# PGIMER BSc Nursing Physics

## Sample Paper – 10

**Duration: 23 Minutes** **Maximum Marks: 25**

### Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of the **PGIMER BSc Nursing** entrance exam.
- Each correct answer carries **+1 mark**. **0.25 mark** is deducted for every incorrect answer. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 and 12 (NCERT) Physics**.
- The exam is conducted as a computer-based test. Personal calculators, mobile phones, log tables, and other electronic gadgets are strictly prohibited.

**Q1.** In a vernier caliper, $10$ vernier scale divisions exactly coincide with $9$ main scale divisions. If $1$ main scale division equals $1$ mm, the least count of the instrument is:

(A) $0.01$ cm

(B) $0.1$ cm

(C) $0.001$ cm

(D) $0.05$ cm

**Q2.** A stone is dropped from the top of a tower of height $100$ m. At the same instant, another stone is thrown vertically upward from the foot of the tower with a speed of $25$ m s$^{-1}$. Neglecting air resistance, the time after which the two stones meet is:

(A) $4$ s

(B) $5$ s

(C) 2 s

(D) 8 s

**Q3.** A body starts from rest and moves with constant acceleration in a straight line. The ratio of the distances covered by it in the first, second, third and fourth seconds of its motion is:

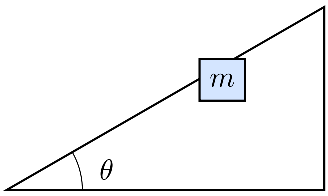
(A) $1:2:3:4$

(B) $1:3:5:7$

(C) $1:4:9:16$

(D) $1:1:1:1$

**Q4.** A block placed on a rough inclined plane just begins to slide when the angle of inclination is increased to $\theta = 30^\circ$, the angle of repose. The coefficient of static friction between the block and the incline is:



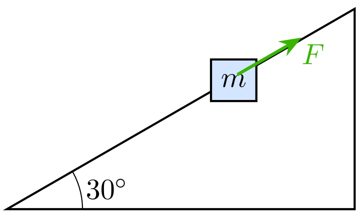

(A) 0.5

(B) 1.0

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

(D) $\sqrt{3}$

**Q5.** A block of mass 10 kg is held in equilibrium on a frictionless inclined plane of angle $30^\circ$ by a force $F$ applied parallel to the incline, as shown. Taking $g = 10$ m s$^{-2}$, the magnitude of $F$ is:



(A) 100 N

(B) 25 N

(C) 50 N

(D) 86.6 N

**Q6.** A block of mass 2 kg moving with a speed of 5 m $s^{-1}$ on a frictionless surface strikes a light spring of force constant 200 N $m^{-1}$. The maximum compression of the spring is:

(A) 0.25 m

(B) 0.5 m

(C) 1.0 m

(D) 0.1 m

**Q7.** A force of magnitude 10 N is applied at a point whose position vector has magnitude 2 m from the axis of rotation. If the angle between the position vector and the force is $30^\circ$, the magnitude of the torque about the axis is:

(A) 20 N m

(B) 17.3 N m

(C) 10 N m

(D) 5 N m

**Q8.** The mass of the Moon is $\frac{1}{100}$ that of the Earth and its radius is $\frac{1}{4}$ that of the Earth. Taking the acceleration due to gravity on the Earth's surface as 10 m $s^{-2}$, the acceleration due to gravity on the Moon's surface is:

(A) 3.2 m $s^{-2}$

(B) 1.6 m $s^{-2}$

(C) 0.16 m $s^{-2}$

(D) 9.8 m $s^{-2}$

**Q9.** A liquid of coefficient of viscosity $0.1$ N s m$^{-2}$ flows between two parallel layers of area $2$ m$^2$ each, across which the velocity gradient is $5$ s$^{-1}$. Using $F = \eta A \dfrac{dv}{dx}$, the viscous force between the layers is:

(A) $1$ N

(B) $0.5$ N

(C) $2$ N

(D) $10$ N

**Q10.** A monatomic ideal gas $\left(\gamma = \dfrac{5}{3}\right)$ at a pressure of $1$ atm is compressed adiabatically to one-eighth of its initial volume. The final pressure of the gas is:

(A) $8$ atm

(B) $16$ atm

(C) $64$ atm

(D) $32$ atm

**Q11.** The internal energy of $2$ moles of a monatomic ideal gas at a temperature of $300$ K is $\left(U = \dfrac{3}{2}nRT,\ R = 8.31 \text{ J mol}^{-1}\text{K}^{-1}\right)$:

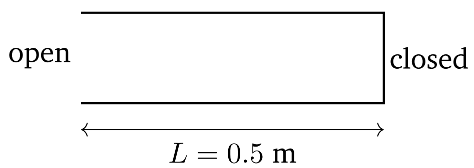
(A) $4986$ J

(B) $7479$ J

(C) $12465$ J

(D) $14958$ J

**Q12.** A closed organ pipe (closed at one end, open at the other) has a length of $0.5$ m. Taking the speed of sound in air as $340$ m s$^{-1}$, the fundamental frequency of the pipe is:



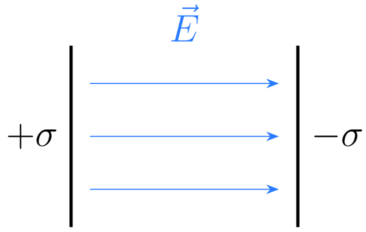
(A) 340 Hz

(B) 85 Hz

(C) 170 Hz

(D) 680 Hz

**Q13.** Two large parallel plates carry surface charge densities $+\sigma$ and $-\sigma$, with $\sigma = 8.85\times10^{-7}$ C m$^{-2}$. Taking $\varepsilon_0 = 8.85\times10^{-12}$ C$^2$N$^{-1}$m$^{-2}$, the magnitude of the electric field in the region between the plates $\left(E = \dfrac{\sigma}{\varepsilon_0}\right)$ is:




(A) $1 \times 10^5$ N C$^{-1}$

(B) $2 \times 10^5$ N C$^{-1}$

(C) $0.5 \times 10^5$ N C$^{-1}$

(D) $1 \times 10^4$ N C$^{-1}$

**Q14.** $n$ identical capacitors, each of capacitance $C$, are connected first all in series and then all in parallel. The ratio of the equivalent capacitance in series to that in parallel is:

(A) $1 : n$

(B) $n : 1$

(C) $1 : n^2$

(D) $n^2 : 1$

**Q15.** A cell of emf $12$ V and internal resistance $0.5\ \Omega$ is being charged by an external source that drives a current of $2$ A through it. The terminal potential difference across the cell during charging $(V = E + Ir)$ is:

(A) 11 V

(B) 13 V

(C) 12 V

(D) 14 V

**Q16.** A carbon resistor has colour bands in the order Brown, Black, Red. Using the colour code (Brown $= 1$, Black $= 0$, Red $= 10^2$ as the multiplier), the resistance of the resistor is:

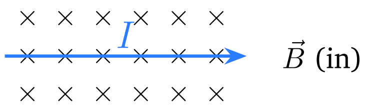
(A) $100\ \Omega$

(B) $10\ \Omega$

(C) $10000\ \Omega$

(D) $1000\ \Omega$

**Q17.** A straight wire of length $0.5$ m carries a current of $4$ A towards the right (east). It is placed perpendicular to a uniform magnetic field of $0.5$ T directed into the plane of the page, as shown. The magnitude and direction of the force on the wire are:



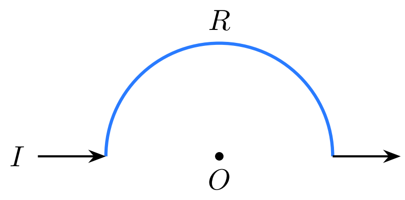

(A) $1$ N, directed downward

(B) $2$ N, directed upward

(C) $0.5$ N, directed upward

(D) $1$ N, directed upward

**Q18.** A wire is bent into a semicircular arc of radius $R = 0.1$ m and carries a current of $2$ A. Taking $\mu_0 = 4\pi \times 10^{-7}$ T m A$^{-1}$, the magnitude of the magnetic field at the centre $O$ of the arc $\left(B = \dfrac{\mu_0 I}{4R}\right)$ is:




(A) $6.28 \times 10^{-6}$ T

(B) $1.26 \times 10^{-5}$ T

(C) $3.14 \times 10^{-6}$ T

(D) $12.56 \times 10^{-6}$ T

**Q19.** In an AC circuit the rms voltage is $220$ V and the rms current is $5$ A, with a phase difference $\phi$ between them such that $\cos\phi = 0.8$. The average power consumed in the circuit $(P = V_{\text{rms}} I_{\text{rms}} \cos\phi)$ is:

(A) $1100$ W

(B) $550$ W

(C) $440$ W

(D) $880$ W

**Q20.** The power of a concave (diverging) lens is $-5$ dioptres. The focal length of the lens is:

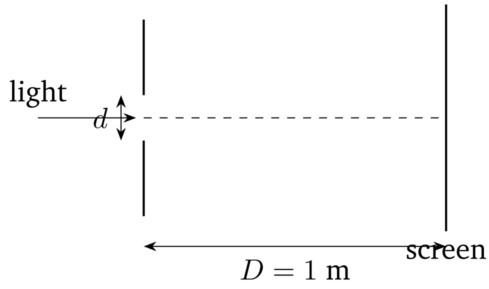
(A) $-10$ cm

(B) $-20$ cm

(C) $+20$ cm

(D) $-5$ cm

**Q21.** In a Young's double-slit experiment, light of wavelength $600$ nm illuminates two slits separated by $0.5$ mm, and the pattern is observed on a screen $1$ m away. The distance of the first dark fringe from the central bright fringe $\left(y = \dfrac{(2n-1)\lambda D}{2d},\ n = 1\right)$ is:




(A) 1.2 mm

(B) 2.4 mm

(C) 0.3 mm

(D) 0.6 mm

**Q22.** In the photoelectric effect, the incident light on a metal surface is changed. Which statement correctly describes the effect of increasing the frequency and the intensity of the light?

(A) Increasing the intensity increases the maximum kinetic energy of the photoelectrons.

(B) Increasing the frequency increases the number of photoelectrons emitted per second.

(C) Both increasing the frequency and increasing the intensity increase the maximum kinetic energy.

(D) Increasing the frequency increases the maximum kinetic energy, while increasing the intensity increases the number of photoelectrons emitted per second.

**Q23.** For the hydrogen atom the Rydberg constant is $R = 1.097 \times 10^7\ \text{m}^{-1}$. The wavelength of the first (longest-wavelength) line of the Lyman series, corresponding to the transition $n = 2 \to n = 1$, is approximately:

(A) 91.2 nm

(B) 656 nm

(C) 121.5 nm

(D) 102.6 nm

**Q24.** The activity of a radioactive sample falls to one-sixteenth of its initial value. The number of half-lives that have elapsed is:

(A) 4

(B) 16

(C) 2

(D) 8

**Q25.** For a transistor in normal operation, the correct relationship between the emitter current $I_E$, the base current $I_B$ and the collector current $I_C$ is:

(A) $I_B = I_E + I_C$

(B) $I_C = I_E + I_B$

(C) $I_E = I_B + I_C$

(D) $I_E = I_C - I_B$

## Detailed Solutions

### Q1.

**Solution**

**Concept — Least count of a vernier caliper:** The least count is the smallest length the instrument can read; it equals the value of one main scale division minus the value of one vernier scale division.

**Step 1 — Value of one main scale division (MSD):**

$$1 \text{ MSD} = 1 \text{ mm}.$$

**Step 2 — Value of one vernier scale division (VSD):** Since 10 VSD coincide with 9 MSD:

$$10 \text{ VSD} = 9 \text{ MSD}.$$

$$1 \text{ VSD} = \frac{9}{10} \text{ MSD} = 0.9 \text{ mm}.$$

**Step 3 — Apply the least-count formula:**

$$\text{LC} = 1 \text{ MSD} - 1 \text{ VSD} = 1 - 0.9 = 0.1 \text{ mm}.$$

**Step 4 — Convert to centimetres:**

$$0.1 \text{ mm} = 0.01 \text{ cm}.$$

**Why other options are wrong:**

- Option B (0.1 cm): equals 1 mm, the full main scale division, not the least count.
- Option C (0.001 cm): off by a factor of ten.
- Option D (0.05 cm): would need 20 vernier divisions, not 10.

**Final Answer:** Least count $= 0.01$ cm $\Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q1

## Q2.

### Solution

**Concept — Relative motion of two bodies under gravity:** Both stones have the same downward acceleration $g$, so their relative acceleration is zero. They approach each other at a constant relative speed equal to the launch speed of the lower stone.

**Step 1 — Set up the relative velocity:** The top stone starts from rest; the bottom stone starts upward at $u = 25$ m s$^{-1}$.

The initial speed of approach (relative velocity) is:

$$v_{\text{rel}} = 25 \text{ m s}^{-1}.$$

**Step 2 — Relative acceleration:** Each stone accelerates downward at $g$, so:

$$a_{\text{rel}} = g - g = 0.$$

The gap closes at the constant rate $v_{\text{rel}}$.

**Step 3 — Time to close the gap (the tower height):**

$$t = \frac{\text{separation}}{v_{\text{rel}}} = \frac{100}{25}.$$

**Step 4 — Simplify:**

$$t = 4 \text{ s}.$$

**Why other options are wrong:**

- Option B (5 s): uses $u = 20$ instead of 25.
- Option C (2 s): halves the correct value.
- Option D (8 s): doubles the correct value.

**Final Answer:** The stones meet after 4 s $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q2

## Q3.

### Solution

**Concept — Distance in the $n$th second:** For a body starting from rest with constant acceleration $a$, the distance covered in the $n$th second is $s_n = \frac{a}{2}(2n-1)$, so the distances form the odd-number sequence.

**Step 1 — Write the formula:** With $u = 0$:

$$s_n = u + \frac{a}{2}(2n-1) = \frac{a}{2}(2n-1).$$

**Step 2 — Evaluate for $n = 1, 2, 3, 4$:**

$$s_1 = \frac{a}{2}(1), \quad s_2 = \frac{a}{2}(3), \quad s_3 = \frac{a}{2}(5), \quad s_4 = \frac{a}{2}(7).$$

**Step 3 — Form the ratio:**

$$s_1 : s_2 : s_3 : s_4 = 1 : 3 : 5 : 7.$$

**Why other options are wrong:**

- Option A $(1 : 2 : 3 : 4)$: would need the velocity, not the distance, to grow linearly.
- Option C $(1 : 4 : 9 : 16)$: is the ratio of total distances $(\propto t^2)$, not distances in successive seconds.
- Option D $(1 : 1 : 1 : 1)$: holds only for uniform (zero-acceleration) motion.

**Final Answer:** The ratio is $1 : 3 : 5 : 7 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q3

## Q4.

### Solution

**Concept — Angle of repose:** The angle of repose is the maximum angle of an incline at which a block just stays in place. At this angle the gravity component along the slope equals the limiting friction, which gives $\mu = \tan\theta$.

**Step 1 — Balance of forces at the point of sliding:** Along the incline: $mg\sin\theta = f_{\max} = \mu N$.

Perpendicular to the incline: $N = mg\cos\theta$.

**Step 2 — Eliminate $N$:**

$$mg\sin\theta = \mu\,(mg\cos\theta).$$

$$\mu = \frac{\sin\theta}{\cos\theta} = \tan\theta.$$

**Step 3 — Substitute $\theta = 30^\circ$:**

$$\mu = \tan 30^\circ = \frac{1}{\sqrt{3}}.$$

**Step 4 — Numerical value:**

$$\mu = \frac{1}{\sqrt{3}} \approx 0.577.$$

**Why other options are wrong:**

- Option A $(0.5)$: equals $\sin 30^\circ$, not $\tan 30^\circ$.
- Option B $(1.0)$: equals $\tan 45^\circ$.
- Option D $(\sqrt{3})$: equals $\tan 60^\circ$, the reciprocal of the correct value.

**Final Answer:** $\mu = \tan 30^\circ = \dfrac{1}{\sqrt{3}} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q4

## Q5.

Solution

**Concept — Equilibrium on a smooth incline:** On a frictionless incline, a force applied parallel to the slope must balance the component of gravity acting down the slope.

**Step 1 — Component of weight along the incline:**

$$F = mg\sin\theta.$$

**Step 2 — List the values:** Mass $m = 10$ kg.

Acceleration due to gravity $g = 10$ m s$^{-2}$.

Angle $\theta = 30^\circ$, so $\sin 30^\circ = 0.5$.

**Step 3 — Substitute:**

$$F = 10 \times 10 \times 0.5.$$

**Step 4 — Simplify:**

$$F = 100 \times 0.5 = 50 \text{ N}.$$

**Why other options are wrong:**

- Option A (100 N): equals the full weight $mg$, ignoring the $\sin\theta$ factor.
- Option B (25 N): uses half the correct mass.
- Option D (86.6 N): equals $mg\cos 30°$, which is the normal reaction, not the holding force.

**Final Answer:** Required force $= 50$ N $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q5

## Q6.

**Solution**

**Concept — Energy conservation with a spring:** At maximum compression the block momentarily stops, so all of its kinetic energy has been stored as elastic potential energy in the spring.

**Step 1 — Equate kinetic and spring energies:**

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2.$$

**Step 2 — Solve for the compression $x$:**

$$x^2 = \frac{mv^2}{k}.$$

$$x = v\sqrt{\frac{m}{k}}.$$

**Step 3 — Substitute the values:** Mass $m = 2$ kg, speed $v = 5$ m s$^{-1}$, force constant $k = 200$ N m$^{-1}$.

$$x = 5\sqrt{\frac{2}{200}} = 5\sqrt{0.01}.$$

**Step 4 — Simplify:**

$$x = 5 \times 0.1 = 0.5 \text{ m}.$$

**Why other options are wrong:**

- Option A (0.25 m): halves the correct value.

- Option C ($1.0$ m): forgets the square root.
- Option D ($0.1$ m): uses only $\sqrt{m/k}$ without the speed.

**Final Answer:** Maximum compression $= 0.5$ m $\Rightarrow$ $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q6

## Q7.

**Solution**

**Concept — Torque as a cross product:** The torque of a force about an axis is $\vec{\tau} = \vec{r} \times \vec{F}$, whose magnitude is $\tau = rF \sin\theta$, where $\theta$ is the angle between $\vec{r}$ and $\vec{F}$.

**Step 1 — List the values:** Position vector magnitude $r = 2$ m.

Force $F = 10$ N.

Angle $\theta = 30°$, so $\sin 30° = 0.5$.

**Step 2 — Substitute into the magnitude formula:**

$$\tau = rF\sin\theta = 2 \times 10 \times 0.5.$$

**Step 3 — Simplify:**

$$\tau = 20 \times 0.5 = 10 \text{ N m}.$$

**Why other options are wrong:**

- Option A ($20$ N m): takes $\sin\theta = 1$, i.e. assumes a right angle.
- Option B ($17.3$ N m): uses $\sin 60°$ instead of $\sin 30°$.
- Option D ($5$ N m): introduces an extra factor of one-half.

**Final Answer:** Torque $= 10$ N m $\Rightarrow$ $\boxed{\text{C}}$

**Answer: (C)** Go Back to Q7

## Q8.

**Solution**

**Concept — Surface gravity from mass and radius:** The acceleration due to gravity at a planet's surface is $g = \frac{GM}{R^2}$, so $g \propto \frac{M}{R^2}$.

**Step 1 — Write the ratio of Moon to Earth:**

$$\frac{g_m}{g_e} = \frac{M_m}{M_e} \times \left(\frac{R_e}{R_m}\right)^2.$$

**Step 2 — Substitute the given ratios:**

$$\frac{M_m}{M_e} = \frac{1}{100}, \qquad \frac{R_m}{R_e} = \frac{1}{4} \Rightarrow \left(\frac{R_e}{R_m}\right)^2 = 4^2 = 16.$$

$$\frac{g_m}{g_e} = \frac{1}{100} \times 16 = \frac{16}{100} = 0.16.$$

**Step 3 — Multiply by the Earth value:**

$$g_m = 0.16 \times g_e = 0.16 \times 10 = 1.6 \text{ m s}^{-2}.$$

**Why other options are wrong:**

- Option A ($3.2$ m s$^{-2}$): doubles the correct value.
- Option C ($0.16$ m s$^{-2}$): forgets to multiply by $g_e = 10$.
- Option D ($9.8$ m s$^{-2}$): is the Earth's value, ignoring the ratios.

**Final Answer:** $g_m = 1.6 \text{ m s}^{-2} \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q8

## Q9.

**Solution**

**Concept — Newton's law of viscosity:** The viscous force between two layers of fluid is $F = \eta A \frac{dv}{dx}$, where $\eta$ is the coefficient of viscosity, $A$ the area and $\frac{dv}{dx}$ the velocity gradient.

**Step 1 — List the values:** Coefficient of viscosity $\eta = 0.1$ N s m$^{-2}$.

Area $A = 2$ m$^2$.

Velocity gradient $\frac{dv}{dx} = 5$ s$^{-1}$.

**Step 2 — Substitute into the formula:**

$$F = \eta A \frac{dv}{dx} = 0.1 \times 2 \times 5.$$

**Step 3 — Simplify:**

$$F = 0.1 \times 10 = 1 \text{ N}.$$

**Why other options are wrong:**

- Option B ($0.5$ N): halves the correct value.
- Option C ($2$ N): drops the factor $0.1$ once.
- Option D ($10$ N): omits the viscosity factor altogether.

**Final Answer:** Viscous force $= 1$ N $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q9

## Q10.

**Solution**

**Concept — Adiabatic process:** For an adiabatic change of an ideal gas, $PV^\gamma =$ constant, so $P_1V_1^\gamma = P_2V_2^\gamma$.

**Step 1 — Rearrange for the final pressure:**

$$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^\gamma.$$

**Step 2 — Substitute the volume ratio:** The gas is compressed to one-eighth of its volume, so $\frac{V_1}{V_2} = 8$ and $\gamma = \frac{5}{3}$.

$$P_2 = 1 \times (8)^{5/3}.$$

**Step 3 — Evaluate the exponent:**

$$8^{5/3} = \left(8^{1/3}\right)^5 = 2^5 = 32.$$

**Step 4 — Final pressure:**

$$P_2 = 1 \times 32 = 32 \text{ atm}.$$

**Why other options are wrong:**

- Option A ($8$ atm): treats the change as isothermal ($P \propto 1/V$).
- Option B ($16$ atm): uses $8^{4/3}$, a wrong exponent.
- Option C ($64$ atm): uses $8^2$, ignoring $\gamma$.

**Final Answer:** Final pressure $= 32$ atm $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q10

## Q11.

### Solution

**Concept — Internal energy of a monatomic ideal gas:** The internal energy of $n$ moles of a monatomic ideal gas at temperature $T$ is $U = \frac{3}{2}nRT$, since it has three translational degrees of freedom.

**Step 1 — List the values:** Number of moles $n = 2$.

Temperature $T = 300$ K.

Gas constant $R = 8.31$ J mol$^{-1}$K$^{-1}$.

**Step 2 — Substitute into the formula:**

$$U = \frac{3}{2} \times 2 \times 8.31 \times 300.$$

**Step 3 — Simplify the leading factors:**

$$\frac{3}{2} \times 2 = 3.$$

$$U = 3 \times 8.31 \times 300.$$

**Step 4 — Complete the arithmetic:**

$$3 \times 8.31 = 24.93.$$

$$U = 24.93 \times 300 = 7479 \text{ J}.$$

**Why other options are wrong:**

- Option A ($4986$ J): drops the factor $\frac{3}{2}$ and uses $U = nRT$.
- Option C ($12465$ J): uses $\frac{5}{2}nRT$, the value for a diatomic gas.
- Option D ($14958$ J): doubles the correct value.

**Final Answer:** Internal energy $= 7479$ J $\Rightarrow$ $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q11

## Q12.

### Solution

**Concept — Fundamental frequency of a closed pipe:** A pipe closed at one end has a node at the closed end and an antinode at the open end, so its fundamental wavelength is $4L$ and its fundamental frequency is $f = \frac{v}{4L}$.

**Step 1 — List the values:** Length $L = 0.5$ m.

Speed of sound $v = 340$ m s$^{-1}$.

**Step 2 — Substitute into the formula:**

$$f = \frac{v}{4L} = \frac{340}{4 \times 0.5}.$$

**Step 3 — Simplify the denominator:**

$$4 \times 0.5 = 2.$$

$$f = \frac{340}{2} = 170 \text{ Hz}.$$

**Why other options are wrong:**

- Option A (340 Hz): uses $f = v/2L$, the formula for an open pipe.
- Option B (85 Hz): uses $f = v/8L$.
- Option D (680 Hz): uses $f = v/L$.

**Final Answer:** Fundamental frequency $= 170$ Hz $\Rightarrow$ $\boxed{\text{C}}$

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

## Q13.

**Solution**

**Concept — Field between oppositely charged plates:** Between two large parallel plates carrying equal and opposite surface charge densities, the uniform electric field has magnitude $E = \frac{\sigma}{\varepsilon_0}$.

**Step 1 — List the values:** Surface charge density $\sigma = 8.85 \times 10^{-7}$ C m$^{-2}$.

Permittivity $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$N$^{-1}$m$^{-2}$.

**Step 2 — Substitute into the formula:**

$$E = \frac{\sigma}{\varepsilon_0} = \frac{8.85 \times 10^{-7}}{8.85 \times 10^{-12}}.$$

**Step 3 — Simplify:**

$$E = \frac{8.85}{8.85} \times 10^{-7-(-12)} = 1 \times 10^5 \text{ N C}^{-1}.$$

**Why other options are wrong:**

- Option B ($2 \times 10^5$): doubles the value, as if using $\sigma/2\varepsilon_0$ wrongly inverted.
- Option C ($0.5 \times 10^5$): uses $\sigma/2\varepsilon_0$, the field of a single plate.
- Option D ($1 \times 10^4$): a power-of-ten slip.

**Final Answer:** Electric field $= 1 \times 10^5$ N C$^{-1}$ $\Rightarrow$ $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q13

## Q14.

**Solution**

**Concept — Capacitors in series and parallel:** For $n$ identical capacitors of capacitance $C$, the series combination gives $C_s = \frac{C}{n}$ while the parallel combination gives $C_p = nC$.

**Step 1 — Series equivalent:**

$$\frac{1}{C_s} = \underbrace{\frac{1}{C} + \frac{1}{C} + \cdots}_{n \text{ terms}} = \frac{n}{C}.$$

$$C_s = \frac{C}{n}.$$

**Step 2 — Parallel equivalent:**

$$C_p = \underbrace{C + C + \cdots}_{n \text{ terms}} = nC.$$

**Step 3 — Form the ratio:**

$$\frac{C_s}{C_p} = \frac{C/n}{nC} = \frac{1}{n^2}.$$

**Step 4 — State the ratio:**

$$C_s : C_p = 1 : n^2.$$

**Why other options are wrong:**

- Option A $(1 : n)$: accounts for only the series factor.
- Option B $(n : 1)$: inverts the ratio.
- Option D $(n^2 : 1)$: is the reciprocal of the correct ratio.

**Final Answer:** The ratio is $1 : n^2 \Rightarrow$ C

**Answer: (C)** Go Back to Q14

## Q15.

**Solution**

**Concept — Terminal voltage during charging:** When a cell is being charged, current flows into its positive terminal, so the internal-resistance drop adds to the emf, giving $V = E + Ir$.

**Step 1 — List the values:** Emf $E = 12$ V.

Internal resistance $r = 0.5\ \Omega$.

Charging current $I = 2$ A.

**Step 2 — Compute the internal drop:**

$$Ir = 2 \times 0.5 = 1 \text{ V}.$$

**Step 3 — Add to the emf:**

$$V = E + Ir = 12 + 1 = 13 \text{ V}.$$

**Why other options are wrong:**

- Option A (11 V): uses $V = E - Ir$, the discharging case.
- Option C (12 V): ignores the internal-resistance drop.
- Option D (14 V): doubles the $Ir$ term.

**Final Answer:** Terminal potential difference $= 13$ V $\Rightarrow$ B

**Answer: (B)** Go Back to Q15

## Q16.

### Solution

**Concept — Resistor colour code:** The first two colour bands give the first two significant figures and the third band gives the power-of-ten multiplier, so $R = (\text{first two digits}) \times (\text{multiplier})$.

**Step 1 — Read the first two digits:** Brown $= 1$ (first digit).

Black $= 0$ (second digit).

So the first two figures give 10.

**Step 2 — Read the multiplier:** Red as a multiplier means $\times 10^2 = \times 100$.

**Step 3 — Combine:**

$$R = 10 \times 100 = 1000\ \Omega.$$

**Why other options are wrong:**

- Option A ($100\ \Omega$): uses a multiplier of $\times 10$ (Brown) instead of Red.
- Option B ($10\ \Omega$): omits the multiplier band.
- Option C ($10000\ \Omega$): uses a multiplier of $\times 10^3$ (Orange) instead of Red.

**Final Answer:** Resistance $= 1000\ \Omega \Rightarrow$ D

**Answer: (D)** Go Back to Q16

## Q17.

### Solution

**Concept — Force on a current-carrying conductor:** The magnitude of the force is $F = BIL\sin\theta$, and its direction is given by Fleming's left-hand rule (or $\vec{F} = I\vec{L} \times \vec{B}$).

**Step 1 — Magnitude (with $\theta = 90°$):** List: $B = 0.5$ T, $I = 4$ A, $L = 0.5$ m,

$\sin 90^\circ = 1$.

$$F = BIL\sin\theta = 0.5 \times 4 \times 0.5 \times 1.$$

**Step 2 — Simplify:**

$$F = 0.5 \times 4 \times 0.5 = 1 \text{ N}.$$

**Step 3 — Direction by Fleming's left-hand rule:** The current points to the right (east, $+x$) and the field points into the page ($-z$).

$$\vec{F} \propto \vec{L} \times \vec{B} = \hat{x} \times (-\hat{z}) = +\hat{y}.$$

So the force on the wire is directed upward.

**Why other options are wrong:**

- Option A (1 N, downward): correct magnitude but the direction is reversed.
- Option B (2 N, upward): drops the length factor 0.5.
- Option C (0.5 N, upward): uses the wrong current or field value.

**Final Answer:** Force = 1 N, directed upward $\Rightarrow$ D

**Answer: (D)** Go Back to Q17

## Q18.

**Solution**

**Concept — Field at the centre of a semicircular arc:** A full circular loop produces $B = \frac{\mu_0 I}{2R}$ at its centre; a semicircle is half of that, giving $B = \frac{\mu_0 I}{4R}$.

**Step 1 — List the values:** Current $I = 2$ A.

Radius $R = 0.1$ m.

$\mu_0 = 4\pi \times 10^{-7}$ T m A$^{-1}$.

**Step 2 — Substitute into the formula:**

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

**Step 3 — Simplify numerator and denominator:** Numerator: $(4\pi \times 10^{-7}) \times 2 = 8\pi \times 10^{-7}$.

Denominator: $4 \times 0.1 = 0.4$.

$$B = \frac{8\pi \times 10^{-7}}{0.4} = 20\pi \times 10^{-7} = 2\pi \times 10^{-6}\ \text{T}.$$

**Step 4 — Numerical value:**

$$B = 2 \times 3.14 \times 10^{-6} = 6.28 \times 10^{-6}\ \text{T}.$$

**Why other options are wrong:**

- Option B ($1.26 \times 10^{-5}$ T): uses $\mu_0 I/2R$, the full-loop value (twice the arc).
- Option C ($3.14 \times 10^{-6}$ T): halves the correct value.
- Option D ($12.56 \times 10^{-6}$ T): doubles the correct value.

**Final Answer:** Field at the centre $= 6.28 \times 10^{-6}$ T $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q18

## Q19.

**Solution**

**Concept — Average power in an AC circuit:** The average power dissipated is $P = V_{\text{rms}} I_{\text{rms}} \cos\phi$, where $\cos\phi$ is the power factor.

**Step 1 — List the values:** Rms voltage $V_{\text{rms}} = 220$ V.

Rms current $I_{\text{rms}} = 5$ A.

Power factor $\cos\phi = 0.8$.

**Step 2 — Substitute into the formula:**

$$P = V_{\text{rms}} I_{\text{rms}} \cos\phi = 220 \times 5 \times 0.8.$$

**Step 3 — Multiply step by step:**

$$220 \times 5 = 1100.$$

$$P = 1100 \times 0.8 = 880\ \text{W}.$$

**Why other options are wrong:**

- Option A ($1100$ W): omits the power factor (takes $\cos\phi = 1$).

- Option B (550 W): uses $\cos\phi = 0.5$.
- Option C (440 W): uses half the current.

**Final Answer:** Average power = 880 W $\Rightarrow$ $\boxed{\text{D}}$

**Answer: (D)** Go Back to Q19

## Q20.

**Solution**

**Concept — Power and focal length of a lens:** The power of a lens in dioptres equals the reciprocal of its focal length in metres, $P = \frac{1}{f}$. A concave (diverging) lens has negative power and negative focal length.

**Step 1 — Write the relation:**

$$f = \frac{1}{P}.$$

**Step 2 — Substitute the power:**

$$f = \frac{1}{-5} = -0.2 \text{ m}.$$

**Step 3 — Convert to centimetres:**

$$f = -0.2 \text{ m} = -20 \text{ cm}.$$

The negative sign confirms the lens is diverging.

**Why other options are wrong:**

- Option A ($-10$ cm): would correspond to a power of $-10$ D.
- Option C ($+20$ cm): has the wrong (positive) sign, implying a converging lens.
- Option D ($-5$ cm): treats the power value as the focal length directly.

**Final Answer:** Focal length = $-20$ cm $\Rightarrow$ $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q20

## Q21.

**Solution**

**Concept — Dark fringes in YDSE:** Dark fringes occur where the path difference is an odd multiple of half a wavelength, giving the position $y = \frac{(2n-1)\lambda D}{2d}$. The first dark fringe corresponds to $n = 1$.

**Step 1 — Write the formula for the first dark fringe:** With $n = 1$:

$$y = \frac{(2 \times 1 - 1)\lambda D}{2d} = \frac{\lambda D}{2d}.$$

**Step 2 — Convert the data to SI units:** Wavelength $\lambda = 600 \text{ nm} = 600 \times 10^{-9}$ m.

Screen distance $D = 1$ m.

Slit separation $d = 0.5 \text{ mm} = 0.5 \times 10^{-3}$ m.

**Step 3 — Substitute:**

$$y = \frac{(600 \times 10^{-9}) \times 1}{2 \times (0.5 \times 10^{-3})}.$$

**Step 4 — Simplify:** Denominator: $2 \times 0.5 \times 10^{-3} = 1 \times 10^{-3}$.

$$y = \frac{600 \times 10^{-9}}{1 \times 10^{-3}} = 600 \times 10^{-6} = 6 \times 10^{-4} \text{ m} = 0.6 \text{ mm}.$$

**Why other options are wrong:**

- Option A ($1.2$ mm): equals the fringe width $\lambda D/d$, twice the first-minimum distance.
- Option B ($2.4$ mm): doubles the fringe width.
- Option C ($0.3$ mm): halves the correct value.

**Final Answer:** First dark fringe at $y = 0.6 \text{ mm} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q21

## Q22.

**Solution**

**Concept — Frequency versus intensity in the photoelectric effect:** The maximum kinetic energy of photoelectrons depends only on the frequency of the light, through $K_{\max} = h\nu - \phi$, while the number of photoelectrons emitted per second depends on the intensity (the rate at which photons arrive).

**Step 1 — Effect of increasing the frequency:** A higher frequency means each photon carries more energy ($E = h\nu$), so $K_{\max} = h\nu - \phi$ increases. The frequency does not change how many electrons are emitted.

**Step 2 — Effect of increasing the intensity:** Greater intensity (at fixed frequency) means more photons per second strike the surface, so more electrons are ejected per second. The maximum kinetic energy of each electron is unchanged.

**Step 3 — Combine the two effects:** Increasing frequency raises $K_{\max}$; increasing intensity raises the number (rate) of photoelectrons. This is exactly option D.

**Why other options are wrong:**

- Option A: intensity does not affect $K_{\max}$.
- Option B: frequency does not affect the number of electrons.
- Option C: intensity does not raise $K_{\max}$, so this is incorrect.

**Final Answer:** Frequency raises $K_{\max}$ and intensity raises the number of photoelectrons $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

## Q23.

**Solution**

**Concept — Lyman series of hydrogen:** The wavelengths of the Lyman series follow $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$, with the longest-wavelength line coming from the $n = 2 \to 1$ transition.

**Step 1 — Substitute $n = 2$:**

$$\frac{1}{\lambda} = R\left(\frac{1}{1} - \frac{1}{4}\right).$$

**Step 2 — Simplify the bracket:**

$$\frac{1}{1} - \frac{1}{4} = \frac{3}{4}.$$

$$\frac{1}{\lambda} = R \times \frac{3}{4} = \frac{3}{4} \times 1.097 \times 10^7.$$

**Step 3 — Compute the reciprocal wavelength:**

$$\frac{1}{\lambda} = 0.75 \times 1.097 \times 10^7 = 8.23 \times 10^6 \text{ m}^{-1}.$$

**Step 4 — Invert to find $\lambda$:**

$$\lambda = \frac{1}{8.23 \times 10^6} = 1.215 \times 10^{-7} \text{ m} = 121.5 \text{ nm}.$$

**Why other options are wrong:**

- Option A ($91.2$ nm): is the Lyman series limit ($n = \infty \to 1$), the shortest wavelength.
- Option B ($656$ nm): is the first Balmer line ($n = 3 \to 2$).
- Option D ($102.6$ nm): is the second Lyman line ($n = 3 \to 1$).

**Final Answer:** Wavelength $\approx 121.5$ nm $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q23

## Q24.

### Solution

**Concept — Decay over whole half-lives:** After $n$ half-lives the activity falls to $\left(\frac{1}{2}\right)^n$ of its initial value.

**Step 1 — Set up the equation:**

$$\left(\frac{1}{2}\right)^n = \frac{1}{16}.$$

**Step 2 — Express one-sixteenth as a power of one-half:**

$$\frac{1}{16} = \frac{1}{2^4} = \left(\frac{1}{2}\right)^4.$$

**Step 3 — Compare exponents:**

$$\left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^4 \Rightarrow n = 4.$$

**Why other options are wrong:**

- Option B (16): confuses the fraction $1/16$ with the number of half-lives.
- Option C (2): would give $1/4$, not $1/16$.
- Option D (8): would give $1/256$.

**Final Answer:** Number of half-lives $= 4 \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q24

## Q25.

**Solution**

**Concept — Transistor currents:** In a transistor, the emitter current splits into the base current and the collector current. By conservation of charge (Kirchhoff's current law), the emitter current equals the sum of the other two.

**Step 1 — Apply Kirchhoff's current law at the transistor:** The current entering the emitter must equal the total current leaving through the base and collector:

$$I_E = I_B + I_C.$$

**Step 2 — Note the relative sizes:** The base current $I_B$ is very small, so $I_C \approx I_E$, but the exact relation remains $I_E = I_B + I_C$.

**Why other options are wrong:**

- Option A ($I_B = I_E + I_C$): makes the (small) base current the largest, which is unphysical.
- Option B ($I_C = I_E + I_B$): makes the collector current exceed the emitter current, violating charge conservation.
- Option D ($I_E = I_C - I_B$): has the wrong sign on the base term.

**Final Answer:** The correct relation is $I_E = I_B + I_C \Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q25

## Answer Key

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