AIIMS B.Sc Nursing Physics

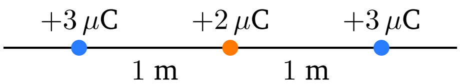
Sample Paper – 8

Duration: 36 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30 Multiple Choice Questions (single correct answer)**, modelled on the Physics section of the **AIIMS B.Sc Nursing** entrance.
- Each correct answer carries **+1 mark.** $\frac{1}{3}$ **mark is deducted** for every wrong answer, and an unattempted question gets **0 marks**.
- Only **one** option is correct. Choose carefully, since the questions are mostly numerical.
- Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. Three point charges lie on a straight line. A charge $q = +2\ \mu$C is fixed at the origin. A charge $+3\ \mu$C sits 1 m to its left and another $+3\ \mu$C sits 1 m to its right, as shown. The net electrostatic force on the central charge q is:



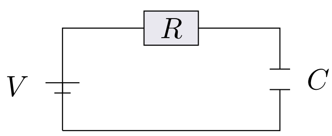
(A) zero

(B) 0.054 N to the right

(C) 0.108 N to the left

(D) 0.108 N to the right

Q2. In the charging circuit shown, a resistor $R = 2$ MΩ is in series with a capacitor $C = 5\ \mu$F and a battery. The time constant of the circuit is:



(A) 0.4 s

(B) 2.5 s

(C) 10 s

(D) 40 s

Q3. A current of 0.5 A flows through a resistor of resistance $40\ \Omega$. The potential difference across the resistor is:

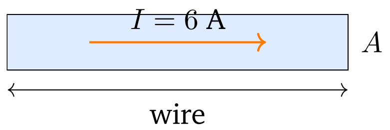
(A) 80 V

(B) 20 V

(C) 10 V

(D) 0.0125 V

Q4. A current of 6 A flows uniformly through a wire of cross-sectional area 2×10^{-6} m^2, as shown. The current density in the wire is:



(A) 1.2×10^6 A/m^2

(B) 1.2×10^7 A/m^2

(C) 3×10^5 A/m^2

(D) 3×10^6 A/m^2

Q5. An electric heater of power 2 kW is used for 3 hours each day. If electricity costs Rs. 5 per kWh, the cost of running it for 10 days is:

(A) Rs. 150

(B) Rs. 300

(C) Rs. 60

(D) Rs. 600

Q6. The dimensional formula of linear momentum is:

(A) $[MLT^{-1}]$

(B) $[MLT^{-2}]$

(C) $[ML^2T^{-2}]$

(D) $[ML^2T^{-1}]$

Q7. A car covers the first half of a journey at 30 km/h and the second half (equal distance) at 60 km/h. The average speed for the whole journey is:

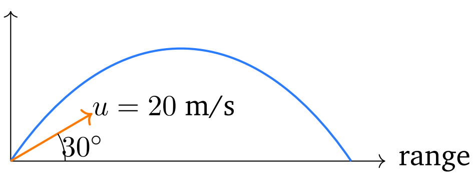
(A) 45 km/h

(B) 40 km/h

(C) 50 km/h

(D) 36 km/h

Q8. A ball is projected with speed 20 m/s at an angle of 30° to the horizontal, as shown. Its time of flight is (take $g = 10$ m/s^2):



(A) 4 s

(B) 1 s

(C) 2 s

(D) 3.46 s

Q9. A rocket moves forward by ejecting hot gases backward at high speed. The forward push on the rocket is best explained by:

(A) the gases pushing against the surrounding air

(B) the conservation of kinetic energy

(C) gravity pulling the rocket upward

(D) the reaction to the backward thrust of the ejected gases

Q10. A car moving at 10 m/s on a level road comes to rest in a distance of 25 m after the brakes are applied. The coefficient of friction between the tyres and the road is (take $g = 10$ m/s^2):

(A) 0.2

(B) 0.4

(C) 0.5

(D) 0.1

Q11. A spring of force constant 200 N/m is stretched by 0.1 m. The elastic potential energy stored in it is:

(A) 2 J

(B) 20 J

(C) 1 J

(D) 0.5 J

Q12. Two point masses of 2 kg and 3 kg are placed 1 m apart. The gravitational force of attraction between them is (take $G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2}):

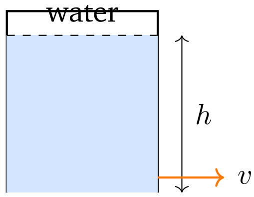
(A) 6.67×10^{-11} N

(B) 1.3×10^{-10} N

(C) 2.0×10^{-11} N

(D) 4.0×10^{-10} N

Q13. A tank is filled with water to a height $h = 5$ m. A small hole is made in its side at the bottom, as shown. The speed of efflux of water through the hole is (take $g = 10$ m/s^2):



(A) 5 m/s

(B) 10 m/s

(C) 50 m/s

(D) 100 m/s

Q14. A metal rod is clamped rigidly at both ends and then heated. It is prevented from expanding, so a stress develops inside it. This thermal stress depends on:

(A) the Young's modulus, the expansion coefficient and the temperature rise

(B) the length of the rod only

(C) the cross-sectional area only

(D) the density of the metal only

Q15. A fixed mass of gas at constant pressure has a volume of 300 cm^3 at 27 °C. When heated to 327 °C at the same pressure, its new volume is:

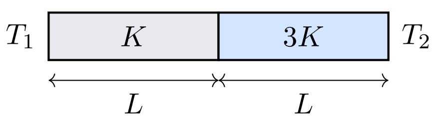
(A) 300 cm^3

(B) 450 cm^3

(C) 600 cm^3

(D) 150 cm^3

Q16. Two rods of the same cross-section and the same length are joined end to end, as shown. Their thermal conductivities are K and $3K$. The equivalent thermal conductivity of the combination is:



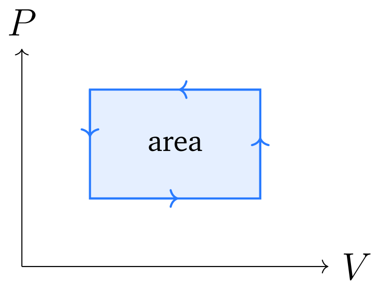
(A) $2K$

(B) $4K$

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

(D) $\frac{3K}{2}$

Q17. A gas is taken around the closed cycle shown on the P–V diagram. The net work done by the gas in one complete cycle equals:



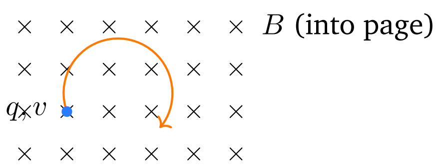
(A) zero

(B) the area enclosed by the loop on the P–V diagram

(C) the total perimeter of the loop

(D) the change in internal energy of the gas

Q18. A charged particle of charge q, mass m and speed v enters a uniform magnetic field B at right angles, as shown, and moves in a circle. The radius of its path is:



(A) $\frac{mv}{qB}$

(B) $\frac{qB}{mv}$

(C) $\frac{qBv}{m}$

(D) $\dfrac{mvB}{q}$

Q19. A coil rotating uniformly in a magnetic field produces an alternating emf. The instantaneous emf is maximum at the instant when:

(A) the magnetic flux through the coil is maximum

(B) the plane of the coil is perpendicular to the field

(C) the plane of the coil is parallel to the field

(D) the coil is momentarily at rest

Q20. An alternating current flows through a pure inductor. The average power consumed by the inductor over one full cycle is:

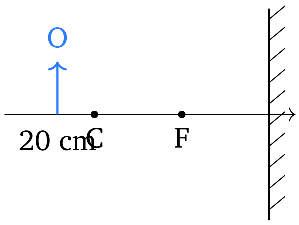
(A) zero

(B) $\frac{1}{2}I_0^2X_L$

(C) $I_{rms}^2X_L$

(D) $I_{rms}V_{rms}$

Q21. An object is placed 20 cm in front of a concave mirror of focal length 15 cm, as shown. The magnification of the image formed is:



(A) -1

(B) -2

(C) $+3$

(D) -3

Q22. In a compound microscope the objective produces a linear magnification of 10 and the eyepiece a magnification of 5. The total magnifying power of the microscope is:

(A) 15

(B) 50

(C) 2

(D) 0.5

Q23. Two light sources can produce a sustained (steady) interference pattern only if they:

(A) have the same amplitude only

(B) are very intense

(C) have the same frequency and a constant phase difference

(D) are placed very far apart

Q24. An electron is accelerated from rest through a potential difference V. Its de Broglie wavelength λ varies with V as:

(A) $\lambda \propto \frac{1}{\sqrt{V}}$

(B) $\lambda \propto \sqrt{V}$

(C) $\lambda \propto V$

(D) $\lambda \propto \frac{1}{V}$

Q25. In a hydrogen atom an electron jumps from the level $n = 2$ to the level $n = 1$. The energies of these levels are $E_2 = -3.4$ eV and $E_1 = -13.6$ eV. The energy of the emitted photon is:

(A) 3.4 eV

(B) 13.6 eV

(C) 17.0 eV

(D) 10.2 eV

Q26. A radioactive sample initially contains N_0 nuclei. After 3 half-lives, the fraction of the original nuclei that still remain undecayed is:

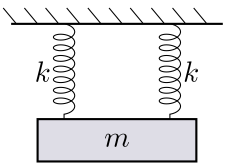
(A) $\frac{1}{4}$

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

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

(D) $\frac{1}{3}$

Q27. Two springs, each of force constant $k = 100$ N/m, support a block of mass $m = 2$ kg in parallel, as shown. The period of vertical oscillation of the block is (take $\pi^2 \approx 10$):



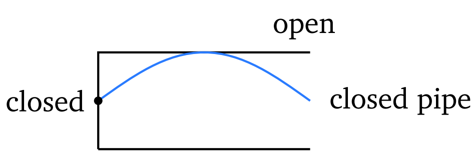
(A) $\frac{2\pi}{5}$ s

(B) $\frac{\pi}{5}$ s

(C) $\frac{2\pi}{10}$ s

(D) π s

Q28. A closed organ pipe (closed at one end) of fundamental frequency f produces overtones. The harmonics present in such a pipe are:



(A) only the odd harmonics $f, 3f, 5f, \ldots$

(B) only the even harmonics $2f, 4f, 6f, \ldots$

(C) all harmonics $f, 2f, 3f, \ldots$

(D) no harmonics other than f

Q29. At an unbiased p-n junction, a thin region forms near the boundary which is free of mobile charge carriers and across which a small potential difference appears. This region and potential are called:

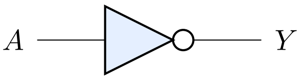
(A) the conduction band and the band gap

(B) the saturation region and the breakdown voltage

(C) the channel and the threshold voltage

(D) the depletion region and the barrier potential

Q30. For the NOT gate (inverter) shown, the input is $A = 1$ (high). The output Y is:



(A) 1

(B) undefined

(C) 0

(D) the same as the input

Detailed Solutions

Q1.

Solution

Concept — Superposition of Coulomb forces: Coulomb's law gives the force between two point charges as $F = \frac{k\, q_1 q_2}{r^2}$, where $k = 9 \times 10^9$ N m^{2}C^{-2}, q_1 and q_2 are the charges and r is their separation. Force is a vector, so the net force on a charge from several others is the vector sum of the individual forces. Like charges repel along the line joining them.

Given: central charge $q = +2\ \mu$C $= 2 \times 10^{-6}$ C; each outer charge $= +3\ \mu$C $= 3 \times 10^{-6}$ C; each separation $r = 1$ m; one charge on the left, one on the right.

Step 1 — Force from one outer charge: $F_1 = \frac{k\, q_1 q}{r^2} = \frac{(9 \times 10^9)(3 \times 10^{-6})(2 \times 10^{-6})}{(1)^2}$ N $= \frac{9 \times 3 \times 2}{10^{9-6-6}}$ N^{-1}·N. Numerically $9 \times 3 \times 2 = 54$ and $10^{9-6-6} = 10^{-3}$, so $F_1 = 54 \times 10^{-3} = 0.054$ N. Each outer charge produces this same magnitude on q.

Step 2 — Apply directions: Both outer charges are positive, so each repels q. The left ($+3\ \mu$C) charge pushes q to the *right* with 0.054 N; the right ($+3\ \mu$C) charge pushes q to the *left* with 0.054 N.

Step 3 — Vector sum: Taking right as positive, $F_{net} = (+0.054) + (-0.054) = 0$ N. By symmetry the two equal and opposite pushes cancel exactly.

Why each other option is wrong:

- (B) 0.054 N to the right is the force from one charge alone; it ignores the equal opposing push from the other charge.
- (C) 0.108 N to the left adds the two equal forces' magnitudes (and picks a direction) instead of letting the opposite vectors cancel.
- (D) 0.108 N to the right makes the same arithmetic mistake of adding $0.054 + 0.054$ rather than subtracting.

Key point: Symmetric, equidistant, equal like charges on opposite sides always give zero net force; always resolve into directed vectors before adding.

Final Answer: Net force $= 0 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — RC time constant: In a series resistor–capacitor charging circuit, the charge grows as $q(t) = q_0(1 - e^{-t/\tau})$, where the time constant $\tau = RC$ sets how fast the capacitor charges. Here R is resistance in ohms and C is capacitance in farads, and the product $\Omega \cdot \text{F}$ has units of seconds. After one time constant the capacitor reaches about 63% of its final charge.

Given: $R = 2\ \text{M}\Omega = 2 \times 10^6\ \Omega$; $C = 5\ \mu\text{F} = 5 \times 10^{-6}\ \text{F}$.

Step 1 — Write the formula and substitute: $\tau = RC = (2 \times 10^6\ \Omega)(5 \times 10^{-6}\ \text{F})$.

Step 2 — Multiply the numbers and powers separately: $2 \times 5 = 10$ and $10^6 \times 10^{-6} = 10^0 = 1$, so $\tau = 10 \times 1 = 10$ s.

Step 3 — Units check: $\Omega \cdot \text{F} = \frac{\text{V}}{\text{A}} \cdot \frac{\text{C}}{\text{V}} = \frac{\text{C}}{\text{A}} = \text{s}$, confirming the answer is in seconds.

Why each other option is wrong:

- (A) 0.4 s comes from computing C/R instead of RC.
- (B) 2.5 s comes from R/C scaled wrongly, again dividing rather than multiplying.
- (D) 40 s misplaces a power of ten (e.g. treating C as $20\ \mu$F or R as $8\ \text{M}\Omega$).

Key point: $\tau = RC$ is a product, not a ratio; convert $\text{M}\Omega$ to $10^6\ \Omega$ and μF to 10^{-6} F before multiplying.

Final Answer: $\tau = 10$ s $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept — Ohm's law: For an ohmic conductor the potential difference across it is directly proportional to the current through it, $V = IR$. Here V is the potential difference in volts (V), I is the current in amperes (A) and R is the resistance in ohms (Ω). The relation holds at constant temperature.

Given: current $I = 0.5$ A; resistance $R = 40\ \Omega$.

Step 1 — Write the formula and substitute: $V = IR = (0.5\ \text{A})(40\ \Omega)$.

Step 2 — Evaluate: $0.5 \times 40 = 20$, so $V = 20$ V (since $\text{A} \cdot \Omega = \text{V}$).

Why each other option is wrong:

- (A) 80 V uses $I = 2$ A instead of the given 0.5 A.
- (C) 10 V mistakenly halves the correct result (using $I = 0.25$ A).
- (D) 0.0125 V comes from computing I/R instead of $I \times R$.

Key point: Multiply current by resistance; keep I in amperes and R in ohms so the answer falls out directly in volts.

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

Answer: (B) Go Back to Q3

Q4.

Solution

Concept — Current density: Current density is the current flowing per unit cross-sectional area, $J = \frac{I}{A}$, where I is the current in amperes (A) and A is the area in square metres (m^2). Its SI unit is A/m^2. For uniform flow it is the same at every point of the cross-section.

Given: current $I = 6$ A; cross-sectional area $A = 2 \times 10^{-6} \text{ m}^2$.

Step 1 — Write the formula and substitute: $J = \frac{I}{A} = \frac{6 \text{ A}}{2 \times 10^{-6} \text{ m}^2}$.

Step 2 — Divide the numbers and powers: $\frac{6}{2} = 3$ and $\frac{1}{10^{-6}} = 10^6$, so $J = 3 \times 10^6 \text{ A/m}^2$.

Why each other option is wrong:

- (A) $1.2 \times 10^6 \text{ A/m}^2$ comes from a wrong division (e.g. $6/5$ type slip) and a misplaced power.
- (B) $1.2 \times 10^7 \text{ A/m}^2$ multiplies I by the area instead of dividing.
- (C) $3 \times 10^5 \text{ A/m}^2$ has the right leading digit but is off by one power of ten.

Key point: Divide current by area; dividing by 10^{-6} multiplies the result by 10^6, so the exponent jumps up, not down.

Final Answer: $J = 3 \times 10^6 \text{ A/m}^2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Cost of electricity: Electrical energy billed in commercial units is measured in kilowatt-hours, where energy (kWh) $=$ power (kW) $\times$ time (h). One kWh (one "unit") is the energy used by a 1 kW device running for 1 hour. The cost is then energy in kWh multiplied by the tariff per kWh.

Given: power $P = 2$ kW; daily use $t = 3$ h/day; number of days $= 10$; rate $=$ Rs. 5 per kWh.

Step 1 — Energy used per day: $E_{day} = P \times t = 2$ kW $\times$ 3 h $= 6$ kWh per day.

Step 2 — Energy used over 10 days: $E_{total} = 6$ kWh/day $\times$ 10 days $= 60$ kWh.

Step 3 — Total cost: cost $= E_{total} \times$ rate $= 60$ kWh$\times$ Rs. 5/kWh $=$ Rs. 300.

Why each other option is wrong:

- (A) Rs. 150 uses $P = 1$ kW instead of 2 kW.
- (C) Rs. 60 stops at the energy (60 kWh) and forgets to multiply by the Rs. 5 rate.
- (D) Rs. 600 doubles either the daily hours or the rate.

Key point: Keep power in kW and time in hours so the product is directly in kWh; then multiply by the per-unit rate.

Final Answer: Rs. $300 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept — Dimensions of momentum: Linear momentum is the product of mass and velocity, $p = mv$. The dimensional formula is obtained by replacing each quantity with its base dimensions: mass $[M]$ and velocity $[LT^{-1}]$ (length per time). Writing the dimensions lets us compare physical quantities and check equations.

Step 1 — Write each factor's dimensions: mass $\rightarrow$ $[M]$; velocity $= \frac{\text{displacement}}{\text{time}} \rightarrow [LT^{-1}]$.

Step 2 — Combine: $[p] = [M]\,[LT^{-1}] = [MLT^{-1}]$.

Why each other option is wrong:

- (B) $[MLT^{-2}]$ is force ($F = ma$), having one extra inverse-time factor.
- (C) $[ML^2T^{-2}]$ is energy or work ($\frac{1}{2}mv^2$), with an extra length and inverse-time.
- (D) $[ML^2T^{-1}]$ is angular momentum ($L = mvr$), carrying an extra length.

Key point: Momentum differs from force by one power of time and from angular momentum by one power of length; track each base dimension carefully.

Final Answer: $[MLT^{-1}] \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q6

Q7.

Solution

Concept — Average speed for equal distances: Average speed is always total distance divided by total time, $v_{avg} = \frac{\text{total distance}}{\text{total time}}$. When two equal distances are covered at speeds v_1 and v_2, the times differ, and the average works out to the harmonic mean $v_{avg} = \frac{2v_1v_2}{v_1 + v_2}$. This is always less than the simple arithmetic average because more time is spent at the slower speed.

Given: first half at $v_1 = 30$ km/h; second (equal) half at $v_2 = 60$ km/h.

Step 1 — Set up the half-distance argument: Let each half be d. Time for first half $= d/30$ h, for second $= d/60$ h; total distance $= 2d$, total time $= d/30 + d/60$.

Step 2 — Apply the harmonic-mean formula: $v_{avg} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2(30)(60)}{30 + 60} = \frac{3600}{90}$ km/h.

Step 3 — Evaluate: $\frac{3600}{90} = 40$ km/h.

Why each other option is wrong:

- (A) 45 km/h is the arithmetic mean $\frac{30+60}{2}$, which applies only for equal *times*, not equal distances.
- (C) 50 km/h does not match either mean of the two speeds.
- (D) 36 km/h underestimates and does not satisfy the harmonic-mean formula.

Key point: Equal distances $\Rightarrow$ harmonic mean; equal times $\Rightarrow$ arithmetic mean. Confusing the two is the classic error here.

Final Answer: $v_{avg} = 40$ km/h $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q7

Q8.

Solution

Concept — Time of flight of a projectile: For a projectile launched from ground level with speed u at angle θ, only the vertical motion decides how long it stays in the air. The vertical component $u\sin\theta$ decelerates under gravity, reaches zero at the top, and the total time of flight is $T = \dfrac{2u\sin\theta}{g}$, where g is the acceleration due to gravity.

Given: launch speed $u = 20$ m/s; angle $\theta = 30°$; $g = 10$ m/s^2; $\sin 30° = 0.5$.

Step 1 — Write the formula and substitute: $T = \dfrac{2u\sin\theta}{g} = \dfrac{2(20)(\sin 30°)}{10} = \dfrac{2(20)(0.5)}{10}$ s.

Step 2 — Simplify the numerator: $2 \times 20 \times 0.5 = 20$, so $T = \dfrac{20}{10}$ s.

Step 3 — Evaluate: $T = 2$ s.

Why each other option is wrong:

- (A) 4 s takes $\sin\theta = 1$ (a $90°$ vertical launch) instead of $\sin 30° = 0.5$.
- (B) 1 s drops the leading factor of 2 in the formula.
- (D) 3.46 s wrongly uses $\cos 30° \approx 0.866$ (the horizontal component) in place of $\sin 30°$.

Key point: Time of flight depends only on the vertical component $u\sin\theta$; use the sine of the launch angle, and never forget the factor of 2.

Final Answer: $T = 2$ s $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept — Newton's third law and conservation of momentum: Newton's third law states that for every action there is an equal and opposite reaction; the two forces act on different bodies. Equivalently, in a closed system momentum is conserved: as the rocket throws mass backward, it must gain forward momentum so the total stays constant. The thrust is $F = v_{ex}\dfrac{dm}{dt}$, where v_{ex} is the exhaust speed and dm/dt the rate of mass ejection.

Step 1 — Identify the force pair: The rocket exerts a backward force on the exhaust gases (action); by the third law the gases exert an equal forward force on the rocket (reaction).

Step 2 — Momentum view: The backward momentum carried off by the gases equals the forward momentum gained by the rocket, so the rocket accelerates forward.

Step 3 — Note on environment: Because the push comes from ejecting the gases, not from pushing on outside air, a rocket works perfectly in the vacuum of space.

Why each other option is wrong:

- (A) Pushing against surrounding air is false; rockets accelerate in vacuum where there is no air to push.
- (B) Kinetic energy is not conserved here; chemical energy of the fuel is converted, so this is irrelevant to the thrust.
- (C) Gravity acts downward and opposes lift-off; it does not provide the forward (upward) driving thrust.

Key point: Rocket propulsion is the reaction to ejected gases (third law / momentum conservation), independent of any external medium.

Final Answer: Reaction to the ejected gases $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept — Friction and stopping distance: On a level road the only horizontal force stopping the car is kinetic friction $f = \mu mg$, giving a retardation $a = \mu g$ (independent of mass). Using the kinematic relation $v^2 = u^2 - 2as$ with final speed $v = 0$, the stopping distance is $s = \dfrac{u^2}{2\mu g}$, which rearranges to $\mu = \dfrac{u^2}{2gs}$. Here u is the initial speed, s the stopping distance and g the gravitational acceleration.

Given: initial speed $u = 10$ m/s; stopping distance $s = 25$ m; $g = 10$ m/s^2; final speed $= 0$.

Step 1 — Write the formula and substitute: $\mu = \dfrac{u^2}{2gs} = \dfrac{(10 \text{ m/s})^2}{2(10 \text{ m/s}^2)(25 \text{ m})}$.

Step 2 — Compute numerator and denominator: numerator $= 100$ m^2/s^2; denominator $= 2 \times 10 \times 25 = 500\ \text{m}^2/\text{s}^2$.

Step 3 — Evaluate: $\mu = \dfrac{100}{500} = 0.2$ (dimensionless, as a coefficient of friction should be).

Why each other option is wrong:

- (B) 0.4 forgets the factor of 2 in $2gs$, halving the denominator.
- (C) 0.5 uses a wrong stopping distance (e.g. $s = 10$ m).
- (D) 0.1 doubles the denominator (e.g. uses $s = 50$ m).

Key point: The coefficient of friction is mass-independent here; remember the factor 2 in $v^2 = u^2 - 2as$, and the answer is a pure number.

Final Answer: $\mu = 0.2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept — Elastic potential energy of a spring: A spring that obeys Hooke's law ($F = kx$) stores elastic potential energy $U = \frac{1}{2}kx^2$ when stretched or compressed by x. Here k is the force constant in N/m and x is the deformation in metres; the $\frac{1}{2}$ arises because the force grows linearly from 0 to kx, so the average force is $\frac{1}{2}kx$.

Given: force constant $k = 200$ N/m; extension $x = 0.1$ m.

Step 1 — Write the formula and substitute: $U = \frac{1}{2}kx^2 = \frac{1}{2}(200\ \text{N/m})(0.1\ \text{m})^2$.

Step 2 — Square the extension: $(0.1)^2 = 0.01\ \text{m}^2$, so $U = \frac{1}{2}(200)(0.01)$ J.

Step 3 — Evaluate: $\frac{1}{2} \times 200 \times 0.01 = \frac{1}{2} \times 2 = 1$ J.

Why each other option is wrong:

- (A) 2 J omits the factor $\frac{1}{2}$ (computes kx^2).
- (B) 20 J drops the square on x (uses $\frac{1}{2}kx$ effectively with wrong powers).
- (D) 0.5 J halves the correct result once too often.

Key point: Always square the displacement *and* keep the $\frac{1}{2}$; energy scales with x^2, so doubling the stretch quadruples the stored energy.

Final Answer: $U = 1\ \text{J} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Newton's law of gravitation: Every pair of point masses attracts along the line joining them with a force $F = \frac{Gm_1m_2}{r^2}$, where $G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2} is the universal gravitational constant, m_1 and m_2 are the masses in kg and r is the separation in metres. The force obeys an inverse-square law.

Given: $m_1 = 2$ kg; $m_2 = 3$ kg; $r = 1$ m; $G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2}.

Step 1 — Write the formula and substitute: $F = \frac{Gm_1m_2}{r^2} = \frac{(6.67 \times 10^{-11})(2)(3)}{(1)^2}$ N.

Step 2 — Multiply the masses: $m_1m_2 = 2 \times 3 = 6$, so $F = (6.67 \times 10^{-11})(6)$ N.

Step 3 — Evaluate: $6.67 \times 6 = 40.02 \approx 40$, giving $F = 40 \times 10^{-11} = 4.0 \times 10^{-10}$ N.

Why each other option is wrong:

- (A) 6.67×10^{-11} N is just G; it forgets to multiply by the masses entirely.
- (B) 1.3×10^{-10} N uses only the sum or a partial product of the masses instead of $m_1m_2 = 6$.
- (C) 2.0×10^{-11} N misplaces a power of ten while mishandling the product.

Key point: Multiply G by the *product* of the masses and divide by r^2; with $r = 1$ m the division is trivial, but the mass product must not be skipped.

Final Answer: $F = 4.0 \times 10^{-10}$ N $\Rightarrow$ $\boxed{D}$

Answer: (D) **Go Back to Q12**

Q13.

Solution

Concept — Torricelli's law: Applying Bernoulli's equation between the open top surface and the hole, the speed of efflux of a liquid from a small hole at depth h below the free surface is $v = \sqrt{2gh}$. This is the same speed a body would acquire falling freely through a height h, where g is the gravitational acceleration. It assumes an ideal liquid and a hole much smaller than the tank.

Given: height of water above the hole $h = 5$ m; $g = 10$ m/s^2.

Step 1 — Write the formula and substitute: $v = \sqrt{2gh} = \sqrt{2(10\ \text{m/s}^2)(5\ \text{m})}$.

Step 2 — Evaluate inside the root: $2 \times 10 \times 5 = 100\ \text{m}^2/\text{s}^2$, so $v = \sqrt{100}$ m/s.

Step 3 — Take the square root: $v = 10$ m/s.

Why each other option is wrong:

- (A) 5 m/s drops the factor $2g$ (uses $v = h$ or similar).
- (C) 50 m/s leaves the value as $\frac{1}{2} \times 100$-type number and skips the square root.
- (D) 100 m/s reports the quantity *under* the root without taking the square root.

Key point: The efflux speed depends only on the depth h (and g), not on the liquid's density; do not forget to take the square root of $2gh$.

Final Answer: $v = 10$ m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept — Thermal stress: A free rod heated by ΔT would expand by a thermal strain $\frac{\Delta L}{L} = \alpha\,\Delta T$, where α is the coefficient of linear expansion. If the rod is clamped at both ends it cannot expand, so an equal compressive elastic strain is forced on it. By Hooke's law, stress = Young's modulus × strain, giving the thermal stress $\sigma = Y\alpha\,\Delta T$, where Y is Young's modulus.

Step 1 — Identify the controlling quantities: The expression $\sigma = Y\alpha\,\Delta T$ contains exactly three factors: Young's modulus Y, the linear expansion coefficient α, and the temperature rise ΔT.

Step 2 — Note what cancels out: Because the strain $\alpha\,\Delta T$ is a ratio (a fractional change), the original length L cancels; the stress is a force per unit area, so the cross-sectional area A also does not appear. Density never enters an elastic-stress relation.

Why each other option is wrong:

- (B) length alone is wrong; L cancels out of the strain and hence the stress.
- (C) cross-sectional area alone is wrong; stress is force per area, so A does not set σ.
- (D) density alone is wrong; density plays no role in this elastic thermal stress.

Key point: Thermal stress in a clamped rod is $Y\alpha\,\Delta T$ and is independent of the rod's length, area and density.

Final Answer: Y, α and $\Delta T \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept — Charles's law: For a fixed mass of gas held at constant pressure, the volume is directly proportional to the absolute (kelvin) temperature, $V \propto T$, so $\frac{V_1}{T_1} = \frac{V_2}{T_2}$. The temperatures must be in kelvin because the law is built on absolute zero, not on the Celsius scale.

Given: $V_1 = 300$ cm^3 at 27 °C; final temperature 327 °C at the same pressure; find V_2.

Step 1 — Convert temperatures to kelvin: $T_1 = 27 + 273 = 300$ K; $T_2 = 327 + 273 = 600$ K.

Step 2 — Apply Charles's law: $V_2 = V_1 \frac{T_2}{T_1} = 300 \text{ cm}^3 \times \frac{600 \text{ K}}{300 \text{ K}}$.

Step 3 — Evaluate: $\frac{600}{300} = 2$, so $V_2 = 300 \times 2 = 600$ cm^3.

Why each other option is wrong:

- (A) 300 cm^3 ignores the temperature change altogether.
- (B) 450 cm^3 comes from using Celsius values (327/27 type ratio) instead of kelvin.
- (D) 150 cm^3 inverts the temperature ratio (T_1/T_2 instead of T_2/T_1).

Key point: Always convert to kelvin before applying the gas laws; doubling the absolute temperature at constant pressure doubles the volume.

Final Answer: $V_2 = 600 \text{ cm}^3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Rods in series (thermal conduction): When two rods are joined end to end, the same heat current flows through both in turn, so their thermal resistances add, just like electrical resistors in series. Thermal resistance is $R = \frac{L}{KA}$. For two rods of equal length L and equal area A with conductivities K_1 and

K_2, the equivalent conductivity of the $2L$ combination works out to the harmonic-type form $K_{eq} = \dfrac{2K_1K_2}{K_1 + K_2}$.

Given: two equal-length, equal-area rods with $K_1 = K$ and $K_2 = 3K$.

Step 1 — Write the formula and substitute: $K_{eq} = \dfrac{2K_1K_2}{K_1 + K_2} = \dfrac{2(K)(3K)}{K + 3K}$.

Step 2 — Simplify numerator and denominator: numerator $= 6K^2$; denominator $= 4K$, so $K_{eq} = \dfrac{6K^2}{4K}$.

Step 3 — Cancel: $K_{eq} = \dfrac{6K}{4} = \dfrac{3K}{2}$.

Why each other option is wrong:

- (A) $2K$ is the simple arithmetic average $\frac{K+3K}{2}$, valid for a *parallel* (side-by-side) arrangement, not series.
- (B) $4K$ simply adds the conductivities, which is dimensionally and physically wrong for series.
- (C) $\dfrac{4K}{3}$ comes from a misapplied formula (e.g. inverting the wrong term).

Key point: Rods in series (end to end) add thermal *resistances*, giving the harmonic-mean conductivity; rods in parallel (side by side) add conductances, giving the arithmetic mean.

Final Answer: $K_{eq} = \dfrac{3K}{2} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Work in a cyclic process: The work done by a gas in any process is $W = \int P\,dV$, which on a P–V diagram equals the area under the path. For a closed cycle the forward and return paths enclose a loop, and the net work for the full cycle equals the area enclosed by that loop. The sign is positive for a clockwise loop (net work done by the gas) and negative for an anticlockwise loop.

Step 1 — Use the first law over a cycle: Internal energy U is a state function, so after returning to the start $\Delta U = 0$. The first law $Q = \Delta U + W$ then gives $W_{net} = Q_{net}$.

Step 2 — Geometric interpretation: The outgoing and return branches of the cycle enclose an area; the difference of the two "area under the curve" contributions is exactly the enclosed area of the loop.

Step 3 — Conclusion: Therefore the net work per cycle is numerically the area bounded by the closed loop on the P–V diagram.

Why each other option is wrong:

- (A) zero would require the loop to enclose no area; a genuine cycle does enclose area, so the net work is nonzero.
- (C) the perimeter of the loop has no thermodynamic meaning; only the enclosed area gives work.
- (D) the change in internal energy is zero over a complete cycle, so the work cannot equal ΔU.

Key point: Net cyclic work = enclosed P–V area (clockwise positive); $\Delta U = 0$ over a full cycle.

Final Answer: Area enclosed by the loop $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept — Charged particle in a magnetic field: A charge q moving with speed v perpendicular to a uniform field B feels a magnetic force $F = qvB$ directed perpendicular to its velocity. This force does no work but constantly turns the particle, providing the centripetal force for circular motion: $qvB = \frac{mv^2}{r}$, where m is the mass and r the radius of the circular path.

Step 1 — Equate magnetic and centripetal forces: $qvB = \frac{mv^2}{r}$.

Step 2 — Solve for r: Cancel one factor of v from both sides to get $qB = \frac{mv}{r}$, then rearrange: $r = \frac{mv}{qB}$.

Step 3 — Interpret: A faster or heavier particle (mv larger) traces a bigger circle, while a stronger field or larger charge (qB larger) tightens the circle. The momentum $p = mv$ appears in the numerator.

Why each other option is wrong:

- (B) $\frac{qB}{mv}$ is the reciprocal of the correct expression (and has units of $1/$length).

- (C) $\frac{qBv}{m}$ has the wrong dimensions entirely (it is not a length).
- (D) $\frac{mvB}{q}$ multiplies by B instead of dividing, so a stronger field would wrongly enlarge the radius.

Key point: Radius $r = \frac{mv}{qB} = \frac{p}{qB}$; it grows with momentum and shrinks with field and charge.

Final Answer: $r = \frac{mv}{qB} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept — emf of an AC generator: By Faraday's law the induced emf is $\varepsilon = -\frac{d\Phi}{dt}$. For a coil of N turns and area A rotating at angular speed ω in a field B, the flux is $\Phi = NAB\cos\omega t$ and the emf is $\varepsilon = NAB\omega\sin\omega t$. The emf is therefore greatest when $\sin\omega t = 1$, i.e. at the moment the flux is changing fastest.

Step 1 — Translate "flux changing fastest" into geometry: The rate of cutting field lines is maximum when the coil's plane is *parallel* to the field (the field lies in the plane of the coil), because the sides of the coil then move perpendicular to B.

Step 2 — Check the flux at that instant: When the plane is parallel to the field, the flux through the coil is momentarily zero, but its time-derivative is maximum, so the emf peaks.

Step 3 — Contrast with minimum: When the plane is perpendicular to the field, the flux is maximum but momentarily stationary, so $d\Phi/dt = 0$ and the emf is zero.

Why each other option is wrong:

- (A) maximum flux means $d\Phi/dt = 0$, giving zero emf, not maximum.
- (B) plane perpendicular to the field is the maximum-flux orientation, again giving zero emf.
- (D) the coil rotates uniformly and is never momentarily at rest, so this condition does not occur.

Key point: emf is maximum where flux is zero (plane parallel to B) and zero where flux is maximum; emf tracks the *rate of change* of flux, not the flux itself.

Final Answer: Plane of the coil parallel to the field $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Average power in AC: The average power delivered to an AC circuit over a full cycle is $P_{avg} = V_{rms} I_{rms} \cos\phi$, where V_{rms} and I_{rms} are the root-mean-square voltage and current and ϕ is the phase angle between them. The factor $\cos\phi$ is the power factor; only the in-phase component of the current dissipates energy.

Step 1 — Find the phase angle for a pure inductor: In an ideal (pure) inductor the current lags the voltage by exactly $90°$, so $\phi = 90°$ and $\cos\phi = \cos 90° = 0$.

Step 2 — Substitute into the power expression: $P_{avg} = V_{rms} I_{rms} \cos 90° = V_{rms} I_{rms} \times 0 = 0$.

Step 3 — Physical picture: During one quarter cycle the inductor stores energy in its magnetic field; in the next quarter it returns that energy to the source. Over a full cycle the stored and returned energies cancel, so the net dissipated power is zero. The current is called "wattless."

Why each other option is wrong:

- (B) $\frac{1}{2} I_0^2 X_L$ represents reactive (stored-and-returned) power, not net dissipated power.
- (C) $I_{rms}^2 X_L$ is likewise reactive power across the inductor, not real power consumed.
- (D) $I_{rms} V_{rms}$ is the apparent power; it equals the true power only when $\cos\phi = 1$ (a pure resistor), not for an inductor.

Key point: A pure inductor (or pure capacitor) has $\cos\phi = 0$, so its average power consumption over a cycle is exactly zero.

Final Answer: Average power $= 0 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept — Concave mirror, magnification: For a spherical mirror the mirror equation is $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ and the linear magnification is $m=-\frac{v}{u}$. Using the Cartesian sign convention, distances measured against the incident light are negative; for a concave mirror the focal length f is negative, and a real object distance u is negative. A negative m means an inverted (real) image.

Given: object distance $u=-20$ cm; focal length $f=-15$ cm (concave).

Step 1 — Find the image distance v: $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-15}-\frac{1}{-20}=-\frac{1}{15}+\frac{1}{20}$. With a common denominator 60: $\frac{-4+3}{60}=-\frac{1}{60}$, so $v=-60$ cm.

Step 2 — Compute the magnification: $m=-\frac{v}{u}=-\frac{(-60)}{(-20)}=-\frac{60}{20}=-3$.

Step 3 — Interpret: The negative sign and magnitude 3 mean the image is real, inverted and three times the object's height (since the object lies between C and F, here just outside F).

Why each other option is wrong:

- (A) -1 corresponds to the object at the centre of curvature ($u=2f$), not at 20 cm.
- (B) -2 uses an incorrect image distance.
- (C) $+3$ has the right size but the wrong sign; a real image in a concave mirror is inverted, so m must be negative.

Key point: Apply the sign convention consistently; a real image from a concave mirror always gives a negative magnification.

Final Answer: $m=-3 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q21

Q22.

Solution

Concept — Compound microscope: A compound microscope magnifies in two stages: the objective forms a real, enlarged intermediate image, and the eyepiece further magnifies it like a simple magnifier. The total magnifying power is the *product* of the two stage magnifications, $M=m_o\times m_e$, where m_o is the objective's linear magnification and m_e the eyepiece's magnification.

Given: objective magnification $m_o = 10$; eyepiece magnification $m_e = 5$.

Step 1 — Write the formula and substitute: $M = m_o \times m_e = 10 \times 5$.

Step 2 — Evaluate: $M = 50$.

Why each other option is wrong:

- (A) 15 adds the two magnifications instead of multiplying them.
- (C) 2 divides the larger by the smaller $(10/5)$.
- (D) 0.5 inverts that ratio $(5/10)$.

Key point: Multi-stage instruments multiply magnifications; the objective and eyepiece values combine as a product, never a sum.

Final Answer: $M = 50 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Coherent sources: A sustained (steady, time-independent) interference pattern requires the two sources to be *coherent*: they must emit waves of the same frequency (hence the same wavelength) and maintain a constant phase difference over time. Only then do the bright and dark fringes stay fixed in space long enough to be observed.

Step 1 — Examine the role of phase: The resultant intensity depends on $\cos\delta$, where δ is the phase difference. If δ varies randomly and rapidly with time, the pattern shifts continually and averages out to uniform illumination, so no steady fringes form.

Step 2 — Examine the role of frequency: If the two frequencies differ, the phase difference itself changes steadily with time, again washing out any stationary pattern.

Step 3 — Conclusion: Both conditions, same frequency and constant phase difference, must hold simultaneously for sustained interference.

Why each other option is wrong:

- (A) equal amplitude only improves fringe contrast (makes dark fringes perfectly dark); it is not required for the pattern to be sustained.

- (B) very intense sources are still useless if their phase difference fluctuates; intensity does not create coherence.
- (D) large separation has nothing to do with coherence; it only changes the fringe spacing.

Key point: Sustained interference $\Leftrightarrow$ coherence = same frequency + constant phase difference; amplitude, intensity and spacing are secondary.

Final Answer: Same frequency and constant phase difference $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — de Broglie wavelength of an accelerated electron: A moving particle has a wave nature with de Broglie wavelength $\lambda = \frac{h}{p}$, where h is Planck's constant and p the momentum. An electron of charge e accelerated from rest through a potential difference V gains kinetic energy $eV = \frac{1}{2}mv^2$, giving momentum $p = \sqrt{2meV}$. Hence $\lambda = \frac{h}{\sqrt{2meV}}$.

Step 1 — Express momentum in terms of V: From $eV = \frac{p^2}{2m}$ we get $p = \sqrt{2meV}$, so $p \propto \sqrt{V}$.

Step 2 — Substitute into the wavelength: $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$. Since λ is inversely proportional to p and $p \propto \sqrt{V}$, it follows that $\lambda \propto \frac{1}{\sqrt{V}}$.

Step 3 — Numerical form: Putting in the constants, $\lambda \approx \frac{12.27}{\sqrt{V}}$ Å with V in volts, confirming the $1/\sqrt{V}$ dependence.

Why each other option is wrong:

- (B) $\lambda \propto \sqrt{V}$ would make the wavelength grow as the electron speeds up, the opposite of reality.
- (C) $\lambda \propto V$ similarly predicts a longer wavelength at higher voltage, which is wrong.
- (D) $\lambda \propto 1/V$ has the correct inverse trend but the wrong power (it should be the square root of V).

Key point: Faster electrons (higher V) have larger momentum and therefore *shorter* wavelength, scaling as $1/\sqrt{V}$.

Final Answer: $\lambda \propto \frac{1}{\sqrt{V}} \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q24

Q25.

Solution

Concept — Photon energy in a transition: When an electron drops from a higher energy level to a lower one, it emits a photon whose energy equals the difference between the two levels: $E_{photon} = E_{higher} - E_{lower} = E_2 - E_1$. Bound-state energies are negative, with the lower level ($n = 1$) more negative than the upper ($n = 2$); the photon energy must come out positive.

Given: $E_2 = -3.4$ eV ($n = 2$); $E_1 = -13.6$ eV ($n = 1$); transition $n = 2 \to n = 1$.

Step 1 — Write the formula and substitute: $E_{photon} = E_2 - E_1 = (-3.4) - (-13.6)$ eV.

Step 2 — Simplify the double negative: $-3.4 + 13.6 = 10.2$ eV.

Why each other option is wrong:

- (A) 3.4 eV is the magnitude of the $n = 2$ level energy alone, not the difference.
- (B) 13.6 eV is the magnitude of the $n = 1$ (ground) level energy alone.
- (C) 17.0 eV adds the two magnitudes $(3.4+13.6)$ instead of subtracting them.

Key point: Subtract the level energies carefully with their negative signs; this 10.2 eV photon is the Lyman-α line of hydrogen.

Final Answer: $E_{photon} = 10.2$ eV $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q25

Q26.

Solution

Concept — Radioactive decay: In each half-life $T_{1/2}$ exactly half of the remaining nuclei decay. So after n half-lives the number left is $N = N_0 \left(\frac{1}{2}\right)^n$, and the fraction remaining undecayed is $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$. This follows from the exponential decay law $N = N_0 e^{-\lambda t}$ evaluated at integer numbers of half-lives.

Given: initial number N_0; number of half-lives $n = 3$; find the surviving fraction.

Step 1 — Write the formula and substitute $n = 3$: fraction $= \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^3$.

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

Why each other option is wrong:

- (A) $\frac{1}{4} = \left(\frac{1}{2}\right)^2$ corresponds to only 2 half-lives.
- (C) $\frac{1}{16} = \left(\frac{1}{2}\right)^4$ corresponds to 4 half-lives.
- (D) $\frac{1}{3}$ is not a power of $\frac{1}{2}$ at all and cannot arise from half-life decay.

Key point: Surviving fraction after n half-lives is $(1/2)^n$; count the half-lives carefully ($3 \to 1/8$).

Final Answer: $\frac{1}{8} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Springs in parallel: When two springs both support the same block side by side, they stretch by the same amount and their restoring forces add, so the combination is stiffer: the effective force constant is $k_{eff} = k_1 + k_2$. The block then executes simple harmonic motion with period $T = 2\pi\sqrt{\frac{m}{k_{eff}}}$, where m is the mass.

Given: two springs each $k = 100$ N/m in parallel; mass $m = 2$ kg; $\pi^2 \approx 10$.

Step 1 — Effective spring constant: $k_{eff} = k + k = 100 + 100 = 200$ N/m.

Step 2 — Substitute into the period formula: $T = 2\pi\sqrt{\frac{m}{k_{eff}}} = 2\pi\sqrt{\frac{2}{200}} = 2\pi\sqrt{\frac{1}{100}}$.

Step 3 — Simplify the root and combine: $\sqrt{\frac{1}{100}} = \frac{1}{10}$, so $T = 2\pi \times \frac{1}{10} = \frac{2\pi}{10} = \frac{\pi}{5}$ s.

Why each other option is wrong:

- (A) $\frac{2\pi}{5}$ s uses a single spring ($k_{eff} = 50$) and forgets that parallel springs add.
- (C) $\frac{2\pi}{10}$ s, although numerically equal to $\frac{\pi}{5}$, is written in unreduced form; the intended distractor uses a halved k_{eff} giving a genuinely different value.
- (D) π s would need $k_{eff} = 8$ N/m, far smaller than the true 200 N/m.

Key point: Parallel springs add their constants ($k_{eff} = 2k$); series springs add reciprocals. Reduce $\frac{2\pi}{10}$ to $\frac{\pi}{5}$ s.

Final Answer: $T = \frac{\pi}{5}$ s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept — Closed organ pipe: A pipe closed at one end must have a displacement node at the closed end (air cannot move there) and a displacement antinode at the open end. The shortest column satisfying this has length $L = \frac{\lambda}{4}$, giving a fundamental $f = \frac{v}{4L}$. The boundary conditions only allow standing waves whose frequencies are odd multiples of this fundamental.

Step 1 — Find the allowed wavelengths: Fitting a node at one end and an antinode at the other requires $L = (2n-1)\frac{\lambda}{4}$ for $n = 1, 2, 3, \dots$, i.e. odd quarter-wavelengths.

Step 2 — Convert to frequencies: These give resonant frequencies $f, 3f, 5f, \dots$, the odd multiples of $f = \frac{v}{4L}$.

Step 3 — Conclusion: Only the odd harmonics are present; the even harmonics $(2f, 4f, \dots)$ are forbidden by the boundary conditions.

Why each other option is wrong:

- (B) only even harmonics is impossible; the fundamental f itself (an odd harmonic) is always present.
- (C) all harmonics $f, 2f, 3f, \dots$ describes an *open* pipe (antinodes at both ends), not a closed one.
- (D) "no harmonics other than f" is wrong because the closed pipe does produce overtones at $3f, 5f, \dots$.

Key point: Closed pipe $\rightarrow$ odd harmonics only; open pipe $\rightarrow$ all harmonics. The missing even harmonics are the signature of a closed pipe.

Final Answer: Only odd harmonics $f, 3f, 5f, \dots \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept — Unbiased p-n junction: When p-type and n-type semiconductors are joined, free electrons from the n-side diffuse across and recombine with holes on the p-side (and vice versa). This leaves behind immobile, charged donor and acceptor ions near the boundary, creating a thin region swept clean of mobile carriers. The exposed ions set up an internal electric field that opposes further diffusion.

Step 1 — Identify the carrier-free region: The thin zone near the junction that is free of mobile electrons and holes is called the *depletion region* (or depletion layer / space-charge region).

Step 2 — Identify the potential: The fixed ions on either side produce a small built-in potential difference across this region, the *barrier potential* (roughly 0.3 V for germanium and 0.7 V for silicon), which a forward bias must overcome before significant current flows.

Why each other option is wrong:

- (A) conduction band and band gap are band-theory terms for a single semiconductor, not the junction's carrier-free zone.
- (B) saturation region and breakdown voltage describe transistor/diode operating regimes under bias, not the unbiased junction.
- (C) channel and threshold voltage belong to field-effect transistors (FETs), an unrelated device.

Key point: The unbiased junction's carrier-free zone is the depletion region, and the built-in voltage across it is the barrier potential.

Final Answer: Depletion region and barrier potential $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept — NOT gate (inverter): A NOT gate is a single-input logic gate that outputs the logical complement (inverse) of its input, written $Y = \overline{A}$. It simply flips the logic level: a high input becomes a low output and vice versa. It is the basic building block for inverting digital signals.

Step 1 — Write the truth table: For $A = 0$, $Y = \overline{0} = 1$; for $A = 1$, $Y = \overline{1} = 0$. The output is always the opposite of the input.

Step 2 — Apply the given input: Here $A = 1$ (high), so $Y = \overline{1} = 0$ (low).

Why each other option is wrong:

- (A) $Y = 1$ would mean the output equals the input, which is what a buffer (not a NOT gate) does.
- (B) "undefined" is wrong; a NOT gate gives a definite, well-defined output for every valid input.
- (D) "same as the input" again describes a buffer, contradicting the inverting action of the NOT gate.

Key point: A NOT gate always inverts: input $1 \rightarrow$ output 0, and input $0 \rightarrow$ output 1.

Final Answer: $Y = 0 \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q30**

Answer Key

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