GAT-B Physics

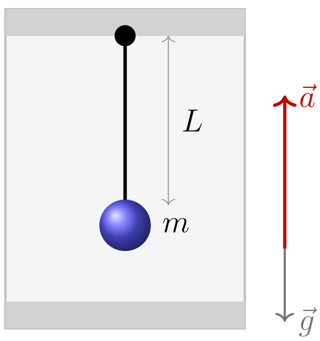
Sample Paper – 7

Duration: 23 Minutes **Maximum Marks: 15**

Instructions

- This paper contains **15 Multiple Choice Questions** (Single Correct Answer), modelled on the Physics portion of **GAT-B** Section A.
- Each correct answer carries **+1 mark**. There is a deduction of **0.5 mark** for each wrong answer. Unattempted questions carry zero marks.
- Only **one** option is correct per question.
- Syllabus level: **Class 11 & 12 (NCERT) Physics** — Mechanics, Thermodynamics, Waves, Optics, Electricity & Magnetism, Modern Physics.
- Personal calculators, mobile phones, and other electronic gadgets are strictly prohibited. A simple on-screen calculator is provided in the CBT interface.

Q1. A simple pendulum of length L is suspended from the ceiling of a lift that accelerates **upward** with acceleration a. The time period of the pendulum is:



(A) $2\pi\sqrt{\dfrac{L}{g-a}}$

(B) $2\pi\sqrt{\dfrac{L}{g+a}}$

(C) $2\pi\sqrt{\dfrac{L}{g}}$

(D) $2\pi\sqrt{\dfrac{L}{a}}$

Q2. A ball of mass m is released from rest at a height h above the ground. Neglecting air resistance, the speed of the ball just before it strikes the ground is:

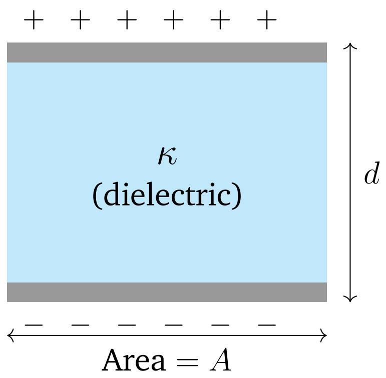
(A) $\sqrt{gh}$

(B) $2\sqrt{gh}$

(C) $\sqrt{2gh}$

(D) $\dfrac{1}{2}gh$

Q3. A parallel-plate capacitor has plate area A, plate separation d, and the gap between the plates is completely filled with a material of relative permittivity κ. The capacitance of the capacitor is:



(A) $\dfrac{\kappa\varepsilon_0 A}{d}$

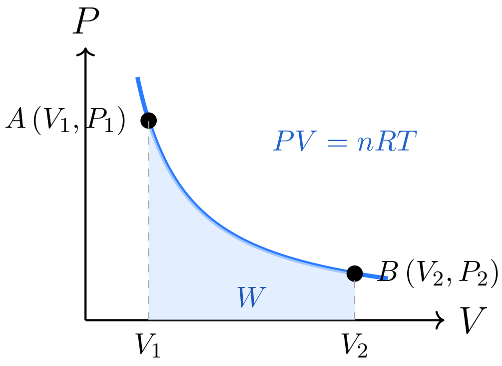
(B) $\dfrac{\varepsilon_0 A}{\kappa d}$

(C) $\dfrac{\kappa^2\varepsilon_0 A}{d}$

(D) $\dfrac{\varepsilon_0 A}{d}$

Q4. n moles of an ideal gas expand isothermally and reversibly at temperature T from volume V_1 to volume V_2 ($V_2 > V_1$). Referring to the P–V

diagram below, the work done *by* the gas equals the shaded area. The expression for this work is:



(A) $nRT\left(\dfrac{V_2}{V_1} - 1\right)$

(B) $nRT\ln\left(\dfrac{V_1}{V_2}\right)$

(C) $nRT(V_2 - V_1)$

(D) $nRT\ln\left(\dfrac{V_2}{V_1}\right)$

Q5. Two perfectly black bodies X and Y have equal surface areas. The temperature of X is $300\,\mathrm{K}$ and of Y is $600\,\mathrm{K}$. The ratio of the power radiated by X to the power radiated by Y is:

(A) $1 : 2$

(B) $1 : 16$

(C) $1 : 4$

(D) $1 : 8$

Q6. The mutual inductance between two coaxial coils is $M = 2\,\mathrm{H}$. If the current in the primary coil changes at a rate $\dfrac{dI}{dt} = 3\,\mathrm{A\,s^{-1}}$, the magnitude of the EMF induced in the secondary coil is:

(A) $6\,\mathrm{V}$

(B) $3\,\mathrm{V}$

(C) $1.5\,\mathrm{V}$

(D) $0.67\,\mathrm{V}$

Q7. An AC generator has a coil of $N = 100$ turns, each of cross-sectional area $A = 0.04\,\mathrm{m}^2$, rotating in a uniform magnetic field $B = 0.5\,\mathrm{T}$ at angular speed $\omega = 100\,\mathrm{rad\,s^{-1}}$. The coil is connected to an external resistance $R = 1000\,\Omega$ (no internal resistance). The peak current through R is:

(A) $0.5\,\mathrm{A}$

(B) $\pi\,\mathrm{A}$

(C) $0.2\,\mathrm{A}$

(D) $0.2\pi\,\mathrm{A}$

Q8. A converging lens of focal length $f_1 = +20\,\mathrm{cm}$ and a diverging lens of focal length $f_2 = -30\,\mathrm{cm}$ are placed in contact coaxially. The focal length of the equivalent lens combination is:

(A) $+10\,\mathrm{cm}$

(B) $-12\,\mathrm{cm}$

(C) $+50\,\mathrm{cm}$

(D) $+60\,\mathrm{cm}$

Q9. Using Heisenberg's uncertainty principle, the *minimum* uncertainty in momentum of an electron whose position is known to within $\Delta x = 1.0 \times 10^{-10}\,\mathrm{m}$ (approximately one Bohr radius) is:

(Given: $\hbar = 1.055 \times 10^{-34}\,\mathrm{J\,s}$)

(A) $1.055 \times 10^{-24}\,\mathrm{kg\,m\,s^{-1}}$

(B) $5.3 \times 10^{-25}\,\mathrm{kg\,m\,s^{-1}}$

(C) $2.1 \times 10^{-24}\,\mathrm{kg\,m\,s^{-1}}$

(D) $1.055 \times 10^{-44}\,\mathrm{kg\,m\,s^{-1}}$

Q10. In a potentiometer experiment, the EMF of a cell balances at a length of $l_1 = 60\,\mathrm{cm}$ on the potentiometer wire. When a resistance $R = 10\,\Omega$ is connected in parallel with the cell, the balance length shifts to $l_2 = 50\,\mathrm{cm}$. The internal resistance of the cell is:

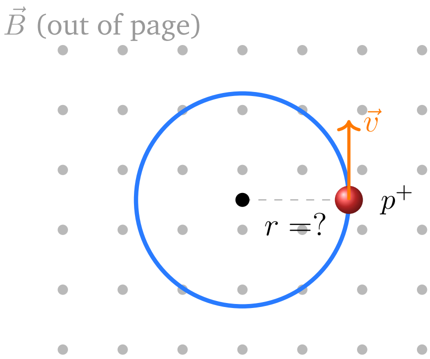
(A) $1\,\Omega$

(B) $3\,\Omega$

(C) $2\,\Omega$

(D) $5\,\Omega$

Q11. A proton ($m_p = 1.6\times10^{-27}\,\mathrm{kg}$, charge $q = 1.6\times10^{-19}\,\mathrm{C}$) moves with speed $v = 2\times10^{6}\,\mathrm{m\,s^{-1}}$ perpendicular to a uniform magnetic field of magnitude $B = 0.2\,\mathrm{T}$ directed out of the page. The radius of the resulting circular orbit is:



(A) $0.10\,\mathrm{m}$

(B) $0.05\,\mathrm{m}$

(C) $0.20\,\mathrm{m}$

(D) $0.02\,\mathrm{m}$

Q12. A radioactive sample has an initial activity $A_0 = 800\,\mathrm{disintegrations\,s^{-1}}$ and a half-life $T_{1/2} = 20\,\mathrm{min}$. The activity of the sample after $t = 60\,\mathrm{min}$ is:

(A) $400\,\mathrm{dis\,s^{-1}}$

(B) $200\,\mathrm{dis\,s^{-1}}$

(C) $50\,\mathrm{dis\,s^{-1}}$

(D) $100\,\mathrm{dis\,s^{-1}}$

Q13. The input to a half-wave rectifier is a sinusoidal AC voltage of rms value $V_{\text{rms}} = 220\,\text{V}$. Assuming an ideal diode (zero forward voltage drop), the peak value of the output voltage across the load resistor is approximately:

(A) $220\,\text{V}$

(B) $311\,\text{V}$

(C) $156\,\text{V}$

(D) $440\,\text{V}$

Q14. Dark lines (Fraunhofer lines) are observed in the otherwise continuous spectrum of sunlight reaching Earth. These dark lines arise because:

(A) excited atoms in the solar corona emit photons of specific wavelengths.

(B) the photosphere reflects certain wavelengths back towards the Sun's interior.

(C) atoms in the cooler outer layers of the Sun absorb specific wavelengths from the continuous spectrum emitted by the hotter interior.

(D) high-energy X-ray photons produced in the core are completely absorbed before reaching the solar surface.

Q15. A resistor of resistance $R = 484\,\Omega$ is connected across an AC source of rms voltage $V_{\text{rms}} = 220\,\text{V}$. The average power dissipated in the resistor is:

(A) $100\,\text{W}$

(B) $50\,\text{W}$

(C) $200\,\text{W}$

(D) $440\,\text{W}$

Detailed Solutions

Q1.

Solution

Concept — Effective Gravitational Acceleration in a Non-Inertial (Accelerating Lift) Frame

Step 1 — Free-body diagram in the ground (inertial) frame.
For the bob of mass m, Newton's second law gives

$$T - mg = ma \quad \implies \quad T = m(g+a),$$

where T is the tension in the string and a is the upward acceleration.

Step 2 — Identify the effective gravity.
In the non-inertial frame of the lift, a pseudo-force ma acts *downward* on the bob, so the effective gravitational field is

$$g_{\text{eff}} = g + a \qquad \text{(lift accelerating upward)}.$$

Step 3 — Write the modified time period.
The formula $T_0 = 2\pi\sqrt{L/g}$ uses g_{eff} in place of g:

$$\boxed{T = 2\pi\sqrt{\frac{L}{g+a}}}.$$

Because $g + a > g$, the restoring acceleration is *larger* and the period is *shorter* than T_0.

Why the other options are wrong:

- **(A)** $2\pi\sqrt{L/(g-a)}$ applies when the lift accelerates *downward*; the effective g is then reduced, giving a *longer* period.
- **(C)** $2\pi\sqrt{L/g}$ is the period in an inertial frame; it ignores the lift's acceleration entirely.
- **(D)** $2\pi\sqrt{L/a}$ has no physical basis — gravity g cannot be omitted; it dominates when $a = 0$.

Final Answer: $\boxed{\textbf{B}}$

Answer: (B) Go Back to Q 1

Q2.

Solution

Concept — Conservation of Mechanical Energy

Step 1 — Choose a reference level.
Take the ground as the zero of potential energy, so $PE_{\text{ground}} = 0$.

Step 2 — Initial and final energy.

$$E_i = KE_i + PE_i = 0 + mgh = mgh.$$

$$E_f = KE_f + PE_f = \tfrac{1}{2}mv^2 + 0 = \tfrac{1}{2}mv^2.$$

Step 3 — Apply conservation ($E_i = E_f$).

$$mgh = \tfrac{1}{2}mv^2 \implies v^2 = 2gh \implies \boxed{v = \sqrt{2gh}}.$$

The mass m cancels; the result is independent of mass, consistent with Galileo's free-fall principle.

Why the other options are wrong:

- **(A)** $\sqrt{gh}$ omits the factor of 2 that arises from the $\frac{1}{2}$ in the kinetic energy expression.
- **(B)** $2\sqrt{gh}$ would require $v^2 = 4gh$, implying four times the potential energy was somehow stored — physically impossible for a freely falling ball.
- **(D)** $\frac{1}{2}gh$ has dimensions of acceleration $\times$ distance $= \mathrm{m^2/s^2}$, which is not a speed (m/s); it is dimensionally inconsistent with speed.

Final Answer: $\boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q 2**

Q3.

Solution

Concept — Capacitance of a Parallel-Plate Capacitor with Dielectric

Step 1 — Vacuum (air) capacitor.
Without any dielectric, the capacitance is $C_0 = \varepsilon_0 A/d$, where $\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$ is the permittivity of free space.

Step 2 — Effect of the dielectric.

A dielectric of relative permittivity $\kappa > 1$ placed between the plates reduces the electric field (at constant charge) by a factor κ, equivalently replacing ε_0 with $\kappa\varepsilon_0$:

$$C = \kappa C_0 = \frac{\kappa\varepsilon_0 A}{d}.$$

Since $\kappa > 1$, the capacitance *increases*.

Step 3 — Physical reasoning.
The dielectric becomes polarised; induced surface charges partially cancel the free charges on the plates, reducing V for the same Q. Hence $C = Q/V$ increases.

Why the other options are wrong:

- **(B)** $\varepsilon_0 A/(\kappa d)$ has κ in the denominator — this would *decrease* capacitance, which contradicts the role of a dielectric.
- **(C)** $\kappa^2\varepsilon_0 A/d$ double-counts the permittivity; only one factor of κ enters the constitutive relation $D = \kappa\varepsilon_0 E$.
- **(D)** $\varepsilon_0 A/d$ is the vacuum result, ignoring the dielectric completely.

Final Answer: $\boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q 3

Q4.

Solution

Concept — Work Done by an Ideal Gas in Isothermal Reversible Expansion

Step 1 — First law of thermodynamics for an isothermal process.
For an ideal gas at constant temperature, internal energy depends only on T, so $\Delta U = 0$. By the first law, $W = Q$ (all heat absorbed goes into work).

Step 2 — Integrate $P\,dV$ using the ideal gas law.

$$W = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} \frac{nRT}{V}\,dV = nRT\left[\ln V\right]_{V_1}^{V_2} = \boxed{nRT\ln\frac{V_2}{V_1}}.$$

Since $V_2 > V_1$, the logarithm is positive and the gas does *positive* work on the surroundings.

Step 3 — Geometric meaning.
W equals the shaded area under the hyperbolic P–V curve between V_1 and V_2 (as shown in the diagram).

Why the other options are wrong:

- **(A)** $nRT(V_2/V_1 - 1)$ is not the result of integrating nRT/V; it would arise from integrating a constant $P = nRT/V_1$ — valid only for isobaric, not isothermal, processes.
- **(B)** $nRT\ln(V_1/V_2)$ has the wrong sign (negative for expansion); it is the work done *on* the gas, not by it.
- **(C)** $nRT(V_2 - V_1)$ is dimensionally wrong: $(V_2 - V_1)$ has units of m^3, so the product has units of J·m^3/mol, not J.

Final Answer: $\boxed{\text{D}}$

$\boxed{\text{Answer: (D)}}$ Go Back to Q 4

Q5.

Solution

Concept — Stefan–Boltzmann Law of Blackbody Radiation

Step 1 — State the law.
The total power radiated by a perfect blackbody of surface area A at absolute temperature T is

$$P = \sigma A T^4,$$

where $\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$ is the Stefan–Boltzmann constant.

Step 2 — Compute the power ratio.
Both bodies have the same surface area A, so:

$$\frac{P_X}{P_Y} = \frac{\sigma A T_X^4}{\sigma A T_Y^4} = \left(\frac{T_X}{T_Y}\right)^4 = \left(\frac{300\,\mathrm{K}}{600\,\mathrm{K}}\right)^4 = \left(\frac{1}{2}\right)^4 = \frac{1}{16}.$$

Why the other options are wrong:

- **(A)** $1:2$ uses a linear (T^1) ratio; the Stefan–Boltzmann law involves T^4, not T^1.
- **(C)** $1:4$ uses T^2; this would be correct for radiation pressure (which depends on T^4/c), but not radiated power.
- **(D)** $1:8$ uses T^3; there is no standard radiation law with a cubic temperature dependence.

Final Answer: $\boxed{\text{B}}$

Answer: (B) Go Back to Q 5

Q6.

Solution

Concept — Mutual Inductance and Faraday's Law

Step 1 — Define mutual inductance.
When a current I flows in the primary coil, the total flux linkage in the secondary is $N_2\Phi_{21} = MI$. By Faraday's law, the induced EMF in the secondary is

$$\mathcal{E}_2 = -M\frac{dI}{dt}.$$

The negative sign indicates Lenz's law (opposition to change); we need the magnitude.

Step 2 — Substitute values.

$$|\mathcal{E}_2| = M\frac{dI}{dt} = 2\,\mathrm{H} \times 3\,\mathrm{A\,s^{-1}} = \boxed{6\,\mathrm{V}}.$$

Why the other options are wrong:

- **(B)** $3\,\mathrm{V}$ would require either $M = 1\,\mathrm{H}$ or $dI/dt = 1.5\,\mathrm{A\,s^{-1}}$; neither matches the given data.
- **(C)** $1.5\,\mathrm{V}$ arises from dividing M by dI/dt ($2/3 \approx 0.67$ V, not even 1.5 V) or from using half of dI/dt without justification.
- **(D)** $0.67\,\mathrm{V}$ comes from inverting the formula: $M/(dI/dt) = 2/3 \approx 0.67$, which has the wrong operation.

Final Answer: $\boxed{\text{A}}$

Answer: (A) Go Back to Q 6

Q7.

Solution

Concept — Peak EMF and Peak Current of an AC Generator

Step 1 — Peak EMF.
The instantaneous EMF of a generator rotating at angular speed ω is $\mathcal{E}(t) = NBA\omega \sin \omega t$, giving a peak value

$$\mathcal{E}_0 = NBA\omega = 100 \times 0.5\,\mathrm{T} \times 0.04\,\mathrm{m}^2 \times 100\,\mathrm{rad\,s^{-1}} = 200\,\mathrm{V}.$$

Step 2 — Peak current through the external resistance.

$$I_0 = \frac{\mathcal{E}_0}{R} = \frac{200\,\mathrm{V}}{1000\,\Omega} = \boxed{0.2\,\mathrm{A}}.$$

Why the other options are wrong:

- **(A)** $0.5\,\mathrm{A}$ would require $\mathcal{E}_0 = 500\,\mathrm{V}$; a student may have multiplied only $B \times A \times \omega = 2\,\mathrm{V}$ and then divided incorrectly.
- **(B)** $\pi\,\mathrm{A}$ would need $\mathcal{E}_0 = 1000\pi\,\mathrm{V}$, far exceeding the correct value; likely a confusion with some other formula.
- **(D)** $0.2\pi\,\mathrm{A}$ results from mistaking $\omega = 100\,\mathrm{rad\,s^{-1}}$ for the frequency $f = 100\,\mathrm{Hz}$ and using $\omega_{\text{wrong}} = 2\pi f = 200\pi\,\mathrm{rad\,s^{-1}}$, which inflates $\mathcal{E}_0$ to $200\pi\,\mathrm{V}$.

Final Answer: $\boxed{\text{C}}$

Answer: (C) Go Back to Q 7

Q8.

Solution

Concept — Equivalent Focal Length of Thin Lenses in Contact

Step 1 — Power addition formula.
When two thin lenses are placed in contact, their powers (reciprocals of focal lengths) add:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}.$$

**Step 2 — Substitute (keeping sign convention: converging positive, diverging

negative).

$$\frac{1}{f} = \frac{1}{+20} + \frac{1}{-30} = \frac{3}{60} - \frac{2}{60} = \frac{1}{60} \implies \boxed{f = +60\,\mathrm{cm}}.$$

The positive result confirms the combination is converging; the weaker diverging lens does not overcome the converging one.

Why the other options are wrong:

- **(A)** $+10\,\mathrm{cm}$ arises from adding the *magnitudes* $1/20 + 1/30 = 5/60$, ignoring the sign of f_2.
- **(B)** $-12\,\mathrm{cm}$ has the wrong sign and magnitude; this would indicate a net diverging lens, which is inconsistent (the converging lens has larger power: $P_1 = 5\,\mathrm{D} > |P_2| = 3.33\,\mathrm{D}$).
- **(C)** $+50\,\mathrm{cm}$ is an arithmetic error, perhaps from computing $f_1 + |f_2| = 20 + 30 = 50$ instead of applying the lens formula.

Final Answer: $\boxed{\textbf{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q 8**

Q9.

Solution

Concept — Heisenberg's Uncertainty Principle

Step 1 — State the principle.

$$\Delta x \cdot \Delta p \;\geq\; \frac{\hbar}{2}.$$

Minimum uncertainty in momentum is achieved when the inequality is saturated (equality holds):

$$\Delta p_{\min} = \frac{\hbar}{2\,\Delta x}.$$

Step 2 — Substitute values.

$$\Delta p_{\min} = \frac{1.055 \times 10^{-34}\,\mathrm{J\,s}}{2 \times 1.0 \times 10^{-10}\,\mathrm{m}} = \frac{1.055 \times 10^{-34}}{2.0 \times 10^{-10}} = 5.275\times 10^{-25}\,\mathrm{kg\,m\,s^{-1}} \approx \boxed{5.3 \times 10^{-25}\,\mathrm{kg\,m\,s^{-1}}}.$$

This is the quantum lower bound on the momentum spread of an electron confined to atomic scales.

Why the other options are wrong:

- **(A)** $1.055 \times 10^{-24}\,\mathrm{kg\,m\,s^{-1}}$ omits the factor of 2 in the denominator, using $\Delta p = \hbar/\Delta x$ instead of $\hbar/(2\Delta x)$.
- **(C)** $2.1\times10^{-24}\,\mathrm{kg\,m\,s^{-1}}$ uses $2\hbar/\Delta x$, which is four times the correct minimum (violates neither the principle nor anything else, but is not the *minimum*).
- **(D)** $1.055 \times 10^{-44}\,\mathrm{kg\,m\,s^{-1}}$ arises from *multiplying* $\hbar$ by Δx instead of *dividing*: $\hbar \times \Delta x = 1.055 \times 10^{-44}$, which is dimensionally an action·length, not momentum.

Final Answer: $\boxed{\text{B}}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q 9

Q10.

Solution

Concept — Potentiometer: Measurement of Internal Resistance

Step 1 — Potentiometer principle.
The balance (null) length is proportional to the terminal voltage of the cell. On open circuit the terminal voltage equals the EMF $\mathcal{E}$, balancing at $l_1 = 60\,\mathrm{cm}$:

$$\mathcal{E} \propto l_1.$$

Step 2 — With external resistance R connected.
The terminal voltage drops to $V = \mathcal{E} - Ir = IR$ (where $I = \mathcal{E}/(R + r)$), and the new balance length is $l_2 = 50\,\mathrm{cm}$:

$$V \propto l_2.$$

Step 3 — Eliminate the proportionality constant.

$$\frac{\mathcal{E}}{V} = \frac{l_1}{l_2} \implies \frac{R+r}{R} = \frac{l_1}{l_2} \implies r = R\left(\frac{l_1}{l_2} - 1\right) = 10\times\left(\frac{60}{50} - 1\right) = 10\times\frac{10}{50} = \boxed{2\,\Omega}.$$

Why the other options are wrong:

- **(A)** $1\,\Omega$ arises from using $(l_1 - l_2)/(l_1 + l_2) \times R = 10/110 \times 10 \approx 0.9\,\Omega$, an incorrect formula.
- **(B)** $3\,\Omega$ results from $r = R\times l_2/(l_1 - l_2) = 10\times 50/10 = 50\,\Omega$ and then dividing by some incorrect factor, or from erroneous transposition.

- **(D)** $5\,\Omega$ would require $(l_1 - l_2)/l_2 = 0.5$, i.e. $l_2 = 40\,\text{cm}$, which contradicts the given $l_2 = 50\,\text{cm}$.

Final Answer: $\boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Radius of Circular Motion of a Charged Particle in a Magnetic Field

Step 1 — Equate Lorentz and centripetal forces.
The magnetic force $F = qvB$ (perpendicular to v) provides the centripetal force:

$$qvB = \frac{mv^2}{r} \implies r = \frac{mv}{qB}.$$

Step 2 — Substitute numerical values.

$$r = \frac{m_p v}{qB} = \frac{(1.6 \times 10^{-27}\,\text{kg})(2 \times 10^6\,\text{m s}^{-1})}{(1.6 \times 10^{-19}\,\text{C})(0.2\,\text{T})} = \frac{3.2 \times 10^{-21}}{3.2 \times 10^{-20}} = \boxed{0.10\,\text{m}}.$$

Note: numerator and denominator share the same coefficient 3.2×10^{-1}, giving $r = 0.10\,\text{m} = 10\,\text{cm}$.

Why the other options are wrong:

- **(B)** $0.05\,\text{m}$ would require $B = 0.4\,\text{T}$, twice the given field; halving r by doubling B is a common error.
- **(C)** $0.20\,\text{m}$ corresponds to $B = 0.1\,\text{T}$, half the given field strength.
- **(D)** $0.02\,\text{m}$ arises from using $v = 4 \times 10^5\,\text{m s}^{-1}$ (a factor of 5 too small), or equivalently using $B = 1\,\text{T}$.

Final Answer: $\boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — Radioactive Decay Law: Activity After n Half-Lives

Step 1 — Count the number of half-lives.

$$n = \frac{t}{T_{1/2}} = \frac{60\,\text{min}}{20\,\text{min}} = 3.$$

Step 2 — Apply the decay law for activity.
Activity $A = A_0\, e^{-\lambda t} = A_0/2^n$ (since $e^{-\lambda T_{1/2}} = 1/2$):

$$A = \frac{A_0}{2^n} = \frac{800}{2^3} = \frac{800}{8} = \boxed{100\,\text{dis}\,\text{s}^{-1}}.$$

Why the other options are wrong:

- **(A)** $400\,\text{dis}\,\text{s}^{-1}$ is the activity after just *one* half-life ($t = 20\,\text{min}$, $n = 1$).
- **(B)** $200\,\text{dis}\,\text{s}^{-1}$ corresponds to $n = 2$ half-lives ($t = 40\,\text{min}$), not $60\,\text{min}$.
- **(C)** $50\,\text{dis}\,\text{s}^{-1}$ corresponds to $n = 4$ half-lives ($t = 80\,\text{min}$); using $t = 60\,\text{min}$ gives $n = 3$, not 4.

Final Answer: $\boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q 12**

Q13.

Solution

Concept — Half-Wave Rectifier: Peak Output Voltage

Step 1 — Relate peak voltage to rms voltage.
For a sinusoidal source, the peak voltage is related to rms by

$$V_0 = \sqrt{2}\,V_{\text{rms}} = \sqrt{2} \times 220\,\text{V} \approx 1.414 \times 220 \approx 311\,\text{V}.$$

Step 2 — Output of a half-wave rectifier.
A half-wave rectifier passes only the positive half-cycles; the negative half-cycles are blocked. For an ideal diode (no forward voltage drop), the output peak voltage equals the input peak voltage:

$$V_{\text{out, peak}} = V_0 \approx \boxed{311\,\text{V}}.$$

(The average output is $V_0/\pi \approx 99\,\mathrm{V}$; the rms output is $V_0/2 \approx 155\,\mathrm{V}$.)

Why the other options are wrong:

- **(A)** $220\,\mathrm{V}$ is the *rms* value of the AC input, not the peak value; students often confuse these.
- **(C)** $156\,\mathrm{V} \approx V_0/2$ is the rms output of a half-wave rectifier, not the peak output.
- **(D)** $440\,\mathrm{V} = 2V_{\mathrm{rms}}$ has no physical significance for a simple half-wave rectifier; it would arise only from a voltage-doubling circuit.

Final Answer: $\boxed{\mathbf{B}}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q 13

Q14.

Solution

Concept — Absorption Spectrum and Fraunhofer Lines

Step 1 — Origin of the continuous solar spectrum.
The hot interior of the Sun ($T \sim 10^6\,\mathrm{K}$ in the core, $\sim 6000\,\mathrm{K}$ at the photosphere) emits a nearly perfect blackbody (continuous) spectrum. This radiation travels outward through the cooler chromosphere and photosphere.

Step 2 — Mechanism of the dark lines.
Atoms in the cooler outer layers (mainly H, He, Na, Ca, Mg, Fe, etc.) are in lower energy states. When the broadband radiation passes through, these atoms **absorb photons** of wavelengths that exactly match their allowed electronic transitions. The absorbed photons are re-emitted in random directions, leaving the original beam deficient at those wavelengths. An observer on Earth sees dark lines — Fraunhofer lines — superimposed on the continuous solar spectrum.

Step 3 — Kirchhoff's third spectroscopic law.
"A cool gas in front of a hot, bright continuum source produces dark (absorption) lines at the wavelengths characteristic of the elements present in the gas."

Why the other options are wrong:

- **(A)** Emission by excited atoms produces *bright* (emission) lines on a dark background — the opposite of Fraunhofer lines.
- **(B)** Reflection by the photosphere is not wavelength-selective in this narrow-

line fashion; it cannot produce sharp dark absorption features.

- **(D)** X-ray photons from the core are indeed absorbed in transit, but this does not selectively remove narrow bands in the *visible* spectrum; Fraunhofer lines are a photospheric/chromospheric phenomenon.

Final Answer: $\boxed{\text{C}}$

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Average Power Dissipated in a Resistor Connected to an AC Source

Step 1 — Power formula for a pure resistor.
A pure resistor has power factor $\cos\phi = 1$. The average power is identical in form to the DC case but uses rms values:

$$P_{\text{avg}} = \frac{V_{\text{rms}}^2}{R} = I_{\text{rms}}^2\, R = V_{\text{rms}}\, I_{\text{rms}}.$$

Step 2 — Substitute values.

$$P = \frac{V_{\text{rms}}^2}{R} = \frac{(220\,\text{V})^2}{484\,\Omega} = \frac{48400}{484} = \boxed{100\,\text{W}}.$$

Why the other options are wrong:

- **(B)** $50\,\text{W}$ would require $R = 968\,\Omega$ (twice the given value), or arises from erroneously using half the rms voltage.
- **(C)** $200\,\text{W}$ corresponds to $P = V_{\text{peak}}^2/R = (220\sqrt{2})^2/484 = 2 \times 100 = 200\,\text{W}$; this is incorrect because peak voltage must not replace rms voltage in the average-power formula.
- **(D)** $440\,\text{W}$ arises from dimensional confusion such as treating $P = V_{\text{rms}} \times R = 220 \times 2 = 440$ (numerically), which is not a valid power formula.

Final Answer: $\boxed{\text{A}}$

Answer: (A) Go Back to Q 15

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	A	4	D	5	B
6	A	7	C	8	D	9	B	10	C
11	A	12	D	13	B	14	C	15	A