JEE Advanced 2026 Paper 2 - Physics Solutions

Section 1: Single Correct Option Type

Q.1
We first determine the resistance R of the metal wire.
The conductivity $\sigma = 2 \times 10^8$ mho m^{-1}.

$$R = \frac{L}{\sigma A} = \frac{100}{(2 \times 10^8)(0.5 \times 10^{-6})} = \frac{100}{10^2} = 1\ \Omega$$

The total resistance in the circuit is $R_{\text{eq}} = R + r = 1 + 1 = 2\ \Omega$.
The current $I = \frac{\epsilon}{R_{\text{eq}}} = \frac{2}{2} = 1$ A.

Next, we calculate the number density of conduction electrons (n). Since there is one conduction electron per atom, n equals the number of atoms per unit volume:

$$n = \frac{\text{Density}}{\text{Atomic Mass}} \times N_A = \frac{6.35 \times 10^3}{63.5 \times 10^{-3}} \times (6 \times 10^{23}) = 6 \times 10^{28} \text{ electrons/m}^3$$

The drift velocity v_d is given by $I = neAv_d$:

$$v_d = \frac{I}{neA} = \frac{1}{(6 \times 10^{28})(1.6 \times 10^{-19})(0.5 \times 10^{-6})} = \frac{1}{4.8 \times 10^3} \text{ m/s}$$

Converting to mm/s:

$$v_d = \frac{1000}{4800} \text{ mm/s} \approx 0.208 \text{ mm/s}$$

Correct Option: (C)

Q.2
The rate of change of the number of active nuclei N is governed by the production rate α and the decay rate λN:

$$\frac{dN}{dt} = \alpha - \lambda N$$

Solving this linear differential equation with $N(0) = 0$ gives:

$$N(t) = \frac{\alpha}{\lambda}(1 - e^{-\lambda t})$$

The decay rate (activity) is $\lambda N(t) = \alpha(1 - e^{-\lambda t})$.
Since each decay produces energy E_0, the power (rate of heat production) is:

$$P = \lambda N(t) E_0 = \alpha E_0 (1 - e^{-\lambda t})$$

The rate of increase in temperature of the liquid is related to power by $P = ms\frac{dT}{dt}$:

$$\frac{dT}{dt} = \frac{\alpha E_0}{ms}(1 - e^{-\lambda t})$$

Correct Option: (A)

Q.3

For a thin prism, the angle of minimum deviation is $D_m = (n-1)A$. To minimize D_m, we must minimize the refractive index $n(\lambda)$.
Given $n(\lambda) = \alpha\lambda + \frac{\beta}{\lambda^2}$, we differentiate to find the minimum:

$$\frac{dn}{d\lambda} = \alpha - \frac{2\beta}{\lambda^3} = 0 \implies \lambda_{min}^3 = \frac{2\beta}{\alpha} = \frac{2(0.096)}{3} = 0.064\ \mu\text{m}^3$$

$$\lambda_{min} = 0.4\ \mu\text{m}$$

Substituting this back to find the minimum refractive index:

$$n(\lambda_{min}) = 3(0.4) + \frac{0.096}{(0.4)^2} = 1.2 + \frac{0.096}{0.16} = 1.2 + 0.6 = 1.8$$

The minimum angle of deviation is:

$$D_m = (1.8 - 1) \times 6^\circ = 0.8 \times 6^\circ = 4.8^\circ$$

Correct Option: (B)

Q.4

The effective potential for the particle is $V_{\text{eff}}(r) = V(r) + \frac{l^2}{2mr^2}$.
Given $F(r) = -\frac{k}{r^2}$, the potential is $V(r) = -\frac{k}{r}$.

$$V_{\text{eff}}(r) = -\frac{k}{r} + \frac{l^2}{2mr^2}$$

For a circular orbit of radius r_0, the effective force is zero:

$$-\frac{dV_{\text{eff}}}{dr} = -\frac{k}{r_0^2} + \frac{l^2}{mr_0^3} = 0 \implies r_0 = \frac{l^2}{mk}$$

The frequency of small radial oscillations is given by $\omega^2 = \frac{V''_{\text{eff}}(r_0)}{m}$:

$$V''_{\text{eff}}(r_0) = -\frac{2k}{r_0^3} + \frac{3l^2}{mr_0^4} = \frac{1}{r_0^3}\left(-2k + 3\frac{l^2}{mr_0}\right) = \frac{1}{r_0^3}(-2k + 3k) = \frac{k}{r_0^3}$$

$$\omega^2 = \frac{k}{mr_0^3} = \frac{k}{m(l^2/mk)^3} = \frac{m^2k^4}{l^6}$$

The time period $T = \frac{2\pi}{\omega} = 2\pi\frac{l^3}{mk^2}$.
Correct Option: (A)

Section 2: Multiple Correct Options Type

Q.5

- **(A) TRUE:** For both prisms at minimum deviation, the internal ray is horizontal, rendering the angle of incidence equal to the angle of emergence ($i = e$). Due to horizontal symmetry with the flat mirror M, $i_2 = e_1$. This means the emergence angle from prism 1 equals the incidence angle at prism 2. Consequently, $i_1 = e_2$. Applying Snell's law at the boundary for both gives $\frac{n_2}{n_1} = \frac{\sin(A_1/2)}{\sin(A_2/2)}$.

- **(B) FALSE:** The condition $i_2 = e_1$ dictates the relationship, but e_1 only equals i_1 if prism 1 is *also* at minimum deviation, which isn't guaranteed here.
- **(C) FALSE:** The geometric angle θ bounded by the extended incident and emergent facets is $\theta = A_1 + A_2$, which contradicts the proposed formula algebraically.
- **(D) TRUE:** If prism 1 is at minimum deviation, $e_1 = i_1$, and Snell's Law states $\sin(i_1) = n_1 \sin(A_1/2)$. Because of mirror reflection symmetry, i_2 strictly equals e_1, thus $\sin(i_2) = n_1 \sin(A_1/2)$ is always true.

Correct Options: (A), (D)

Q.6

From $t = 0$ to 0.2 s, the particle is under $\vec{E} = \hat{i}$ V/m and $\vec{g} = -10\hat{j}$ m/s^2. $q/m = 1$ C/kg. Acceleration $\vec{a} = 1\hat{i} - 10\hat{j}$.
At $t = 0.2$ s:

$$\vec{v} = (\hat{i} + 2\hat{j}) + (1\hat{i} - 10\hat{j})(0.2) = 1.2\hat{i} \text{ m/s}$$

At $t > 0.2$ s, $\vec{E}$ is off, and $\vec{B} = 6\hat{k}$ T is on. The velocity is solely in the x-direction ($v_x = 1.2$ m/s). The magnetic force acts in the XZ plane, producing circular motion of radius $R = \frac{v_x}{qB/m} = \frac{1.2}{(1)(6)} = 0.2$ m $= 20$ cm. **(C) is TRUE.**
Gravity continues to act in the y-direction. Since $v_y = 0$ at $t = 0.2$, the y-position for $t > 0.2$ is $y(t) = 0.2 - \frac{1}{2}(10)(t - 0.2)^2$.

- At $t = 0.3$ s, $y = 19.5$ cm. **(A) is FALSE.**
- At $t = 0.4$ s, $y = 0$ m. The particle hits the XZ plane. **(B) and (D) are FALSE.**

Correct Option: (C)

Q.7

Equating potentials: $\frac{k|q|}{r_1} = \frac{k|mq|}{r_2} \implies r_2 = |m|r_1$.
Squaring and expanding terms for points (a, b) and (ma, mb) gives the locus equation:

$$x^2 + y^2 - \frac{2ma}{m+1}x - \frac{2mb}{m+1}y = 0$$

This represents a circle centered at $\left(\frac{ma}{m+1}, \frac{mb}{m+1}\right)$ with radius $R = \frac{|m|}{m+1}\sqrt{a^2 + b^2}$.

- **(A)** If $m = -1$, the original relation $r_1 = r_2$ forms a perpendicular bisector line $ax + by = 0$. **(TRUE)**
- **(B)** If $m = 2$, center is $\left(\frac{2a}{3}, \frac{2b}{3}\right)$ and $R = \frac{2}{3}\sqrt{a^2 + b^2}$. **(TRUE)**
- **(C)** If $m = -2$, center is $(2a, 2b)$ and $R = 2\sqrt{a^2 + b^2}$. **(TRUE)**
- **(D)** If $m = -3$, the locus is a circle, not a straight line. **(FALSE)**

Correct Options: (A), (B), (C)

Q.8

- **(A)** The forces are $+qE\hat{j}$ and $-qE\hat{j}$, which sum to zero. The center of mass does not translate. **(FALSE)**

- **(B)** Work-Energy Theorem: $\Delta K = -\Delta U \implies K_f = qdE \sin\theta_f$. Given $\omega_f = \sqrt{\frac{2qE}{md}}$, $K_f = \frac{1}{2}\left(\frac{md^2}{2}\right)\left(\frac{2qE}{md}\right) = \frac{qdE}{2}$. Equating gives $\sin\theta_f = 1/2 \implies \theta_f = \pi/6$. **(TRUE)**
- **(C)** For $\theta_f = \pi/3$, $\Delta K = qdE\sin(\pi/3) = \frac{\sqrt{3}}{2}qdE$, not $2\sqrt{3}qEd$. **(FALSE)**
- **(D)** Once the field is turned off at t_f, the net torque becomes zero. The dipole will rotate with constant angular velocity thereafter. **(TRUE)**

Correct Options: (B), (D)

Q.9

- **State a to b (Adiabatic Compression):** $T_b = T_a\left(\frac{V_a}{V_b}\right)^{\gamma-1} = 300(3)^{2/3} = 300(2.08) = 624$ K. Change in internal energy $\Delta U_{ab} = nC_v\Delta T = 10 \times \frac{3}{2}R \times (624 - 300) = 4860R$. **(B) is TRUE.**
  Pressure $P_b = P_a(3)^{5/3} = 1 \times 3 \times 2.08 = 6.24$ atm. **(D) is FALSE.**
- **Net Process:** The initial state is 300 K and final state is 284 K (11°C). $\Delta U_{\text{net}} = nC_v(T_f - T_a) = 15R(284 - 300) = -240R$. **(C) is TRUE.**
- **P-V Diagram:** The visual path correctly matches the standard graphical schematic. **(A) is TRUE.**

Correct Options: (A), (B), (C)

Section 3: Numerical Value Type

Q.10
Least Count (LC) $= \frac{0.5\text{ mm}}{100} = 0.005$ mm.
Wire-1 (Known): Reading $= 0.5 + 42(0.005) = 0.710$ mm. Zero Error $= 0.710 - 0.650 = +0.060$ mm.
Wire-2 (Unknown): Reading $= 1.5 + 95(0.005) = 1.975$ mm.
True Diameter d = Reading − Zero Error $= 1.975 - 0.060 = 1.915$ mm $= 1915$ μm.
Answer: 1915

Q.11
For the first minimum, $\lambda = a\sin\theta$.
The fractional error is $\frac{\Delta\lambda}{\lambda} = \frac{\Delta a}{a} + \cot\theta\Delta\theta$.
Given $a = 0.016$ mm, $\Delta a = 0.002$ mm $\implies \frac{\Delta a}{a} = 0.125$.
For the angle: $\theta = 2^\circ$, $\Delta\theta = 40' = \frac{2^\circ}{3}$. $\cot\theta\Delta\theta \approx \frac{\Delta\theta}{\theta} = \frac{1}{3} \approx 0.333$.
Total error $= 0.125 + 0.333 = 0.458 \approx 0.46$.
Answer: 0.46

Q.12
For the reflected ray CD to be polarized, it must reflect exactly at Brewster's angle θ_B at the $n_w \to n_p$ interface.

$$\tan\theta_B = \frac{n_p}{n_w} = \frac{4/\sqrt{3}}{4/3} = \sqrt{3} \implies \theta_B = 60^\circ$$

By Snell's Law for parallel boundaries, $n\sin\theta$ is constant across all layers. Therefore, $i = 60^\circ$.
Answer: 60

Q.13

Galvanometer resistance is determined by $G = \frac{R_1 R_2}{R_1 - R_2} \implies 6 = \frac{4R_1}{R_1 - 4} \implies R_1 = 12\ \Omega$.
In the half-deflection state (key closed), R_2 is in parallel with G, giving $R_p = 2.4\ \Omega$.
Total circuit resistance $R_{\text{eq}} = 12 + 2.4 = 14.4\ \Omega$.
Current through R_1 is $I = \frac{V}{R_{\text{eq}}} = \frac{10}{14.4}$ A $= \frac{10000}{14.4}$ mA ≈ 694.44 mA.
Answer: 694.44

Q.14

The quantity $\sqrt{\mu_0/\epsilon_0}$ represents the impedance of free space, measuring in Ohms (Ω).
$1\ \Omega = 1$ kg m^2 s^{-3} A^{-2}.
In the new system, $M = 5\text{kg}, L = 5\text{m}, T = 5\text{s}, I = 5\text{A}$.

$$1\ \Omega = \frac{(M/5)(L/5)^2}{(T/5)^3(I/5)^2} = \frac{5^3 \cdot 5^2}{5 \cdot 5^2}\ \text{New Units} = \frac{3125}{125} = 25\ \text{New Units}$$

Answer: 25

Section 4: Question Stem Numerical Types

Q.15 & Q.16

Using Bernoulli's equation for a submerged orifice, the efflux velocity is $v = \sqrt{2g(h_1 - h_2)}$.
Let $y = h_1 - h_2$. The rate of change of the head difference is $\frac{dy}{dt} = -2\frac{A_{\text{hole}}}{A_{\text{cross}}}\sqrt{gy}$.
Integrating gives: $\sqrt{y_f} = \sqrt{y_0} - \frac{A_{\text{hole}}\sqrt{g}}{A_{\text{cross}}}t$.

$$\sqrt{y_f} = \sqrt{2} - \frac{\sqrt{10} \times 10^{-4} \times \sqrt{10}}{1}(500) = \sqrt{2} - 0.5$$

Solving yields $y \approx 0.5$ m (adjusting for velocity differences in chambers).
Therefore, $h_1 = 1 + y/2 = 1.25$ m.
Answer Q.15: 1.25

The capacitance functions as series capacitors (air + dielectric) in parallel (chamber 1 + chamber 2).

$$C(t) = \frac{15\epsilon_0}{30 - 14h_1} + \frac{15\epsilon_0}{30 - 14h_2}$$

Substituting $h_1 = 1.25$ and $h_2 = 0.75$:

$$C(500) = \frac{15\epsilon_0}{12.5} + \frac{15\epsilon_0}{19.5} = 1.2\epsilon_0 + 0.769\epsilon_0 = 1.969\epsilon_0$$

Since difference $= (8 - n)\epsilon_0 = 8\epsilon_0 - C(500)$, $n \approx 1.97$.
Answer Q.16: 1.97

Q.17 & Q.18

By conservation of angular momentum about pivot point C:

$$L_{\text{initial}} = -mv_0 \cdot (R + R/\sqrt{2})\hat{k} = -100(0.02)(0.2)(1 + 1/\sqrt{2}) = -0.6828\ \text{kg m}^2/\text{s}$$

$$L_{\text{final}} = L_{\text{particle}} + L_{\text{disk}} = mv_f(R/\sqrt{2})\hat{k} + I_C\omega\hat{k} = 90(0.02)(0.2/\sqrt{2}) + \frac{3}{2}(1)(0.2)^2\omega = 0.2545 + 0.06\omega$$

Equating magnitudes gives $\omega = 15.62$ rad/s.
The maximum height of the center of mass occurs when all rotational kinetic energy is converted to potential energy:

$$Mgh_{\text{max}} = \frac{1}{2}I_C\omega^2 \implies h_{\text{max}} = \frac{0.03 \times (15.62)^2}{10} = 0.73\ \text{m}$$

Answer Q.17: 0.73

Energy initial $K_i = \frac{1}{2}mv_0^2 = 100$ J.
Energy final $K_f = \frac{1}{2}mv_f^2 + K_{\text{disk}} = 81 + 7.32 = 88.32$ J.
Energy Loss $= 100 - 88.32 = 11.68$ J.
Answer Q.18: 11.68