}.$$

So the magnitude is 6 N m and the direction is along $-\hat{k}$.

Why other options are wrong:

- 6 N m along $+\hat{k}$: this reverses the order to $\hat{\imath} \times \hat{\jmath}$, giving the wrong sign.
- 5 N m along $-\hat{k}$: wrong magnitude; $2 \times 3 = 6$, not 5.
- 6 N m along $+\hat{\imath}$: torque is perpendicular to both $\vec{r}$ and $\vec{F}$, so it cannot point along $\hat{\imath}$.

Final Answer: $\vec{\tau} = -6\,\hat{k}$ N m $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 1

Q2.

Solution

Concept — Relative motion: When two bodies move along the same line, the faster one closes the gap at the relative speed $v_{rel} = v_B - v_A$. The time to cover the initial gap is gap divided by relative speed.

Step 1 — Relative speed: With $v_B = 30$ m s^{-1} and $v_A = 20$ m s^{-1}:

$$v_{rel} = 30 - 20 = 10 \text{ m s}^{-1}.$$

Step 2 — Time to close the gap: The initial gap is 100 m:

$$t = \frac{\text{gap}}{v_{rel}} = \frac{100}{10} = 10 \text{ s.}$$

Why other options are wrong:

- 5 s: uses $v_{rel} = 20$ m s^{-1} by adding the speeds, which applies only to opposite directions.
- 20 s: divides by 5 m s^{-1}, an incorrect relative speed.
- 2 s: divides the gap by 50, mixing the speeds wrongly.

Final Answer: $t = 10$ s $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 2

Q3.

Solution

Concept — Area under a v–t graph: On a speed–time graph the distance travelled equals the area between the curve and the time axis. Here the shape is a trapezium.

Step 1 — Identify the shape: The graph rises from 0 to 10 m s^{-1} over 0 to 2 s, stays at 10 m s^{-1} from 2 to 5 s, then falls back to 0 from 5 to 8 s. This is a trapezium of height 10.

Step 2 — Use the trapezium-area formula: The two parallel sides are the top length (from 2 to 5 s, i.e. 3 s) and the base length (from 0 to 8 s, i.e. 8 s):

$$\text{Area} = \tfrac{1}{2}(\text{top} + \text{base}) \times \text{height} = \tfrac{1}{2}(3 + 8) \times 10.$$

Step 3 — Compute:

$$\text{Area} = \tfrac{1}{2} \times 11 \times 10 = 55 \text{ m.}$$

Why other options are wrong:

- 40 m: counts only the flat middle plus one ramp.
- 50 m: treats the base as 10 s wrongly or drops a ramp.
- 80 m: uses a full rectangle 10×8, ignoring the sloping ends.

Final Answer: Distance $= 55$ m $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 3

Q4.

Solution

Concept — Apparent weight in an accelerating lift: The scale reads the normal reaction N. Newton's second law on the person gives $N - mg = ma$ when the lift accelerates upward, so $N = m(g + a)$.

Step 1 — List the values: $m = 60$ kg, $g = 10$ m s^{-2}, $a = 2$ m s^{-2} (upward).

Step 2 — Substitute:

$$N = m(g + a) = 60 \times (10 + 2).$$

Step 3 — Compute:

$$N = 60 \times 12 = 720 \text{ N}.$$

Why other options are wrong:

- 600 N: the true weight mg, valid only when the lift is at rest or moving uniformly.
- 480 N: uses $g - a$, which applies to downward acceleration, not upward.
- 120 N: equals $m\,a$ alone, omitting the weight term.

Final Answer: $N = 720 \text{ N} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 4

Q5.

Solution

Concept — Block on a smooth incline: On a frictionless incline of angle θ, the only force along the slope is the gravity component $mg\sin\theta$. Dividing by the mass, the acceleration down the slope is $a = g\sin\theta$, independent of the mass.

Step 1 — List the values: $g = 10$ m s^{-2}, $\theta = 30°$, $\sin 30° = \frac{1}{2}$.

Step 2 — Substitute:

$$a = g\sin\theta = 10 \times \tfrac{1}{2}.$$

Step 3 — Compute:

$$a = 5 \text{ m s}^{-2}.$$

Why other options are wrong:

- 10 m s^{-2}: this is free fall, which would need $\theta = 90°$.
- 8.66 m s^{-2}: uses $g\cos 30°$, but the cosine component is along the normal, not the slope.
- 2.5 m s^{-2}: halves the correct value by an extra factor.

Final Answer: $a = 5 \text{ m s}^{-2} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q 5**

Q6.

Solution

Concept — Minimum speed at the top of a vertical circle: At the highest point, for the string to stay just taut, gravity alone supplies the centripetal force: $mg = \frac{mv_{top}^2}{r}$, giving $v_{top} = \sqrt{gr}$.

Step 1 — List the values: $g = 10 \text{ m s}^{-2}$, $r = 0.4 \text{ m}$.

Step 2 — Substitute:

$$v_{top} = \sqrt{gr} = \sqrt{10 \times 0.4}.$$

Step 3 — Compute:

$$v_{top} = \sqrt{4} = 2 \text{ m s}^{-1}.$$

Why other options are wrong:

- 4 m s^{-1}: uses $\sqrt{5gr}$, the speed needed at the *bottom*, not the top.
- 1.6 m s^{-1}: takes gr directly without the square root.
- 8 m s^{-1}: arbitrary, far above the threshold.

Final Answer: $v_{top} = 2 \text{ m s}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q 6**

Q7.

Solution

Concept — Instantaneous power: When a force acts along the direction of motion, the instantaneous power is the product of force and speed: $P = Fv$.

Step 1 — List the values: $F = 50$ N, $v = 12$ m s^{-1}.

Step 2 — Substitute:

$$P = Fv = 50 \times 12.$$

Step 3 — Compute:

$$P = 600 \text{ W}.$$

Why other options are wrong:

- 300 W: halves the product wrongly, as if averaging.
- 62 W: adds $50 + 12$ instead of multiplying.
- 150 W: divides 600 by 4 for no reason.

Final Answer: $P = 600$ W $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 7

Q8.

Solution

Concept — Torque of a couple: A couple is a pair of equal, opposite, parallel forces. Its torque (moment) equals one force times the perpendicular distance between their lines of action: $\tau = F \times d$. The couple's torque is the same about every point.

Step 1 — List the values: $F = 5$ N, $d = 0.4$ m.

Step 2 — Substitute:

$$\tau = F \times d = 5 \times 0.4.$$

Step 3 — Compute:

$$\tau = 2 \text{ N m}.$$

Why other options are wrong:

- 1 N m: uses half the separation, perhaps an arm of 0.2 m.

- 0 N m: assumes the two forces cancel; they cancel as a net force but not as a torque.
- 4 N m: doubles the force to 10 N, but each force is 5 N.

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

Answer: (B) Go Back to Q 8

Q9.

Solution

Concept — Gravitational potential energy of two masses: The PE of a pair of point masses separated by r is $U = -\dfrac{Gm_1m_2}{r}$. It is negative because gravity is attractive.

Step 1 — List the values: $m_1 = 4$ kg, $m_2 = 6$ kg, $r = 0.2$ m, $G = 6.67 \times 10^{-11}$.

Step 2 — Substitute:

$$U = -\frac{(6.67 \times 10^{-11})(4)(6)}{0.2}.$$

Step 3 — Simplify the numerator:

$$6.67 \times 10^{-11} \times 24 = 1.6 \times 10^{-9}.$$

Step 4 — Divide by the separation:

$$U = -\frac{1.6 \times 10^{-9}}{0.2} = -8.0 \times 10^{-9} \text{ J}.$$

Why other options are wrong:

- -4.0×10^{-9} J: forgets to divide by 0.2 (off by a factor of 2).
- $+8.0 \times 10^{-9}$ J: correct magnitude but wrong sign; gravitational PE is negative.
- -1.6×10^{-8} J: uses $r = 0.1$ m instead of 0.2 m.

Final Answer: $U = -8.0 \times 10^{-9}$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 9

Q10.

Solution

Concept — Pascal's law in a hydraulic lift: Pressure is transmitted equally, so $\frac{F_1}{A_1} = \frac{F_2}{A_2}$. The output force scales with the area ratio: $F_2 = F_1 \frac{A_2}{A_1}$.

Step 1 — List the values: $A_1 = 5$ cm^2, $A_2 = 250$ cm^2, $F_1 = 40$ N.

Step 2 — Form the area ratio:

$$\frac{A_2}{A_1} = \frac{250}{5} = 50.$$

Step 3 — Compute the output force:

$$F_2 = F_1 \times \frac{A_2}{A_1} = 40 \times 50 = 2000 \text{ N}.$$

Why other options are wrong:

- 200 N: multiplies by 5 instead of 50.
- 800 N: uses an area ratio of 20.
- 1250 N: divides areas the wrong way and mis-scales.

Final Answer: $F_2 = 2000 \text{ N} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 10

Q11.

Solution

Concept — Wien's displacement law: The wavelength of peak emission and the absolute temperature are related by $\lambda_{max} T = b$, where $b = 2.9 \times 10^{-3}$ m K. Hence $T = \frac{b}{\lambda_{max}}$.

Step 1 — Convert the wavelength: $\lambda_{max} = 1.45\ \mu\text{m} = 1.45 \times 10^{-6}$ m.

Step 2 — Substitute:

$$T = \frac{b}{\lambda_{max}} = \frac{2.9 \times 10^{-3}}{1.45 \times 10^{-6}}.$$

Step 3 — Simplify:

$$T = \frac{2.9}{1.45} \times 10^{-3-(-6)} = 2 \times 10^3 = 2000 \text{ K}.$$

Why other options are wrong:

- 1450 K: confuses the numerical value of λ with the temperature.
- 4000 K: doubles the correct result.
- 1000 K: halves the correct result.

Final Answer: $T = 2000\text{ K} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — Work in a closed P–V cycle: The net work done by a gas per cycle equals the area enclosed by the cycle on the P–V diagram. For a rectangular cycle this area is $\Delta P \times \Delta V$.

Step 1 — Find the pressure range:

$$\Delta P = (3 - 1) \times 10^5 = 2 \times 10^5 \text{ Pa}.$$

Step 2 — Find the volume range:

$$\Delta V = (5 - 2) \times 10^{-3} = 3 \times 10^{-3} \text{ m}^3.$$

Step 3 — Compute the enclosed area:

$$W = \Delta P \times \Delta V = (2 \times 10^5)(3 \times 10^{-3}) = 600 \text{ J}.$$

Why other options are wrong:

- 300 J: uses half the rectangle area, as for a triangular cycle.
- 1200 J: doubles the area by an extra factor.
- 150 J: takes a quarter of the correct rectangle.

Final Answer: $W = 600\text{ J} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 12

Q13.

Solution

Concept — SHM starting from the mean position: With $x = A\sin(\omega t)$, the particle reaches displacement $x = A/2$ when $\sin(\omega t) = \frac{1}{2}$, i.e. $\omega t = \frac{\pi}{6}$.

Step 1 — Find the angular frequency: With $T = 12$ s:

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{12} = \frac{\pi}{6}\ \text{rad s}^{-1}.$$

Step 2 — Set up the displacement condition:

$$\frac{A}{2} = A\sin(\omega t) \;\Rightarrow\; \sin(\omega t) = \tfrac{1}{2} \;\Rightarrow\; \omega t = \frac{\pi}{6}.$$

Step 3 — Solve for the time:

$$t = \frac{\pi/6}{\omega} = \frac{\pi/6}{\pi/6} = 1\ \text{s}.$$

Why other options are wrong:

- 2 s: uses $\omega t = \pi/3$, which corresponds to $x = A\sqrt{3}/2$, not $A/2$.
- 3 s: uses $\omega t = \pi/2$, where $x = A$ (the extreme), not $A/2$.
- 4 s: equals $T/3$, not the time for half amplitude from the mean.

Final Answer: $t = 1$ s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 13

Q14.

Solution

Concept — Wave speed on a stretched string: The speed of a transverse wave depends only on the tension and the linear mass density: $v = \sqrt{\frac{T}{\mu}}$.

Step 1 — List the values: $T = 90$ N, $\mu = 2.5 \times 10^{-3}$ kg m^{-1}.

Step 2 — Form the ratio inside the root:

$$\frac{T}{\mu} = \frac{90}{2.5 \times 10^{-3}} = 3.6 \times 10^{4}.$$

Step 3 — Take the square root:

$$v = \sqrt{3.6 \times 10^4} = \sqrt{36000} = 190 \text{ m s}^{-1} \text{ (to 3 s.f.)}.$$

Why other options are wrong:

- 36 m s^{-1}: stops at T/μ scaled wrongly, taking the root of 36×10^2 as 36.
- 90 m s^{-1}: just quotes the tension as a speed.
- 150 m s^{-1}: uses $\mu = 4 \times 10^{-3}$ instead of the given value.

Final Answer: $v \approx 190 \text{ m s}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 14

Q15.

Solution

Concept — Charged ball in equilibrium: Three forces act: weight mg (down), the horizontal electric force F_E, and the thread tension along the string. Resolving the tension, the horizontal and vertical balances give $T \sin\theta = F_E$ and $T \cos\theta = mg$. Dividing, $\tan\theta = \frac{F_E}{mg}$.

Step 1 — Apply the angle condition: The thread makes $\theta = 45°$ with the vertical:

$$\tan 45° = \frac{F_E}{mg}.$$

Step 2 — Evaluate the tangent: Since $\tan 45° = 1$:

$$1 = \frac{F_E}{mg}.$$

Step 3 — Solve for the electric force:

$$F_E = mg.$$

Why other options are wrong:

- $F_E = \frac{mg}{\sqrt{2}}$: this would be the tension's horizontal share if T equalled mg, but tension is larger here.
- $F_E = \sqrt{2}\,mg$: equals the tension magnitude, not the horizontal force.
- $F_E = \frac{mg}{2}$: corresponds to $\tan\theta = \frac{1}{2}$, not $45°$.

Final Answer: $F_E = mg \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 15

Q16.

Solution

Concept — Energy density of an electric field: The energy stored per unit volume in an electric field in free space is $u = \frac{1}{2}\varepsilon_0 E^2$.

Step 1 — List the values: $E = 2 \times 10^4$ V m^{-1}, $\varepsilon_0 = 8.85 \times 10^{-12}$.

Step 2 — Square the field:

$$E^2 = (2 \times 10^4)^2 = 4 \times 10^8 \text{ V}^2\text{m}^{-2}.$$

Step 3 — Substitute and compute:

$$u = \tfrac{1}{2}(8.85 \times 10^{-12})(4 \times 10^8) = \tfrac{1}{2} \times 3.54 \times 10^{-3} = 1.77 \times 10^{-3} \text{ J m}^{-3}.$$

Why other options are wrong:

- 3.5×10^{-3} J m^{-3}: forgets the factor of $\frac{1}{2}$.
- 8.85×10^{-4} J m^{-3}: drops a factor of 2 from E^2.
- 3.5×10^{-4} J m^{-3}: an error of one power of ten.

Final Answer: $u = 1.77 \times 10^{-3}$ J m^{-3} $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 16

Q17.

Solution

Concept — Two dielectrics filling each half of the plate area: When each dielectric fills half the area over the full gap, the arrangement is two capacitors in *parallel*, each with plate area $A/2$. A half-area air capacitor has capacitance $C_0/2$, so each dielectric half is $K_i\,(C_0/2)$, and the parallel total adds them.

Step 1 — Capacitance of each half:

$$C_1 = K_1 \cdot \frac{C_0}{2} = 2 \cdot \frac{C_0}{2} = C_0, \qquad C_2 = K_2 \cdot \frac{C_0}{2} = 4 \cdot \frac{C_0}{2} = 2C_0.$$

Step 2 — Add in parallel:

$$C = C_1 + C_2 = C_0 + 2C_0.$$

Step 3 — Simplify:

$$C = 3C_0.$$

Why other options are wrong:

- $6C_0$: adds $K_1 + K_2 = 6$ as if each filled the full area.
- $\frac{8}{3}C_0$: this is the result for dielectrics stacked in *series* (split gap), not side by side.
- $2C_0$: averages the constants without the area-halving correctly.

Final Answer: $C = 3C_0 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 17

Q18.

Solution

Concept — Balanced Wheatstone bridge: The galvanometer shows zero deflection when the bridge is balanced, which requires $\frac{P}{Q} = \frac{R}{S}$. Solving for the unknown arm gives $S = \frac{Q\,R}{P}$.

Step 1 — List the arms: $P = 10\ \Omega$, $Q = 20\ \Omega$, $R = 15\ \Omega$.

Step 2 — Rearrange the balance condition:

$$S = \frac{Q\,R}{P} = \frac{20 \times 15}{10}.$$

Step 3 — Compute:

$$S = \frac{300}{10} = 30\ \Omega.$$

Why other options are wrong:

- $7.5\ \Omega$: uses $\frac{P\,R}{Q}$, inverting the ratio.
- $22.5\ \Omega$: not consistent with $P/Q = R/S$.
- $10\ \Omega$: simply repeats arm P, ignoring the balance relation.

Final Answer: $S = 30\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 18

Q19.

Solution

Concept — Kirchhoff's junction rule: The total current entering a node equals the total current leaving it (charge conservation): $\sum I_{in} = \sum I_{out}$.

Step 1 — Sum the known incoming currents:

$$I_{in} = 3 + 5 = 8 \text{ A}.$$

Step 2 — Account for the known outgoing current: One wire carries 4 A out. Let the fourth wire carry I. Balance requires:

$$8 = 4 + I.$$

Step 3 — Solve for the fourth current:

$$I = 8 - 4 = 4 \text{ A}, \text{ flowing out of the node.}$$

Why other options are wrong:

- 4 A into the node: wrong direction; the inflow already exceeds the known outflow.
- 2 A into the node: wrong magnitude and direction.
- 12 A out of the node: adds all three given currents, double-counting.

Final Answer: 4 A out of the node ⇒ C

Answer: (C) Go Back to Q 19

Q20.

Solution

Concept — Bulbs in series: A bulb rated power P at supply voltage V has resistance $R = \frac{V^2}{P}$. Two such bulbs in series have total resistance $2R$, so the pair draws less power from the same supply.

Step 1 — Single-bulb resistance:

$$R = \frac{V^2}{P}.$$

Step 2 — Series resistance of the pair:

$$R_{series} = R + R = 2R = \frac{2V^2}{P}.$$

Step 3 — Power across the same supply:

$$P_{series} = \frac{V^2}{R_{series}} = \frac{V^2}{2V^2/P} = \frac{P}{2}.$$

Why other options are wrong:

- $2P$: this is the *parallel* result, where resistance halves.
- $4P$: would require resistance to drop to a quarter, not occur in series.
- P: ignores the doubling of total resistance.

Final Answer: $P_{series} = \frac{P}{2} \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q 20

Q21.

Solution

Concept — Converting a galvanometer to an ammeter: A low shunt resistance S is connected in parallel to carry the excess current. It is given by $S = \frac{I_g G}{I - I_g}$.

Step 1 — List the values: $G = 90\ \Omega$, $I_g = 10$ mA $= 0.01$ A, $I = 1$ A.

Step 2 — Compute the denominator:

$$I - I_g = 1 - 0.01 = 0.99 \text{ A}.$$

Step 3 — Substitute:

$$S = \frac{0.01 \times 90}{0.99} = \frac{0.9}{0.99} = 0.909\ \Omega.$$

Why other options are wrong:

- $9\ \Omega$: drops the factor of I_g in the numerator.
- $0.9\ \Omega$: uses $I = I_g + I$ wrongly, taking the denominator as 1.
- $90\ \Omega$: this is the galvanometer's own resistance, not the shunt.

Final Answer: $S \approx 0.909\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 21

Q22.

Solution

Concept — Field at the centre of a semicircular wire: A full circular loop gives $\frac{\mu_0 I}{2R}$ at its centre; a semicircle (half the loop) gives half of that: $B = \frac{\mu_0 I}{4R}$.

Step 1 — List the values: $\mu_0 = 4\pi \times 10^{-7}$, $I = 2$ A, $R = 0.1$ m.

Step 2 — Substitute:

$$B = \frac{\mu_0 I}{4R} = \frac{(4\pi \times 10^{-7})(2)}{4 \times 0.1}.$$

Step 3 — Simplify:

$$B = \frac{8\pi \times 10^{-7}}{0.4} = 20\pi \times 10^{-7} = 6.28 \times 10^{-6}\ \text{T}.$$

Why other options are wrong:

- 1.26×10^{-5} T: uses the full-loop formula $\frac{\mu_0 I}{2R}$, double the semicircle value.
- 2.51×10^{-5} T: off by a factor of 4 in the radius placement.
- 3.14×10^{-6} T: halves the correct semicircle value.

Final Answer: $B = 6.28 \times 10^{-6}\ \text{T} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 22

Q23.

Solution

Concept — Mutual inductance: The emf induced in one coil by a changing current in a neighbouring coil is $\varepsilon = -M\dfrac{dI}{dt}$. Taking magnitudes, $M = \dfrac{|\varepsilon|}{|dI/dt|}$.

Step 1 — List the values: $|\varepsilon| = 4\ \text{mV} = 4 \times 10^{-3}\ \text{V}$, $\left|\dfrac{dI}{dt}\right| = 20\ \text{A s}^{-1}$.

Step 2 — Substitute:

$$M = \frac{4 \times 10^{-3}}{20}.$$

Step 3 — Simplify:

$$M = 2 \times 10^{-4}\ \text{H} = 0.2\ \text{mH}.$$

Why other options are wrong:

- 80 mH: multiplies emf by the rate instead of dividing.
- 5 mH: inverts the ratio, dividing the rate by the emf.
- 2 mH: an error of one power of ten.

Final Answer: $M = 0.2\ \text{mH} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 23

Q24.

Solution

Concept — Frequency of LC oscillations: A charge oscillating in an ideal LC circuit has angular frequency $\omega = \dfrac{1}{\sqrt{LC}}$.

Step 1 — List the values: $L = 2\ \text{mH} = 2 \times 10^{-3}\ \text{H}$, $C = 5\ \mu\text{F} = 5 \times 10^{-6}\ \text{F}$.

Step 2 — Compute the product LC:

$$LC = (2 \times 10^{-3})(5 \times 10^{-6}) = 10 \times 10^{-9} = 1 \times 10^{-8}.$$

Step 3 — Take the reciprocal square root:

$$\omega = \frac{1}{\sqrt{1 \times 10^{-8}}} = \frac{1}{1 \times 10^{-4}} = 1 \times 10^{4}\ \text{rad s}^{-1}.$$

Why other options are wrong:

- 10^6 rad s^{-1}: uses $LC = 10^{-12}$, off by four orders of magnitude.
- 2×10^4 rad s^{-1}: doubles the correct value.
- 10^5 rad s^{-1}: takes $\sqrt{LC} = 10^{-5}$, an error of one order.

Final Answer: $\omega = 1 \times 10^4$ rad s^{-1} $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 24

Q25.

Solution

Concept — Mirror formula: Using the sign convention, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$, with u and f negative for a real object in front of a concave mirror.

Step 1 — List the values: $u = -30$ cm, $f = -20$ cm.

Step 2 — Rearrange for $\frac{1}{v}$:

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

Step 3 — Combine the fractions:

$$\frac{1}{v} = -\frac{1}{20} + \frac{1}{30} = \frac{-3+2}{60} = -\frac{1}{60}.$$

Step 4 — Invert:

$$v = -60 \text{ cm}.$$

The negative sign means the image is real and in front of the mirror; for a concave mirror this image is inverted.

Why other options are wrong:

- $+60$ cm (virtual, erect): a positive v would need the object inside the focus.
- -12 cm (real, inverted): comes from mishandling the fraction signs.
- -20 cm (real, inverted): merely repeats the focal length.

Final Answer: $v = -60$ cm, real and inverted $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 25

Q26.

Solution

Concept — Dispersion by a prism: The deviation produced by a thin prism is $\delta = (\mu - 1)A$, where A is the prism angle. Since deviation increases with refractive index, the colour with the larger μ bends more.

Step 1 — Compare the indices: Violet has $\mu_v = 1.52$ and red has $\mu_r = 1.50$, so $\mu_v > \mu_r$.

Step 2 — Apply the deviation formula: With the same prism angle A:

$$\delta_v = (1.52 - 1)A = 0.52A, \qquad \delta_r = (1.50 - 1)A = 0.50A.$$

Step 3 — Conclude: Since $0.52A > 0.50A$, violet is deviated more than red.

Why other options are wrong:

- Red deviated more than violet: contradicts $\mu_v > \mu_r$; red actually bends least.
- Both deviated equally: would require equal refractive indices.
- Neither deviated: a prism always deviates light unless $\mu = 1$.

Final Answer: Violet is deviated more than red $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 26

Q27.

Solution

Concept — Resolving power of a telescope: The smallest resolvable angle is $\Delta\theta = \frac{1.22\,\lambda}{D}$. The resolving power is the reciprocal, $\frac{1}{\Delta\theta} = \frac{D}{1.22\,\lambda}$, so it is directly proportional to the aperture D.

Step 1 — Express the resolving power:

$$\text{R.P.} = \frac{1}{\Delta\theta} = \frac{D}{1.22\,\lambda} \;\propto\; D.$$

Step 2 — Double the aperture: Replace D by $2D$ at fixed λ:

$$\text{R.P.}_{new} = \frac{2D}{1.22\,\lambda} = 2 \times \frac{D}{1.22\,\lambda}.$$

Step 3 — Conclude: The resolving power doubles.

Why other options are wrong:

- Is halved: this is what happens to the resolution *angle*, not the resolving power.
- Stays the same: ignores the dependence on D.
- Becomes four times: would need R.P. $\propto D^2$, which is not the case.

Final Answer: Resolving power is doubled $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 27

Q28.

Solution

Concept — Photons from a source: If a source radiates total power P and each photon carries energy E, the number of photons emitted per second is $n = \dfrac{P}{E}$.

Step 1 — List the values: $P = 8$ W $= 8$ J s^{-1}, $E = 4 \times 10^{-19}$ J.

Step 2 — Substitute:

$$n = \frac{P}{E} = \frac{8}{4 \times 10^{-19}}.$$

Step 3 — Simplify:

$$n = 2 \times 10^{19} \text{ photons per second.}$$

Why other options are wrong:

- 2×10^{18}: an error of one power of ten in the division.
- 4×10^{19}: divides 8 by 2×10^{-19} wrongly.
- 0.5×10^{19}: inverts the ratio, dividing energy by power.

Final Answer: $n = 2 \times 10^{19}$ s$^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 28

Q29.

Solution

Concept — Series limit of the Lyman series: The series limit is the shortest-wavelength line, from $n = \infty$ to $n = 1$. The Rydberg formula gives $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R$, so $\lambda = \frac{1}{R}$.

Step 1 — List the value: $R = 1.1 \times 10^7\ \text{m}^{-1}$.

Step 2 — Take the reciprocal:

$$\lambda = \frac{1}{R} = \frac{1}{1.1 \times 10^7}.$$

Step 3 — Compute:

$$\lambda = 9.1 \times 10^{-8}\ \text{m} = 91\ \text{nm}.$$

Why other options are wrong:

- 364 nm: this is the Balmer series limit ($n = 2$), using $R/4$.
- 122 nm: this is the first Lyman line ($n = 2 \to 1$), not the series limit.
- 46 nm: halves the correct value.

Final Answer: $\lambda \approx 91\ \text{nm} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 29

Q30.

Solution

Concept — Peak inverse voltage of a half-wave rectifier: In a simple half-wave rectifier with a single diode, during the reverse half cycle the entire peak secondary voltage appears across the non-conducting diode. Hence PIV $= V_0$, the peak value.

Step 1 — Identify the peak voltage: The secondary supplies a peak of $V_0 = 220$ V.

Step 2 — Apply the PIV rule for a half-wave rectifier: The full peak reverse-biases the diode:

$$\text{PIV} = V_0 = 220\ \text{V}.$$

Why other options are wrong:

- 110 V: halves the peak, as if a centre-tapped circuit split it.

- 440 V: this is the PIV for a centre-tapped full-wave rectifier ($2V_0$), not a single-diode half-wave circuit.
- 311 V: confuses the rms-to-peak factor with the PIV; 311 V would be the peak of a 220 V rms supply, but here 220 V is already the peak.

Final Answer: $\text{PIV} = 220\text{ V} \Rightarrow \boxed{\text{B}}$

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

Answer Key

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