JEE(ADVANCED)–2026 (EXAMINATION)

(Held On Sunday 17th MAY, 2026)

PHYSICS | **TEST PAPER WITH ANSWER AND SOLUTION**

SECTION-1 : (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +3 If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : −1 In all other cases.

1. A metal wire of cross-sectional area 0.5 mm^2 and length 100 m is connected across a battery of e.m.f. 2 V and internal resistance 1 Ω. The density, atomic mass and electrical conductivity of the metal are 6.35×10^3 kg m^{-3}, 63.5 gm/mole and 2×10^8 mho m^{-1}, respectively. Assuming one conduction electron per atom of the metal, the drift velocity (in mm s^{-1}) of the electrons in the wire is:

[Take Avogadro's number as 6×10^{23} and charge of the electron as 1.6×10^{-19} C.]

(A) 0.052 (B) 0.104

(C) 0.208 (D) 0.156

Ans. **(C)**

Sol. $A = 0.5\ mm^2 = 0.5 \times 10^{-6}\ m^2$

$L = 100$ m

$E = 2V,\ r = 1\Omega,\ \sigma = 2 \times 10^8$ mho/m

Density $= 6.35 \times 10^8\ kg/m^3$

Atomic mass = 63.5 g/mol = 0.0635 kg/mol

$$R = \frac{\rho L}{A} = \frac{1}{\sigma}\frac{L}{A} = \frac{100}{2\times10^8\times0.5\times10^{-6}} = 1\Omega$$

$R_{total} = R + r = 1 + 1 = 2\Omega$

$$I = \frac{E}{R_{total}} = \frac{2}{2} = 1A$$

Electron number density $(\eta) = \frac{\rho N_A}{M} = 6\times10^{28}\ m^{-3}$

$$I = neAv_d\ ;\ v_d = \frac{i}{neA} = \frac{1}{6\times10^{28}\times1.6\times10^{-19}\times0.5\times10^{-6}}$$

$= 2.08 \times 10^{-4}$ m/s = 0.208 mm/sec

2. A nuclear reactor starts producing a radioactive nuclide X from $t = 0$, at a constant rate of α per second. Each decay of X produces energy E_0, which is utilized to heat a liquid of mass m and specific heat s. Assuming no heat loss from the liquid and taking λ as the decay constant of X, the rate of increase in the temperature of the liquid is:

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

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

(C) $\frac{\lambda E_0}{ms}(1-e^{-\lambda t})$

(D) $\frac{E_0}{ms}(\alpha-\lambda e^{-\lambda t})$

Ans. (A)

Sol. $\boxed{\text{Nuclear reactor}} \xrightarrow{\alpha} \underset{N}{X} \xrightarrow{\lambda} Y$

$1X \longrightarrow$ Produces E_0 energy

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

$$\int_0^N \frac{dN}{\alpha - \lambda N} = \int_0^t dt \text{ on solving}$$

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

$$N_y = \alpha t - \frac{\alpha}{\lambda}\left(1-e^{-\lambda t}\right)$$

$$E_0 N_y = msdT$$

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

3. A beam of polychromatic light passes through a thin prism of prism angle 6°. The refractive index of the material of the prism varies with wavelength (λ) as $n(\lambda)=\alpha\lambda + \frac{\beta}{\lambda^2}$, where $\alpha = 3\ \mu m^{-1}$ and $\beta = 0.096\ \mu m^2$. If λ_{min} is the wavelength at which the angle of minimum deviation D_m is smallest, then the correct value of D_m at λ_{min} is

(A) 6.4°

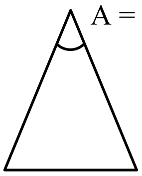
(B) 4.8°

(C) 3.2°

(D) 2.4°

Ans. (B)

Sol.



$n(\lambda) = \alpha\lambda + \frac{\beta}{\lambda^2}$

$\delta = A(\mu - 1)$

$= A\left(\alpha\lambda + \frac{\beta}{\lambda^2} - 1\right)$

For δ min

$\frac{d\delta}{d\lambda} = 0$

$\frac{d\delta}{d\lambda} = \alpha - \frac{2\beta}{\lambda^3} = 0 \Rightarrow \lambda^3 = \frac{2\beta}{\alpha} \Rightarrow \alpha = \frac{2\beta}{\lambda^3}$

$\frac{d^2\delta}{d\lambda^2} = \frac{6\beta}{\lambda^4} > 0 \qquad \lambda^3 = \frac{2\times 0.096}{3} = 0.064 \Rightarrow \lambda = 0.4\mu m$

$n = \alpha\lambda + \frac{\beta}{\lambda^2}$

$= \frac{2\beta}{\lambda^3}\lambda + \frac{\beta}{\lambda^2} = \frac{3\beta}{\lambda^2} = \frac{3\times 0.096}{0.16} = 1.8$

$\delta_{min} = 6(1.8 - 1) = 0.8 \times 6° = 4.8°$

4. A particle of mass m, and angular momentum ℓ is moving in a circular orbit of radius r_0 under the influence of an attractive force $\vec{F}(r) = -\frac{k}{r^2}\hat{r}$. Keeping its angular momentum unchanged, the particle is displaced radially by a small distance $\delta r \ll r_0$, due to which its radial distance varies periodically. The corresponding time period is:

(A) $\frac{2\pi\ell^3}{mk^2}$

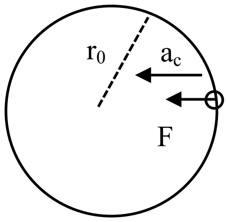
(B) $2\pi\sqrt{\frac{m}{k}}$

(C) $\frac{2\pi\ell^3}{3mk^2}$

(D) $\frac{2\pi\ell^3}{5mk^2}$

Ans. **(A)**

Sol.



$F_{field} = F_{centrifugal}$ (in rotating frame)

$$\Rightarrow \frac{k}{r_0^2} = \frac{mv_0^2}{r_0} \quad \ldots\ldots\ldots\ldots\ldots\text{(i)}$$

and $\ell = mv_0r_0$........ (ii)

$$\Rightarrow v_0 = \frac{\ell}{mr_0}$$

$$\therefore \frac{k}{r_0^2} = \frac{m}{r_0}\left(\frac{\ell}{mr_0}\right)^2 \Rightarrow r_0 = \frac{\ell^2}{mk}$$

Now if radius become $r = r_0 + dr$

velocity become v

then $mvr = mv_0r_0$

$$\Rightarrow v = \frac{v_0r_0}{r}$$

$$\Rightarrow v = \frac{v_0r_0}{r_0+dr} \simeq v_0\left(1-\frac{dr}{r_0}\right)$$

$\therefore$ restoring force

$F_R = -[F_{field} - F_{cent.}]$

$$= -\left[\frac{k}{(r_0+dr)^2} - \frac{mv^2}{(r_0+dr)}\right]$$

$$= -\left[\frac{k}{r_0^2}\left(1-2\frac{dr}{r_0}\right) - \frac{mv_0^2}{r_0}\frac{\left[1-\frac{dr}{r_0}\right]^2}{\left[1+\frac{dr}{r_0}\right]}\right]$$

$$= -\left[\frac{k}{r_0^2}\left(1-2\frac{dr}{r_0}\right) - \frac{mv_0^2}{r_0}\left(1-\frac{3dr}{r_0}\right)\right]$$

$$= -\left[\frac{k}{r_0^2} - 2\frac{k}{r_0^2}\frac{dr}{r_0} - \frac{mv_0^2}{r_0} + \frac{3mv_0^2}{r_0}\frac{dr}{r_0}\right]$$

$$= -\left[\frac{-2k}{r_0^3}dr + \frac{3mv_0^2}{r_0^2}dr\right]$$

$$= -\left[\frac{-2k}{r_0^3}dr + \frac{3}{r_0}\left[\frac{k}{r_0^2}\right]dr\right]$$

$$F_{rest} = -\frac{k}{r_0^3}dr$$

$$\because \ F_r = -\frac{k}{r_0^3}dr$$

$$\Rightarrow \ a = -\frac{k}{mr_0^3}dr$$

$$\therefore \ \omega = \sqrt{\frac{k}{mr_0^3}}$$

$$\therefore \ T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{mr_0^3}{k}} = 2\pi\sqrt{\frac{m}{k}\left(\frac{\ell^6}{m^3k^3}\right)}$$

$$\Rightarrow \ T = \frac{2\pi}{m}\frac{\ell^3}{k^2} \text{ option A}$$

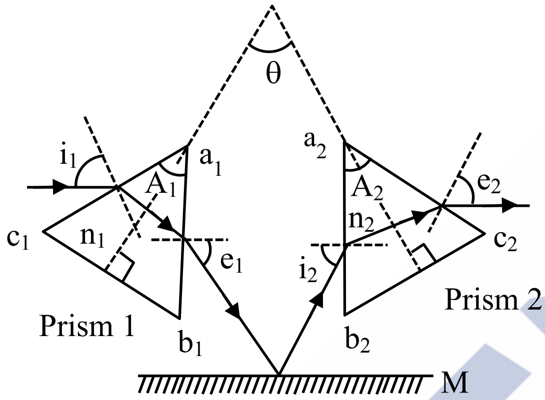
SECTION-2 : (Maximum Marks : 20)

- This section contains **FIVE (05)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +4	**ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks	: +3	If all the four options are correct but **ONLY** three options are chosen;
Partial Marks	: +2	If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks	: +1	If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
choosing ONLY (A), (B) and (D) will get +4 marks;
choosing ONLY (A) and (B) will get +2 marks;
choosing ONLY (A) and (D) will get +2 marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 marks;
choosing ONLY (B) will get +1 marks;
choosing ONLY (D) will get +1 marks;
choosing no option (i.e. the question is unanswered) will get 0 marks ; and
choosing any other combination of option(s) will get –1 marks.

5. Consider two isosceles prisms 1 and 2 with prism angles A_1 and A_2 and refractive indices n_1 and n_2, respectively, as shown in the figure. The faces a_1b_1 and a_2b_2 are parallel to each other and perpendicular to the mirror M. If a ray of light is incident on the face a_1c_1 and emerges from the face a_2c_2, then the correct statement(s) is/are:



(A) If both the prisms are at minimum deviation condition, then $\frac{n_2}{n_1} = \sin\left(\frac{A_1}{2}\right) / \sin\left(\frac{A_2}{2}\right)$

(B) If prism 2 is at minimum deviation condition, then $\sin i_1 = n_2 \sin\left(\frac{A_2}{2}\right)$ is always true.

(C) If both the prisms 1 and 2 are thin and are at minimum deviation condition with angles of deviation δ_{m_1} and δ_{m_2}, respectively, then $\theta = \frac{\delta_{m1}}{2(n_1-1)} + \frac{\delta_{m2}}{2(n_2-1)}$.

(D) If prism 1 is at minimum deviation condition, then $\sin i_2 = n_1 \sin\left(\frac{A_1}{2}\right)$ is always true.

Ans. **(A,C,D)**

Sol. $i_1 = e_1$

$i_2 = e_2$

By symmetry $e_1 = i_2$

$\therefore\ i_1 = e_1 = i_2 = e_2$

$1 \sin i_1 = n_1 \sin\frac{A_1}{2}$ and $1 \sin i_2 = n_2 \sin\frac{A_2}{2}$ $\Big\}$ $\frac{n_2}{n_1} = \frac{\sin\frac{A_1}{2}}{\sin\frac{A_2}{2}}$

Option (A) correct

Option (B)

$i_2 = e_1$ By symmetry

$\left.\begin{array}{l}\text{and } i_2 = e_2 \\ \text{But } i_1 \neq e_1\end{array}\right\} \therefore i_1 \neq i_2$

$\sin i_2 = n_2 \sin\left(\frac{A_2}{2}\right)$

But $\sin i_1 \neq n_2 \sin\frac{A_2}{2}$

Option (B) incorrect

Option (D)

$\left.\begin{array}{l} i_1 = e_1 \\ e_1 = i_2\end{array}\right\} \text{min. deviation } i_1 = i_2$

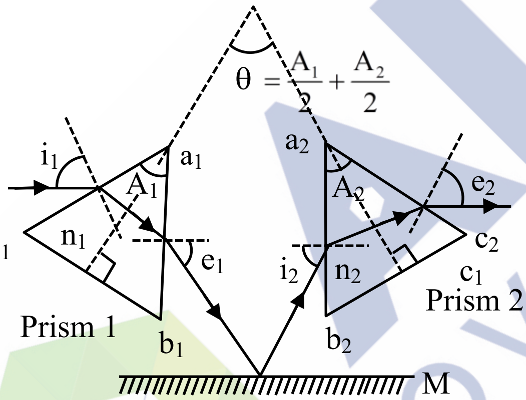
But $i_2 \neq e_2$

$\because$ Min. deviation for 1

$\sin i_1 = n_1 \sin\frac{A_1}{2}$

$\Rightarrow \sin i_2 = n_1 \sin\frac{A_1}{2}$

Option (D) correct



Option (C)

$(\delta_m)_1 = (n_1 - 1)A_1$

$(\delta_m)_2 = (n_2 - 1)A_2$

$i_1 = e_1 = i_2 = e_2$

$\therefore \theta = \frac{A_1}{2} + \frac{A_2}{2}$

$= \frac{1}{2}\left(\frac{(\delta_m)_1}{n_1 - 1} + \frac{(\delta_m)_2}{n_2 - 1}\right)$

Option (C) correct

6. In a vacuum chamber, a particle of charge 1 μC and mass 1 mg is projected with a velocity $(\hat{i}+2\hat{j})$ ms^{-1} from the XZ plane at time $t = 0$ in an electric field of $1\hat{\imath}$ Vm^{-1}. At $t = 0.2$ s, the electric field is switched off and a magnetic field of $6\hat{j}$ T is switched on. The acceleration due to gravity is $-10\hat{j}$ ms^{-2}. Correct option(s) is/are:

(A) The vertical distance of the particle from the XZ plane at $t = 0.3$ s is 15 cm.

(B) The vertical distance of the particle from the XZ plane at $t = 0.4$ s is 10 cm.

(C) The radius of the trajectory of the particle for $t > 0.2$ s is 20 cm.

(D) The particle will be in the XZ plane at $t = 0.35$ s.

Ans. **(A,C or A)**

Sol. Given m = 1mg = 1×10^{-6} kg

$q = 1 \times 10^{-6}$ C

$v_0 = (\hat{i}+2\hat{j})\,m/s$

Initial position : XZ plane i.e. $y_0 = 0$

(1) t = 0 to t = 0.2 sec

$\vec{a}_1 = \frac{q\vec{E}}{m} + \vec{g} = \hat{i} - 10\hat{j}\ \ m/s^2$

$\therefore \vec{v} = \vec{u} + \vec{a}t$

$\Rightarrow \vec{v}_{(0.2)} = (\hat{i}+2\hat{j}) + (\hat{i}-10\hat{j})(0.2)$

$\Rightarrow \vec{v}_{(0.2)} = 1.2\hat{i}$

and y position

$s_y = u_y t + \frac{1}{2}a_y t^2$

$= 2(0.2) + \frac{1}{2}(-10)(0.2)^2$

$\Rightarrow y - 0 = 0.4 - 0.2 = 0.2$ m

$\Rightarrow$ y = 20 cm

(2) After t > 0.2 sec

$\vec{B} = (6\hat{j})T$ and $\vec{g} = -10\hat{j}$

New initial velocity $v_1 = 1.2\hat{i}$

$\vec{F}_B = q(\vec{v} \times \vec{B})$ -

Acceleration due to magnetic force

$\vec{a}_B = \frac{\vec{F}_B}{m} = \frac{q}{m}\left[1.2\hat{i} \times 6\hat{j}\right]$

$\Rightarrow \vec{a} = 7.2\hat{k}\ m/s^2$

Due to magnetic force it will perform circular motion in X-Z plane and doesn't affect y component of Velocity

Let $\tau = t - 0.2$

$\therefore s_y = ut + \frac{1}{2}at^2$

$\Rightarrow s_y = 0 + \frac{1}{2}(-10)\tau^2$

$\Rightarrow y - 0.2 = -5\tau^2$

$\Rightarrow y = 0.2 - 5\tau^2$

Now

(A) $y = 0.2 - 5(0.3 - 0.2)^2$

$= 0.2 - 5(0.1)^2$

$= 0.15 = 15$ cm correct

(B) $y = 0.2 - 5(0.4 - 0.2)^2$

$= 0.2 - 5(0.2)^2$

$= 0.2 - 5 \times 0.04 = 0$

B incorrect

(C) $R = \frac{mv_\perp}{qB} = \frac{1\times10^{-6}}{1\times10^{-6}} \times \frac{1.2}{6} = 0.2\ m = 20$ cm

(C) Correct if in question radius of the trajectory of the particle is considered as radius of the helix but if it is radius of curvature then it will be different from 20 cm in that case option (C) will be incorrect.

(D) $y = 0.2 - 5\tau^2 = 0$

$\Rightarrow 0.2 - 5(t - 0.2)^2 = 0$

$\Rightarrow t = 0.4$ sec

(D) incorrect

7. Two charges $Q_1 = q$ and $Q_2 = mq$ are placed at the points $P_1(a, b)$ and $P_2\ (ma, mb)$, respectively, in the XY plane, where $a,\ b \neq 0$ and $m \neq 0,\ 1$. If V_1 is the potential at a point in the XY plane due to charge Q_1 and V_2 is the potential at that point due to charge Q_2. Correct statement(s) for the points at which $|V_1| = |V_2|$ is/are:

(A) For $m = -1$, locus of these points is $ax + by = 0$.

(B) For $m = 2$, the locus of these points is a circle of radius $\frac{2}{3}\sqrt{a^2+b^2}$ centered at $\left(\frac{2}{3}a, \frac{2}{3}b\right)$

(C) For $m = -2$, the locus of these points is a circle of radius $2\sqrt{a^2+b^2}$ centered at (2a, 2b)

(D) For $m = -3$, locus of these points is $3bx + 3ay = 0$.

Ans. (A,B,C)

Sol. For the point P(x,y) the potentials are :

$$V_1 = \frac{Kq_1}{r_1},\ V_2 = \frac{Kmq}{r_2}$$

The condition $|v_1| = |v_2|$ gives

$$\frac{1}{r_1} = \frac{|m|}{r_2} \Rightarrow r_2^2 = m^2 r_1^2$$

Expanding with

$$r_1^2 = (x-a)^2 + (y-b)^2$$

and $r_2^2 = (x-ma)^2 + (y-mb)^2$

After expanding and simplifying

$(m + 1)(x^2 + y^2) = 2m (ax + by)$

Let's check each option

Option A : $m = -1$

$$ax + by = 0$$

A is correct.

Option B : $m = 2$

$3(x^2 + y^2) = 4(ax + by)$

This is circle

Centre : $\left(\frac{2a}{3}, \frac{2b}{3}\right)$

Radius : $\frac{2}{3}\sqrt{a^2 + b^2}$

B is correct

Option C : $m = -2$

$x^2 + y^2 = 4(ax + by)$

This is a circle

centre : (2a , 2b)

Radius : $2\sqrt{a^2 + b^2}$

C is correct

Option D : $m = -3$

$x^2 + y^2 = 3(ax + by)$

This is a circle

D is not correct

8. Consider an electric dipole comprising two charges $+q$ and $-q$ each with mass m, separated by a fixed distance d and initially at rest with its dipole moment pointing along $\hat{\imath}$. A uniform electric field $E\,\hat{j}$ is turned on at time $t = 0$ and it is turned off at $t = t_f$, when the dipole moment makes an angle θ_f with $\hat{i}$ Neglecting any sources of energy loss, correct option(s) is/are:

(A) The center of mass of the dipole is deflected towards $\hat{j}$ in the presence of the field.

(B) If the magnitude of the final angular velocity $\omega_f = \sqrt{\dfrac{2qE}{md}}$ then $\theta_f = \dfrac{\pi}{6}$

(C) If $\theta_f = \pi/4$, then the change in kinetic energy of the dipole is given by $2\sqrt{3}\ qEd$.

(D) For $\theta_f = \pi/4$, the dipole rotates around its center of mass with a constant angular velocity after $t > t_f$.

Ans. **(B,D)**

Sol. **Option A:** Net force on centre of mas is

$F_{net} = qE - qE = 0$

A is not correct

torque : $\vec{\tau} = \vec{p} \times \vec{E}$

$$= qd\left[\cos\theta\hat{i} + \sin\theta\hat{j}\right] \times E\hat{j} = qEd\cos\theta\hat{k}$$

Moment of Inertia :

$$I = 2m\left(\frac{d}{2}\right)^2 = \frac{md^2}{2}$$

$$\Delta KE = qEd\sin\theta_f$$

$$\frac{1}{2}I\omega_f^2 = qEd\sin\theta_f$$

Let's check option B :

If $\omega_f = \sqrt{\dfrac{2qE}{md}}$ then $\theta_f = \dfrac{\pi}{6}$

B is correct

Option C : If $\theta_f = \dfrac{\pi}{3}$

$\Delta KE = \dfrac{\sqrt{3}}{2} qEd$

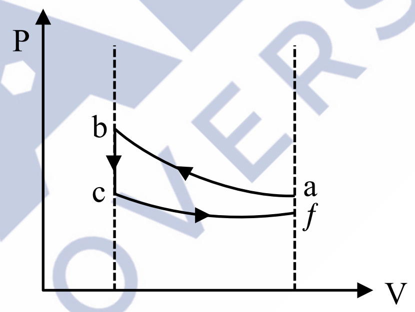
C is not correct

Option D : For $\theta_f = \dfrac{\pi}{4}$, angular velocity is constant after $t > t_f$ because net torque is zero.

D is correct.

9. Ten moles of an ideal monoatomic gas, initially in state ***a*** at atmospheric pressure and temperature T_a = 27°C, is enclosed in a metal cylinder of volume V_0 fitted with a frictionless piston. The gas is suddenly compressed to state ***b*** with volume $V_0/3$. Now, keeping the piston stationary, the cylinder is submerged in a water bath of temperature 11°C until the gas reaches the temperature of the water bath, which is denoted as state ***c***. Finally, while still in the water bath, the piston is brought slowly to its initial position, which is denoted as state ***f***. If R is universal gas constant, then the correct option(s) is/are: [Given: $9^{1/3} = 2.08$]

(A) The schematic P-V diagram of the processes described above is:



(B) The change in internal energy in going from state ***a*** to ***b*** is 4860R.

(C) The net change in the internal energy in the whole process is −240R.

(D) The pressure and temperature of the state ***b*** are 2.08 times the atmospheric pressure and 624 K, respectively.

Ans. **(A,B,C)**

Sol. Process a → b : adiabatic compression

Process b → c : Isochoric cooling

Process c → f : Isothermal expansion

Option A is correct.

Option B :

$\Delta U = nCv\Delta T = 10 \times \frac{3R}{2} \times (624 - 300) = 4860\ R$

B is correct.

Option C :

$\Delta U_{net} = nC_v(T_f - T_a) = 10 \times \frac{3R}{2} \times (284 - 300) = -240\ R$

C is correct.

Option D :

$TV^{\gamma-1} = \text{constant}$

$T_b = T_a\left(\frac{V_0}{V_0/3}\right)^{\gamma-1}$

$= 300 \times 3^{2/3} = 300 \times 9^{1/3}$

$T_b = 624\ K$

$PV^{\gamma} = \text{Constant}$

$P_b = P_0 \times 3^{5/3} = 6.24\ P_0$

D is not correct.

SECTION-3 : (Maximum Marks : 20)

- This section contains **FIVE (05)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

  Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;

  Zero Marks : 0 In all other cases.

10. Two thin wires, Wire-1 of diameter 0.650 mm and Wire-2 of unknown diameter *d* are given. To obtain the value of *d*, the diameters of the two wires are measured with a screw gauge. The screw gauge has a pitch of 0.5 mm and there are 100 divisions on the circular scale (CS). The smallest division on the linear scale (LS) is 0.5 mm. The table shows the readings of LS and CS for the measurements. The value of *d* (in μm) is:

	Readings	
	LS (mm)	CS
Wire-1	0.5	42
Wire-2	1.5	95

Ans. **(1915.00)**

Sol. Least count of screw gauge $= \frac{0.5mm}{100} = 0.005$ mm ...(1)

Measure value of wire (1) diameter = main scale reading + circular scale reading

$= 0.5mm + 42 \times 0.005 = 0.71$ mm

& true value of wire (1) diameter = 0.65 mm

So, screw gauge is giving ⊕ zero error.

⊕ zero error $= (d)_{measure} - (d)_{true} = 0.71 - 0.65 = 0.060$ mm

Now, for true diameter of wire (2)

$d_{true} = d_{measure} - error$

& $(d)_{measure} = MSR + CSR = 1.5mm + 95 \times 0.005\ mm = 1.975\ mm$

$d_{true} = 1.975\ mm - 0.060\ mm = 1.915\ mm$

Now in μm = $d_{true} = 1915\ \mu$

11. In a single slit diffraction experiment, a slit of width (0.016 ± 0.002) mm is used to measure the wavelength of a monochromatic light source. In the diffraction pattern, the angular distance between the central maximum and first minimum is measured to be $(2° \pm 40')$. The value of the fractional error in the measurement of wavelength is: [Given: $\sin(2°) = 0.035$]

Ans. **(0.45 or 0.46)**

Sol. In a single slit diffraction experiment the position of first minima given by

For fractional error in λ

$\boxed{d\sin\theta = \lambda}$

$\lambda = d\sin\theta$

$\ell n\, \lambda = \ell n d + \ell n \sin\theta$

Differentiate

$$\frac{1}{\lambda}d\lambda = \frac{1}{d}d(d) + \frac{1}{\sin\theta}\cos\theta d\theta$$

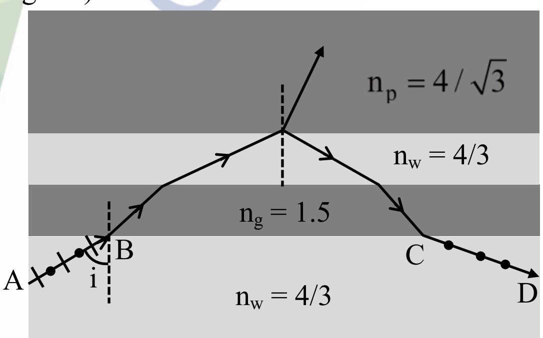
$$\frac{d\lambda}{\lambda} = \frac{\Delta d}{d} + \frac{\sqrt{1-\sin^2\theta}}{\sin\theta} \times d\theta$$

$$\frac{d\lambda}{\lambda} = \frac{0.002}{0.016} + \sqrt{\left(\frac{1-\sin^2\theta}{\sin\theta}\right)^2 - 1} \times \frac{\pi}{270} \qquad \left(40' = \frac{2}{3} \times \frac{\pi}{180} = \frac{\pi}{270}\text{radian}\right)$$

$$= 0.125 + 28.55 \times \frac{\pi}{270}$$

$$= 0.125 + 0.332 = 0.457$$

12. As shown in the figure, a ray *AB* of unpolarized light enters from water of refractive index $n_w = 4/3$ into a medium of refractive index $n_p = 4/\sqrt{3}$ after passing through a glass plate of refractive index $n_g = 1.5$ and a layer of water. At a particular incident angle *i* the reflected ray *CD* is polarized in the direction as shown in the figure. The value of *i* (in degrees) is:



Ans. **(60.00)**

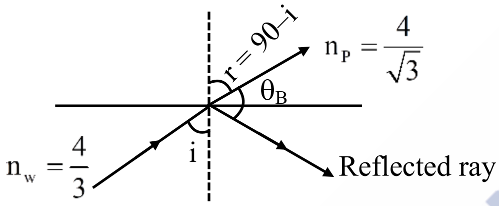
Sol. If Reflected ray is polarized then it occurs when light incident at Brewster's angle (θ_B)

By Snell's law for series of parallel interference

$n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$

apply Snell's law at initially incident medium & final medium or surface from which reflection take place

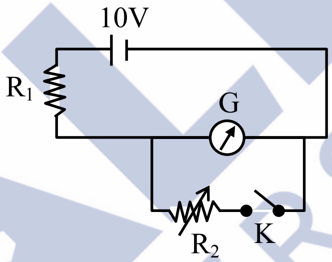
$n_i \sin_i = n_p \sin r$ & $r = 90 - i$



$$\left(\frac{4}{3}\sin i = \frac{4}{\sqrt{3}}\sin(90-i)\right) \Rightarrow \left|\tan i = \sqrt{3}\right|$$

$\boxed{i = 60°}$

13. As shown in the figure, the resistance of a galvanometer *G* can be found by the half-deflection method. Here the resistance R_2 is adjusted such that when the key *K* is closed the deflection in the galvanometer becomes half of the value as compared to when *K* is open. Half-deflection is obtained at $R_2 = 4\ \Omega$ and thus the galvanometer resistance is found to be 6 Ω. In this half-deflection condition the current (in mA) through the resistor R_1 is:



Ans. **(694.44)**

Sol. When key is open,

$$I_g = \frac{10}{R_1 + 6} \quad \ldots(1)$$

When key is closed, current through battery

$$i = \frac{10}{R_1 + \left(\frac{6 \times 4}{6+4}\right)} = \frac{10}{R_1 + 2.4} \quad \ldots(2)$$

Current through galvanometer,

$$I_g' = \frac{R_2}{G + R_2} i = \left(\frac{4}{6+4}\right) i$$

$$I_g' = \frac{4}{10} \times \left(\frac{10}{R_1 + 2.4}\right)$$

$$I_g' = \frac{4}{R_1 + 2.4}$$

$$I_g' = \frac{I_g}{2}$$

$$\frac{4}{R_1 + 2.4} = \frac{1}{2}\left(\frac{10}{R_1 + 6}\right)$$

$8(R_1 + 6) = 10(R_1 + 2.4)$

$8R_1 + 48 = 10R_1 + 24$

$2R_1 = 24$

$R_1 = 12\Omega$

Now, $i = \frac{10}{R_1 + 2.4} = \frac{10}{12 + 2.4} = \frac{10}{14.4}A$

$= 694.44$ mA

14. In a new system of units, the units of mass, length, time and current are 5 kg, 5 m, 5 s and 5 A, respectively. If μ_0 and ϵ_0 are the permeability and permittivity of free space, respectively, then in this new system of units, the magnitude of one SI unit of $\sqrt{\mu_0/\epsilon_0}$, is :

Ans. **(25.00)**

Sol. $\left[\sqrt{\frac{\mu_0}{\varepsilon_0}}\right] = [M^1L^2T^{-3}A^{-2}]$

SI new

$n_1v_1 = n_2v_2$

$1kgm^2s^{-3}A^{-2} = n_2[(5kg)(5m)^2(5s)^{-3}(5A)^{-2}]$

$$n_2 = \frac{1kgm^2s^{-3}A^{-2}}{(5kg)(5m)^2(5s)^{-3}(5A)^{-2}}$$

$$n_2 = \left(\frac{1}{5}\right)\left(\frac{1}{5}\right)^2\left(\frac{1}{5}\right)^{-3}\left(\frac{1}{5}\right)^{-2}$$

$n_2 = 5^2 = 25$

SECTION-4 : (Maximum Marks : 8)

- This section contains **TWO (02)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

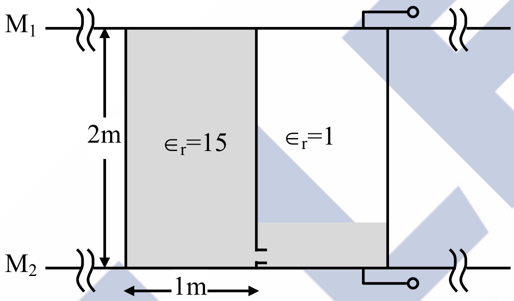
  Full Marks : +2 If **ONLY** the correct numerical value is entered in the designated place;

  Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 15 and 16

A container of height 2 m, length 2 m and breadth 1 m is made of insulating vertical walls and two large area horizontal metal plates (M_1 and M_2) which extend far beyond the vertical walls in all directions. The container is partitioned into two equal chambers with a thin insulating vertical wall. The partition wall contains a small hole of cross-sectional area $\sqrt{10}$ cm^2 near its bottom edge. Initially the hole is closed and the left chamber of the container is completely filled with a liquid of dielectric constant $\epsilon_r = 15$ and the right chamber is empty ($\epsilon_r = 1$). At time $t = 0$, the hole is opened and the liquid flows from the left chamber to the right chamber. In both the chambers, the space above the liquid has $\epsilon_r = 1$ and is maintained at atmospheric pressure. The schematic of the container at a time $t > 0$ is shown in the figure.

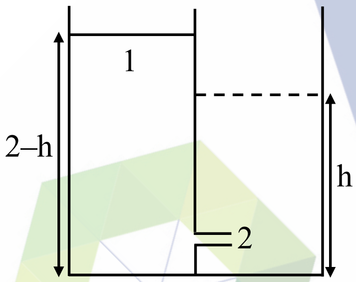
[Given: acceleration due to gravity is 10 ms^{-2}.]



15. The height (in m) of the liquid in left chamber at $t = 500$ s is :

Ans. **(1.25)**

Sol.



Bernoulli's theorem at pt 1 & 2

$$\rho_0 + \rho g(2-h) + \frac{1}{2}\rho(0)^2 = (\rho_0 + \rho gh) + \frac{1}{2}\rho v^2$$

$$\Rightarrow 2g(1-h) = \frac{1}{2}v^2$$

$$\Rightarrow 4g(1-h) = v^2$$

$$\Rightarrow v = 2\sqrt{g(1-h)}$$

Now

$$\Rightarrow av = A\frac{dh}{dt}$$

$$\frac{2a}{A}\sqrt{g}\int_0^t dt = \int_0^h \frac{dh}{\sqrt{1-h}}$$

let $(1-h) = y$

$- \quad dh = dy$

$$\frac{2a}{A}\sqrt{g}t = -\int_1^{1-h}\frac{dy}{\sqrt{y}} = -\left[2\sqrt{y}\right]_1^{1-h}$$

$$\frac{a}{A}\sqrt{g}t = -\left(\sqrt{1-h}-1\right)$$

$$1-h = \left[1-\frac{a}{A}\sqrt{g}t\right]^2$$

$1-h = [1 - 10 \times 500 \times 10^{-4}]^2$

$1-h = 0.25$

$h = 0.75$ m

so height in left chamber

$= 2 - 0.75 = 1.25$ m

16. The difference in the capacitance (in F) between the metal plates at $t = 0$ and that at $t = 500$ s is $(8 - n)\,\epsilon_0$, where ϵ_0 is the permittivity of free space. The value of n is :

Ans. **(1.97)**

Sol. $C_i = C_0 + \frac{\varepsilon_r\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d}$

$$= C_0 + 15\frac{\varepsilon_0 1}{2} + \varepsilon_0\frac{1}{2} = \varepsilon_0 8 + C_0$$

$$C_f = C_0 + \frac{\varepsilon_0}{\frac{0.75}{1}+\frac{1.25}{15}} + \frac{\varepsilon_0}{\frac{0.75}{15}+\frac{1.25}{1}}$$

$$= C_0 + \frac{128\varepsilon_0}{65}$$

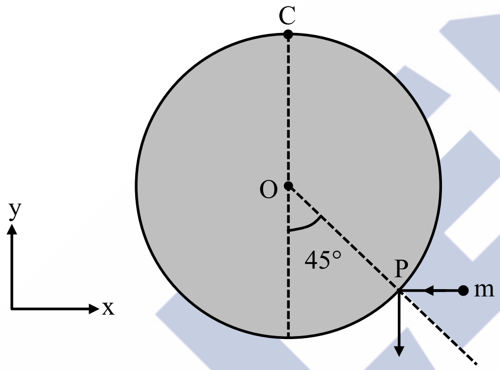
$$C_f - C_i = \left(8-\frac{128}{65}\right)\varepsilon_0$$

$$n = \frac{128}{65} = 1.97$$

Question Stem for Question Nos. 17 and 18

A uniform circular disk of radius 0.2 m and mass 1 kg is pivoted at its top point *C* such that it can rotate freely around *C* in the *XY* plane, as shown in the figure. Initially, when the disk is at rest, a particle of mass 20 g, travelling along negative *x* direction in the *XY* plane with speed 100 ms^{-1}, hits the circumference of the disk at a point *P*. After collision the particle moves along negative *y* direction at a speed of 90 ms^{-1}.

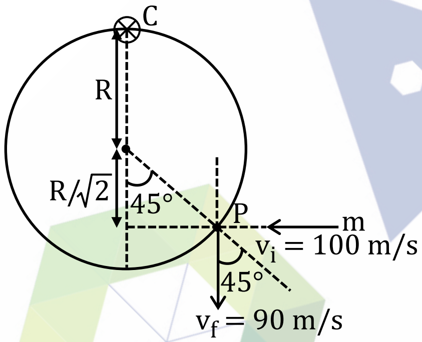
[Given: the acceleration due to gravity (g) = $-10\ \hat{j}\ ms^{-2}$]



17. After the collision the disk starts to rotate around point C in the XY plane. The maximum change in the height (in m) of its center O is:

Ans. **(0.15)**

Sol.



A.M.C. :

$$\left(R + \frac{R}{\sqrt{2}}\right) mv_i = I\omega + \left(\frac{R}{\sqrt{2}}\right) mv_f$$

$$(2)\left(1 + \frac{1}{\sqrt{2}}\right) \times \frac{20}{1000} \times 100 = \frac{3}{2} \times 1 \times 2 \times \frac{\sqrt{2} \times \omega}{10 \times 1000} \times 1000 + \frac{(2)}{\sqrt{2}} \times \frac{20}{1000} \times 90$$

$$(1 + 0.707)10 = \frac{3}{2}\omega + 9(0.707)$$

$$17.07 = 1.5\omega + 6.363$$

$10.707 = 1.5\omega$

$\omega = 7.138$ rad/sec

$$-MgR(1-\cos\theta) = -\frac{1}{2}\times I\omega^2$$

$$1\times 10R(1-\cos\theta) = \frac{1}{2}\times\frac{3}{2}\times 1\times\frac{2}{10}\times\frac{2}{10}\times 50.95$$

$R(1 - \cos\theta) = 0.152$ m

Height raised = $R(1 - \cos\theta) = 0.15$ m

18. Amount of energy loss (in J) in the collision is:

Ans. **(17.47)**

Sol. $(K.E.)_{Loss} = (K.E.)_i - (K.E.)_f$

$$= -\frac{1}{2}\times\frac{20}{1000}(90^2 - 100^2) - \frac{1}{2}\times\frac{3}{2}\times 1\times\frac{2}{10}\times\frac{2}{10}\times 7.138\times 7.138$$

$$= \frac{1900}{100} - \frac{152.85}{100} = 19 - 1.52 = 17.47 \text{ J}$$