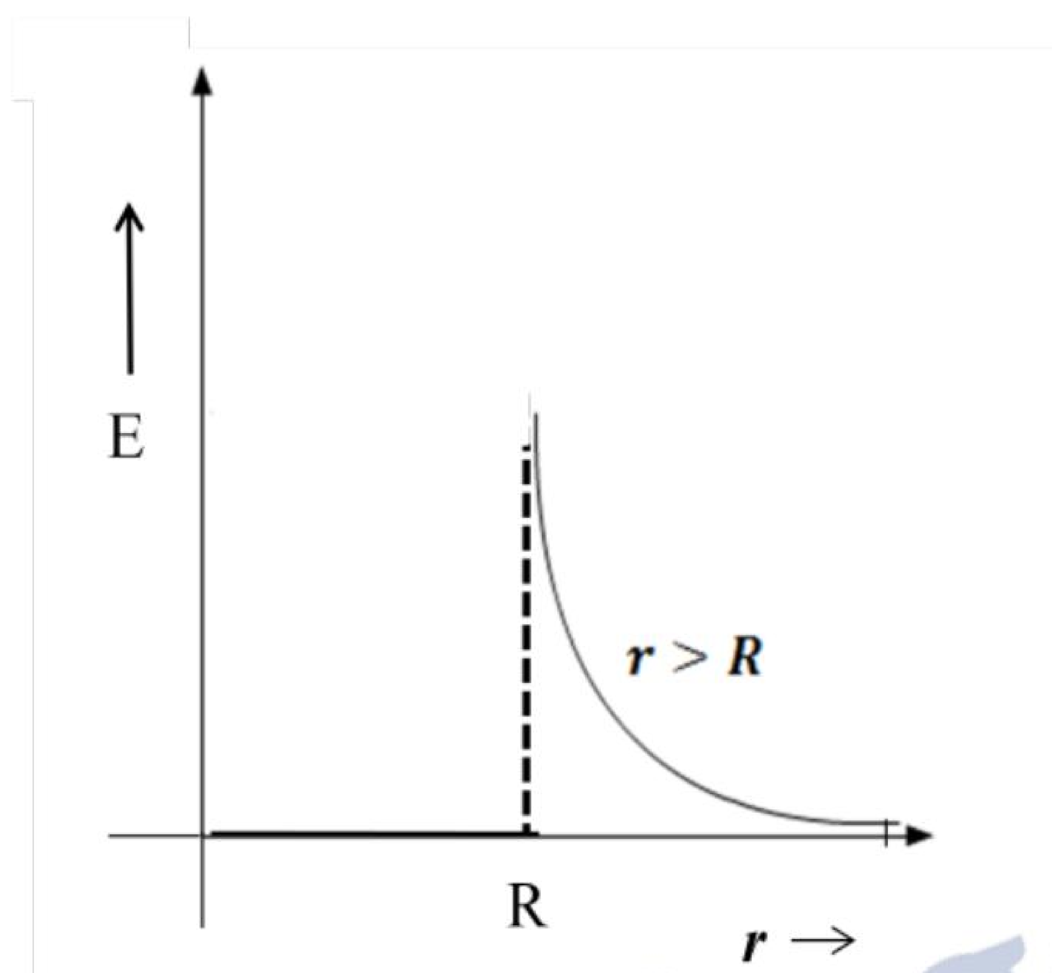
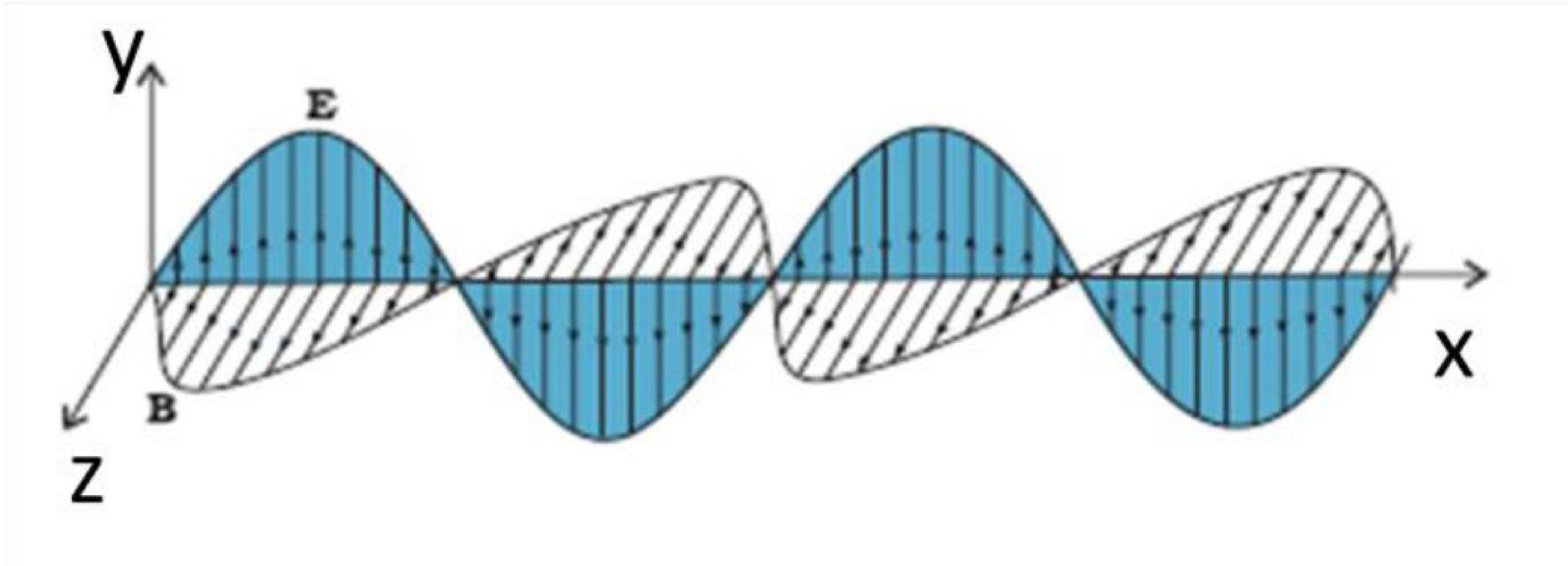
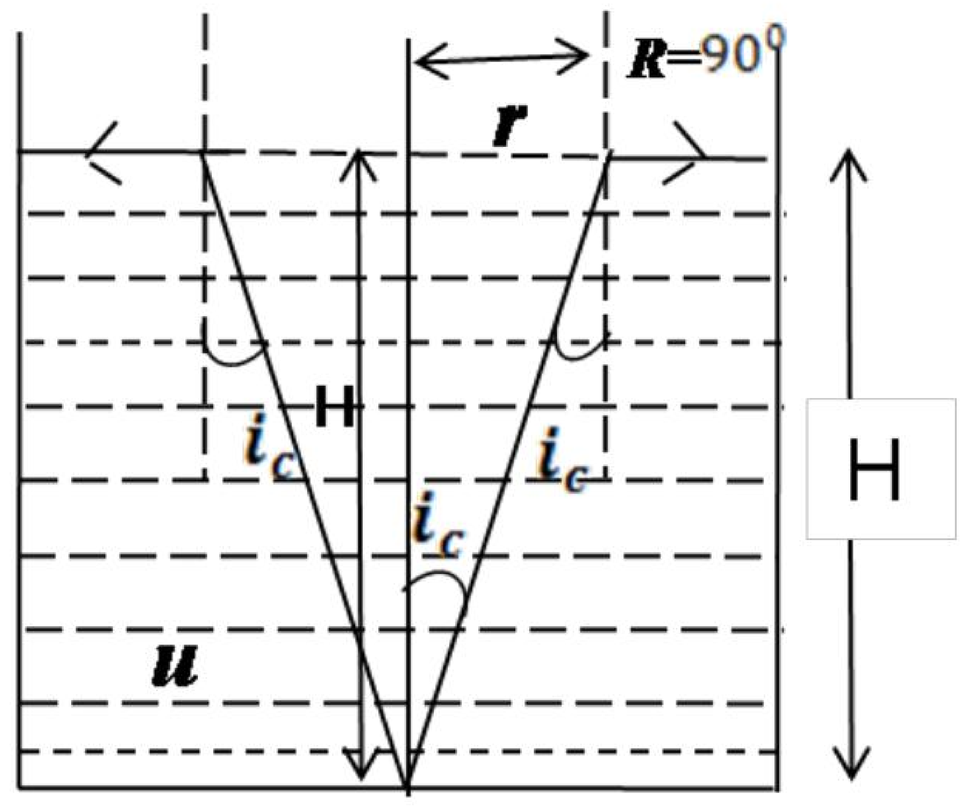
SET 55/1/1

MARKING SCHEME

Q. No.	Expected Answer/ Value Points	Marks	Total Marks
	SECTION A		
Q1		1	1
Q2	Number of photons emitted per second.	1	1
Q3	Relative permeability $\mu_r = \frac{L}{L_0} = \frac{2.8}{2.0 \times 10^{-3}}$ $= 1400$	½ ½	1
Q4	Virtual/ erect/ diminished	½+½	1
Q5	No	1	1
	SECTION B		
Q6	Production of e m waves 1 Diagram depicting the oscillating electric and magnetic fields. 1 Electromagnetic waves are produced due to oscillating/ accelerating charged particles.	1	

		1	2
Q7	Derivation of the expression for radius 2 Force experienced by charged particle in magnetic field $\vec{F} = q\,(\vec{v} \times \vec{B})$ As v *and* B are perpendicular, $F = qvB$ This force is perpendicular to the direction of velocity and hence acts as centripetal force. $\frac{mv^2}{r} = qvB$ $r = \frac{mv}{qB}$	½ ½ ½ ½	2
Q8	Calculation of shortest wavelength 1½ Part of electromagnetic spectrum to which this wavelength belongs ½ $\lambda^{-1} = R_H\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$ For shortest wavelength $n_i = \infty, n_f = 3$ $\therefore\ \lambda^{-1} = 1.1 \times 10^7 \left(\frac{1}{9}\right)$ $\therefore\quad \lambda = 8.18 \times 10^{-7}\text{m}$ $= 818\text{ nm}$ Infrared	½ ½ ½ ½	2
Q9	Derivation of the expression of the diameter of opaque disc 2		



½

It is only the light coming out from a cone of semi vertical angle i_c ($i_c = \sin^{-1}\frac{1}{\mu}$ = critical angle) that needs to be stopped by the opaque disc ½

Now $\sin i_c = \frac{1}{\mu}$

$$\therefore \quad \cos i_c = \sqrt{1 - \frac{1}{\mu^2}}$$

Also $\tan i_c = \frac{r}{H}$

$$\Rightarrow r = H \tan i_c = H \frac{\sin i_c}{\cos i_c}$$ ½

$$= H.\frac{\frac{1}{\mu}}{\sqrt{1 - \frac{1}{\mu^2}}}$$

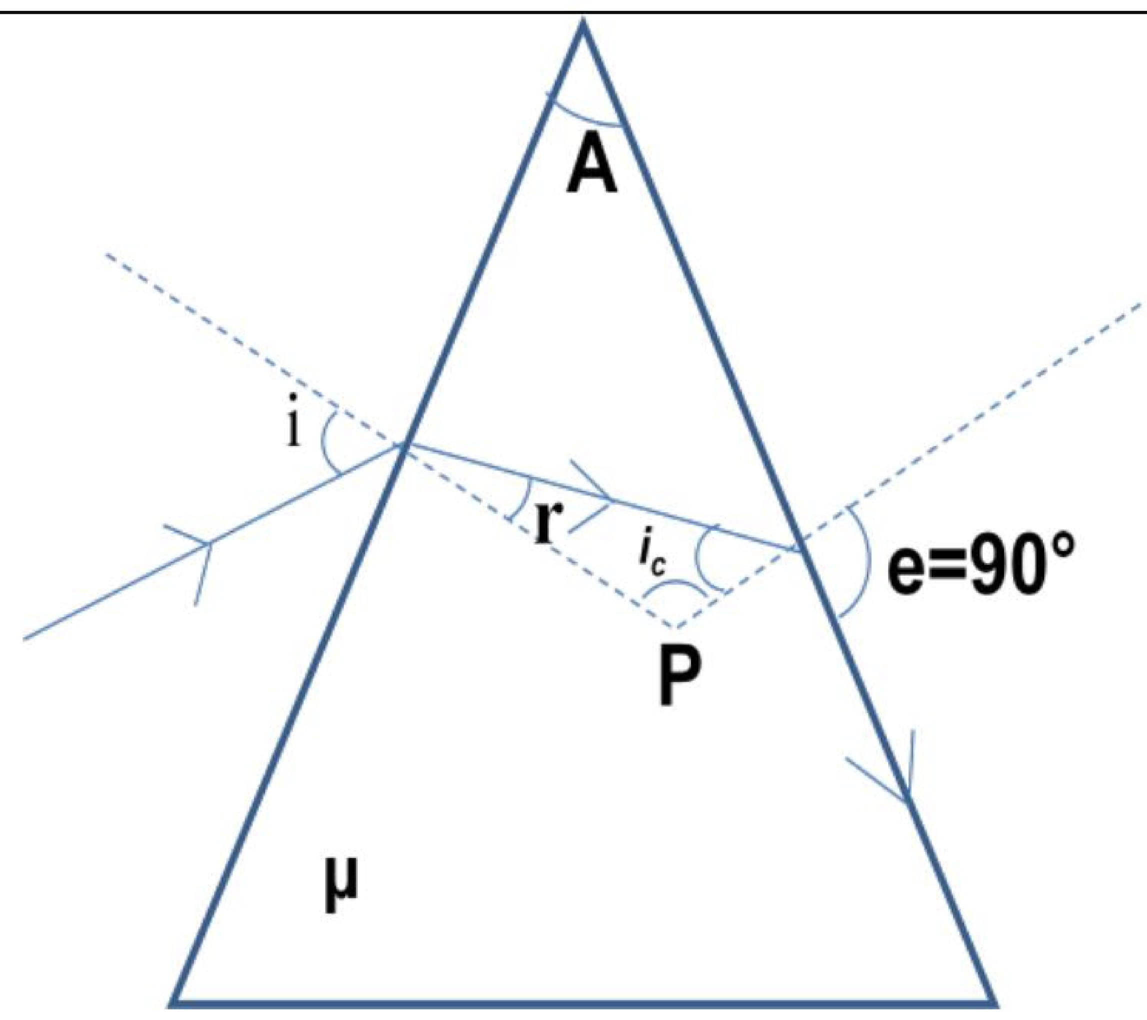
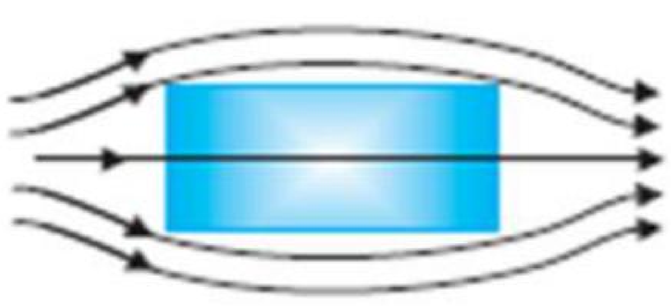
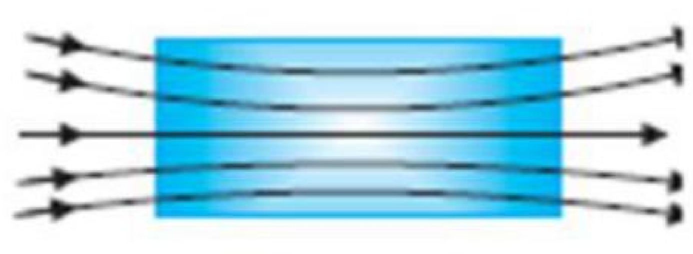
$$r = \frac{H}{\sqrt{\mu^2 - 1}}$$

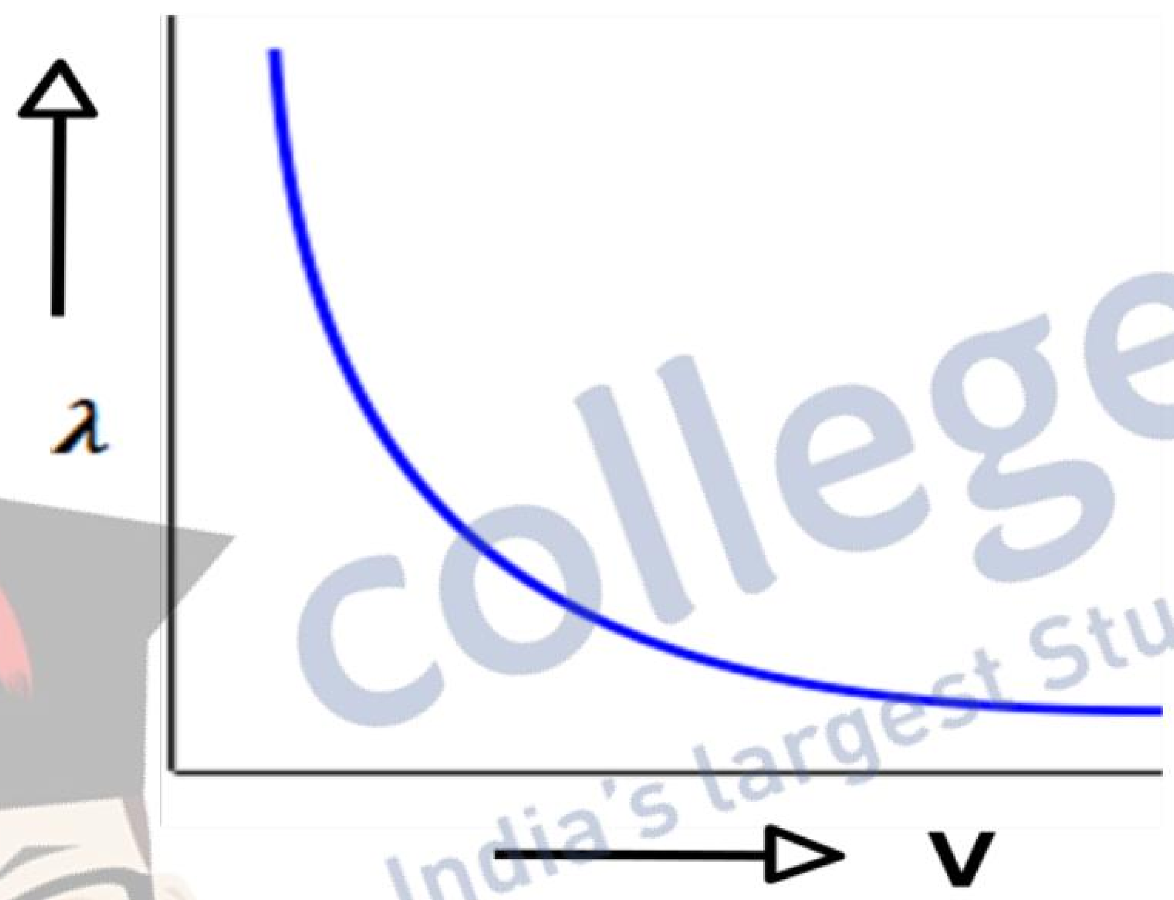
Diameter of the opaque disc $= 2r$

$$= \frac{2H}{\sqrt{\mu^2 - 1}}$$ ½ 2

OR

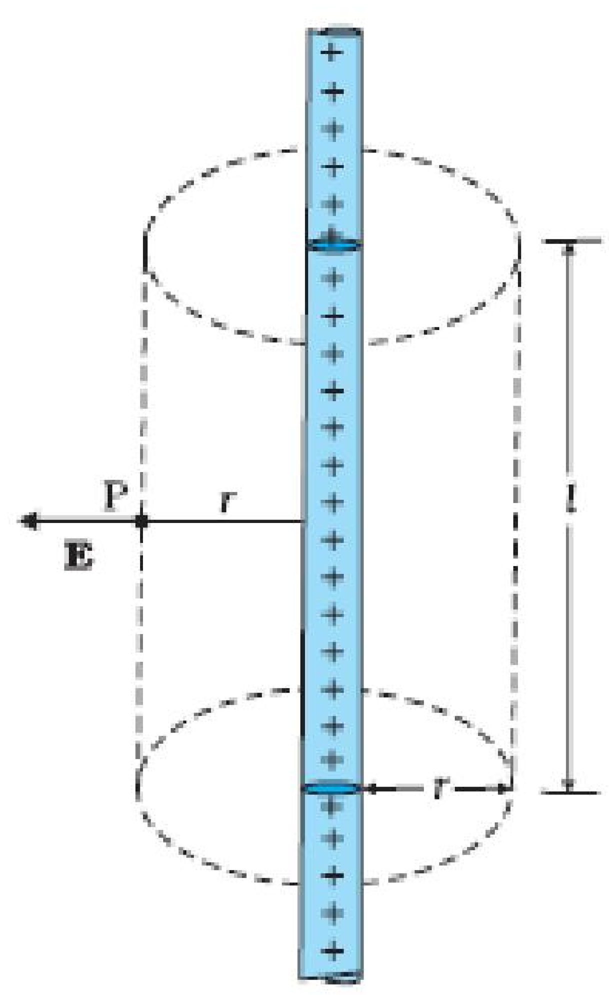
Obtaining an expression relating angle of incidence, angle of prism and critical angle. 2

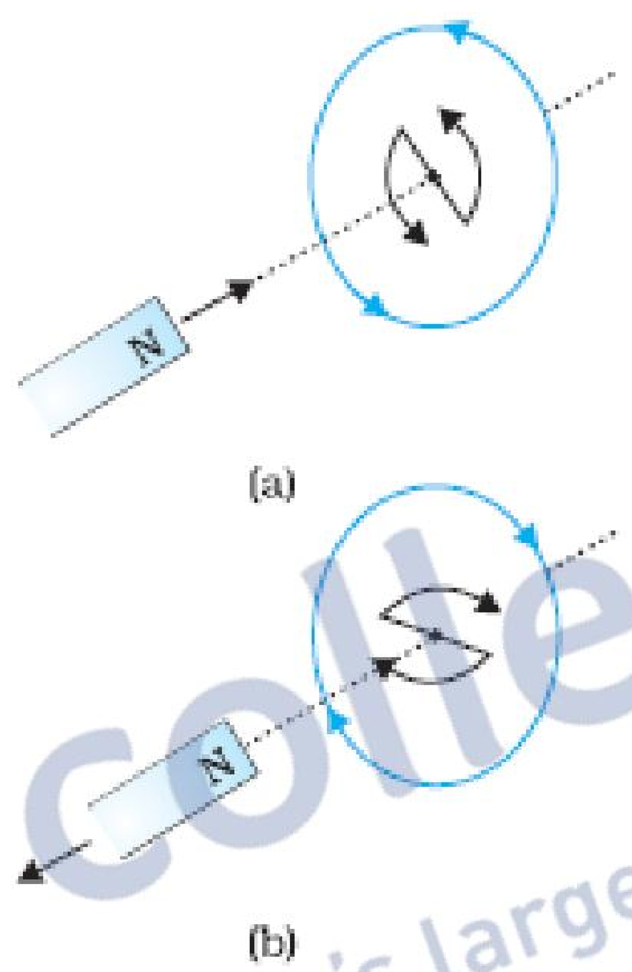
<table>
<tr><td></td><td></td><td>½</td><td></td></tr>
<tr><td></td><td>$$\mu = \frac{\sin i}{\sin r}$$
and $$\frac{1}{\mu} = \frac{\sin i_c}{\sin e} = \sin i_c$$
$$\angle A + \angle P = 180$$
and $$\angle r + \angle i_c = 180 - \angle P = \angle A$$
$$\Rightarrow \angle r = \angle A - \angle i_c$$
$$\Rightarrow \mu = \frac{\sin i}{\sin(A - i_c)}$$
$$\frac{1}{\sin i_c} = \frac{\sin i}{\sin(A - i_c)}$$</td><td>½
½
½</td><td>2</td></tr>
<tr><td>Q10</td><td>Depiction of behaviour
(i) Diamagnetic ½
Paramagnetic ½
(ii) Their justification ½ + ½

</td><td>½
½</td><td></td></tr>
</table>

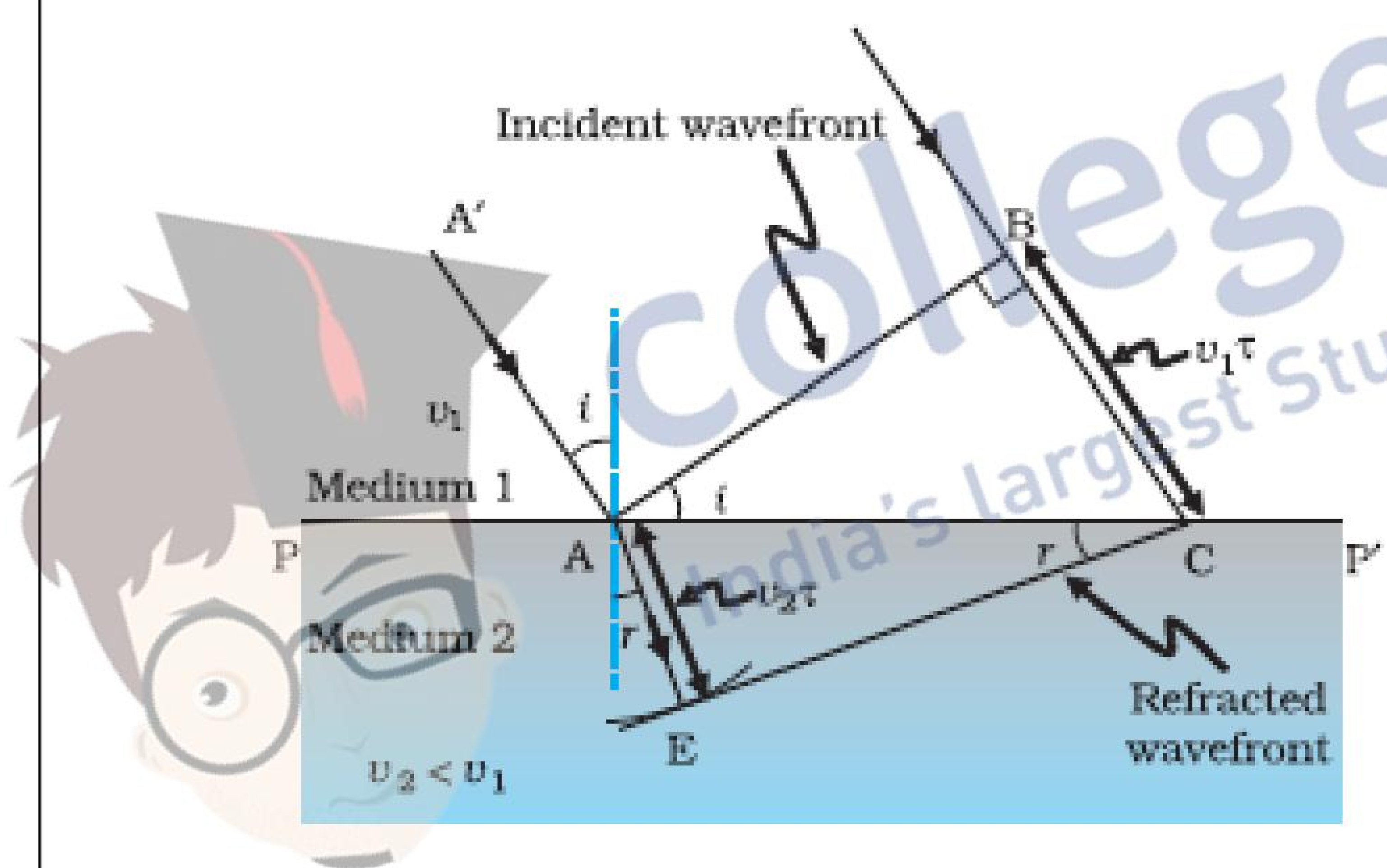
	The Field lines are repelled or expelled and the field inside the material is reduced. In the presence of magnetic field, the individual atomic dipoles can get aligned in the direction of the applied magnetic field. Therefore, field lines get concentrated inside the material and the field inside is enhanced.	½ ½	 2
	SECTION C		
Q11	Drawing of Graph 1 Comparison and explanation of kinetic energy difference 2  We have $\lambda = \frac{h}{\sqrt{2mqV}} = \frac{h}{\sqrt{2mK}}$ $(K = qV = K.E.)$ Now $m_d > m_p$ ∴ For same λ, we must have $K_p > K_d$ i.e. the proton has more kinetic energy	1 ½ ½ ½ ½	 3
Q12	Explanation of amplitude modulation 1 Calculation of modulation index 2 It is a process of superposition of a message signal over a carrier wave in which amplitude of the carrier wave is varied in accordance with the message/ information signal. We are given that	 1	

	$a_m + a_c = 10$ $a_c - a_m = 2$ $\therefore \quad 2a_c = 12 \Rightarrow a_c = 6V$ $\therefore \quad a_m = 4V$ $\mu = \frac{a_m}{a_c} = \frac{4}{6} = \frac{2}{3}$	½ ½ ½ ½	 3
Q13	Lorentz force ½ Expression in vector form ½ Identification of pair of vectors ½ Derivation of expression of force 1 ½ Lorentz magnetic force is force experienced by a charged particle of charge $'q'$ moving in magnetic field $\vec{B}$ with velocity $\vec{v}$. $\overrightarrow{F_m} = q(\vec{v} \times \vec{B})$ $\therefore \quad \overrightarrow{F_m} \perp \vec{v}$ and $\overrightarrow{F_m} \perp \vec{B}$ [The student can write any one pair] Consider a conductor of uniform cross-sectional area A and length $'L'$ having number density of electrons as $'n'$ Total force on charge carriers in the conductor $\vec{F} = (nAL)q\,\overrightarrow{v_d} \times \vec{B}$ But as $I\vec{L} = nqA\overrightarrow{v_d}L$ $\therefore \quad \vec{F} = I\vec{L} \times \vec{B}$	½ ½ ½ ½ ½ ½	3
Q14	Naming the optical instrument 1 Calculation of Magnifying Power 2 Compound microscope Focal Length of objective lens $(f = \frac{1}{p})$ $f_0 = \frac{100}{50}\text{ cm} = 2\text{ cm}$	 1 ½	

	Focal Length of eye lens $$f_e = \frac{100}{16}\text{cm} = 6.67\text{ cm}$$ Magnifying Power $$m = \frac{L}{f_0} \times \frac{D}{f_e}$$ $$= \frac{16.25}{2.0} \times \frac{25}{6.67} = 30.45$$	½ ½ ½	3
Q15	Explanation of two processes 1+1 Definition of barrier potential 1 Diffusion: It is the process of movement of majority charge carriers from their majority zone (.i.e., electrons from $n \rightarrow p$ and holes from $p \rightarrow n$) to the minority zone across the junction on account of different concentration gradient on the two sides of the junction. Drift: Process of movement of minority charge carriers (i.e., holes from $n \rightarrow p$ and electrons from $p \rightarrow n$) due to the electric field developed at the junction. Barrier potential: The loss of electrons from the n-region and gain of electrons by p-region causes a difference of potential across the junction, whose polarity is such as to oppose and then stop the further flow of charge carriers. This (stopping) potential is called Barrier potential.	1 1 1	3
Q16	a. Two properties ½+ ½ b. Derivation of expression for potential energy 2 a. (i) Electric field is in the direction in which potential decreases at the maximum rate (ii) Magnitude of electric field is given by change in the magnitude of potential per unit displacement normal to a charged conducting surface. [Alternatively: award half mark of part 'a' if student writes only $E = -\frac{dV}{dr}$] b. Work done in bringing the charge q_1 to a point	½ ½	

	against external electric field. $$W_1 = q_1 V(\vec{r_1})$$	½	
	Work done in bringing the charge q_2 against the external electric field and the Electric field produced due to charge q_1 $$W_2 = q_2 V(\vec{r_2}) + \frac{1}{4\pi\varepsilon_0}.\frac{q_1 q_2}{r_{12}}$$	½	
	Therefore Total work done = Electrostatic potential energy $$U = q_1 V(\vec{r_1}) + q_2 V(\vec{r_2}) + \frac{1}{4\pi\varepsilon_0}.\frac{q_1 q_2}{r_{12}}$$	1	3
	OR		
	Statement of Gauss's Law — 1 Derivation of electric field due to an infinitely long straight uniformly charged wire. — 2		
	The surface integral of electric field over a closed surface is equal to $\frac{1}{\varepsilon_0}$ times the charge enclosed by the surface. Alternatively, $$\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$$	1	
		½	
	Flux through the Gaussian surface = flux through the curved cylindrical part of the surface $$= E \times 2\pi rl$$	½	
	Charge enclosed by the surface = λl	½	
	$$\Rightarrow E \times 2\pi rl = \frac{\lambda l}{\varepsilon_0}$$		

	$\Rightarrow E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$	½	3
Q17	Statement of Lenz's Law 1 Explanation (with example) 2 The Polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.	1	
		½ ½	
	When the north pole of a bar magnet is pushed towards the close coil, the magnetic flux through coil increases and the current is induced in the coil in such a direction that it opposes the increase in flux. This is possible when the induced current in the coil is in the anticlockwise direction. Just the opposite happens when the north pole is moved away from the coil.	½	
	In either case, it is the work done against the force of magnetic repulsion/attraction that gets 'converted' into the induced emf.	½	3
Q18	Calculation of V and unknown capacitance 2 Calculation of charge when voltage is increased by 120 V 1 Capacitance $C = \frac{Q_1}{V_1}$		

	Also $C = \frac{Q_2}{V_2}$ & $C = \frac{Q_3}{V_3}$ $\frac{360\mu C}{V} = \frac{120\mu C}{(V-120)}$ $\Rightarrow 3V - 360 = V \Rightarrow 2V = 360 \Rightarrow V = 180\ V$ $C = \frac{360\mu C}{180V} = 2\mu F$ $2\mu F = \frac{Q_3}{300}$ $Q_3 = 600\mu C$	½ ½ ½ ½ ½ ½	3
Q19	Diagram showing incident wavefront and refracted wavefront 1 Verification of Snell's Law 2  $BC = v_1\tau$ & $AE = v_2\tau$ $\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$ $\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$ $\Rightarrow \frac{\sin i}{\sin r} = \frac{v_1\tau}{v_2\tau} = \frac{v_1}{v_2} = \mu$	1 ½ ½ ½ ½	3
Q20	Distinction between sky wave and space wave modes of communication 2 Limitation of space wave mode ½ Expression for optimum separation ½		

*These answers are meant to be used by evaluators

In sky wave mode of communication waves reach from transmitting antenna to receiving antenna through reflections from ionosphere, while in space wave mode of communications wave travel either directly from transmitter to receiver or through satellite. — 1+1

Direct waves get blocked at some point due to the curvature of earth. — ½

Optimum distance between transmitting and receiving antenna. — ½ — 3

$$= \sqrt{2h_T R} + \sqrt{2h_R R}$$

Q21

Drawing of output waveform	1
Identification of Logic gate	1
Truth Table	1

— 1

NAND GATE — 1

Truth Table — 1 — 3

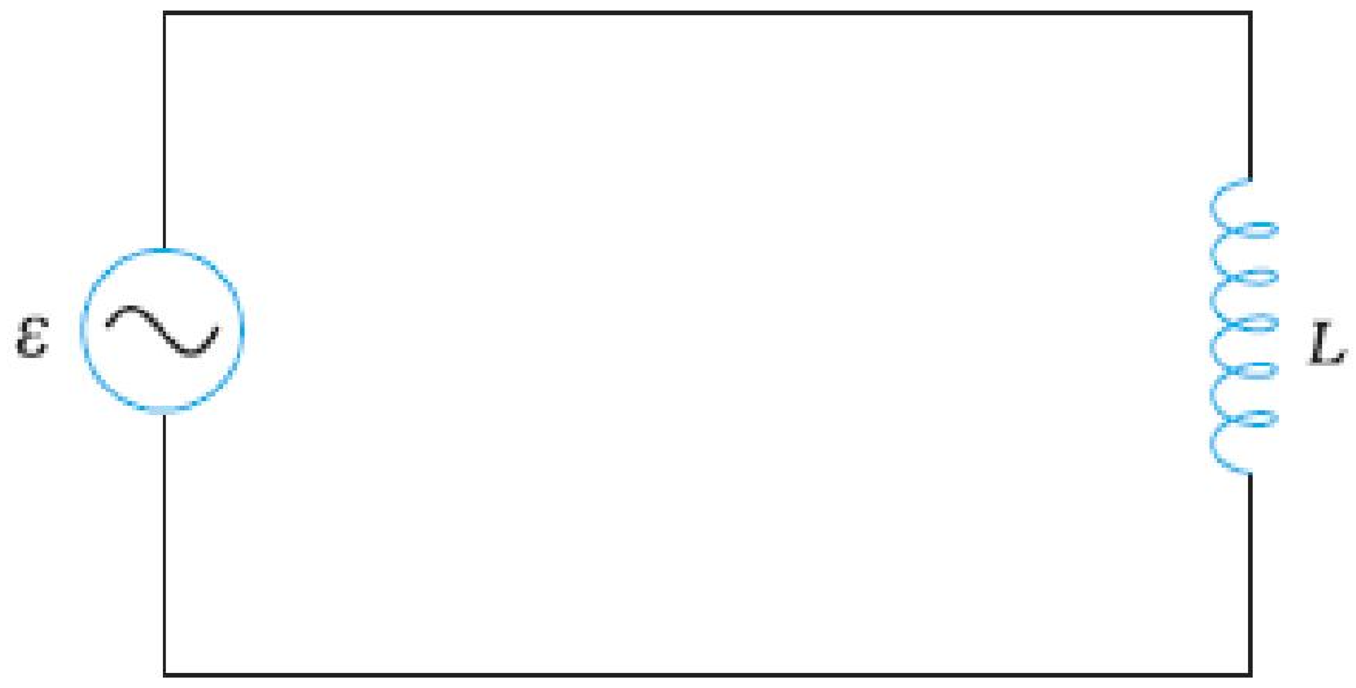
Inputs		Output
A	B	
1	1	0
0	0	1
1	1	1
0	0	1

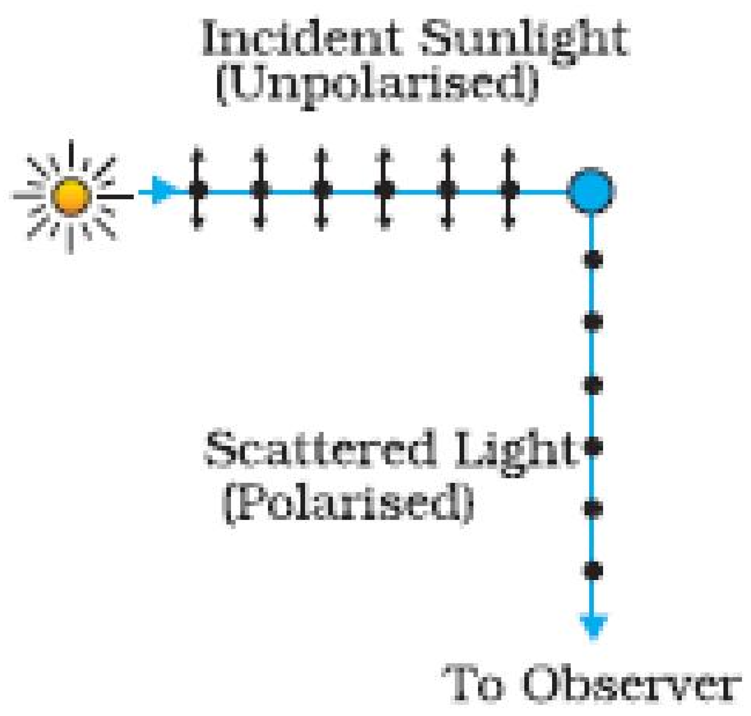
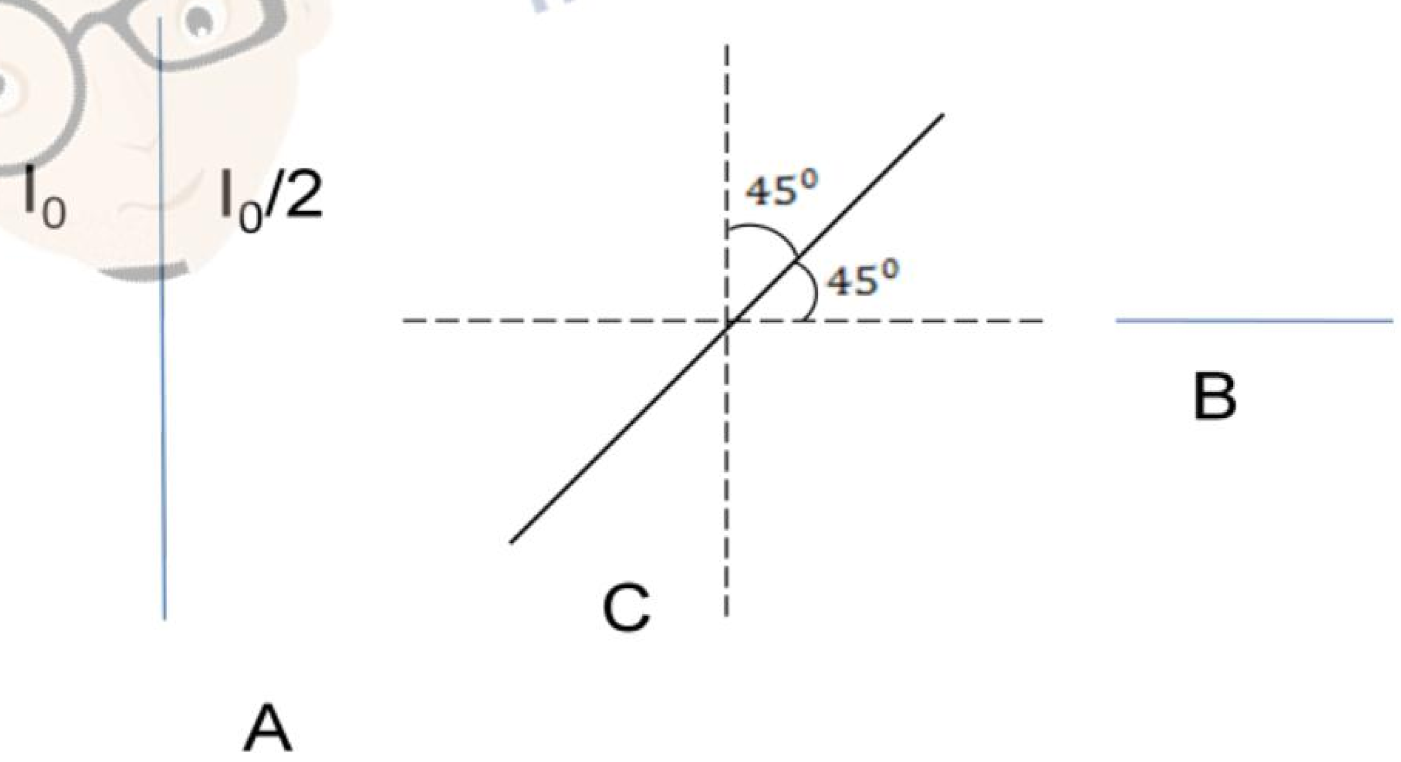
Q22

Derivation of current density	2
Explanation with reason the change in mobility of electrons	1

	Using Ohm's law $$V = IR = \frac{I\rho l}{A}$$ Potential difference (V), across the ends of a conductor of length $'l'$, where field $'E'$ is applied, is given by $$V = El$$ $$\therefore \quad El = \frac{I\rho l}{A}$$ But current density $J = \frac{I}{A}$ $$El = J\rho l = \frac{Jl}{\sigma}$$ $$\Rightarrow J = \sigma E$$ No change mobility $\mu = \frac{v_d}{E}$ and $v_d = \frac{eV\tau}{ml}$ As potential is doubled, drift velocity also gets doubled, therefore, no change in mobility.	½ ½ ½ ½ ½ ½	3
	SECTION D		
Q23	(1) Moral values of Prof. Srivastava ½ + ½ (2) Relation between mean life & half life 1 (3) Calculation of half life and initial activity 1+1 Care, concern, helping attitude [any two values] Mean life = (half life/0.693)/(1.44 times half life) $$\left(= 1.44\, T_{\frac{1}{2}}\right)$$ Half life = 10 $hour$ (as per given information) $$R = R_0(\frac{1}{2})^n \Rightarrow \frac{R_0}{R} = (2)^n$$ $$\frac{R_0}{10000} = (2)^2$$ $$\Rightarrow R_0 = 40000 \text{ dps}$$	½ +½ 1 ½ ½ ½ ½	4
	SECTION E		

Q24	Calculation of (a) Capacitance 1 (b) Q-factor of circuit and its importance 2 Calculation of average power dissipated 2		
	(a) As power factor is unity, $\therefore \quad X_L = X_C$	½	
	$\Rightarrow \omega = \frac{1}{\sqrt{LC}}$		
	$100 = \frac{1}{\sqrt{200 \times 10^{-3} \times C}}$		
	$10^4 \times 2 \times 10^2 \times 10^{-3} \times C = 1$	½	
	$C = \frac{1}{2 \times 10^3}\text{F} = 0.5 \times 10^{-3}\text{F}$		
	$= 0.5 \text{ mF}$	½	
	(b) Quality factor		
	$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	½	
	$= \frac{1}{10}\sqrt{\frac{200 \times 10^{-3}}{0.5 \times 10^{-3}}}$		
	$= \frac{1}{10} \times 20 = 2$	½	
	Significance: It measures the sharpness of resonance.	½	
	Average Power dissipated		
	$P = V_{rms} I_{rms} \cos\varphi$	1	
	$= 50 \times \frac{50}{10} \times 1\text{W}$ $= 250 \text{ watts}$	1	5
	OR		
	(a) Showing that of current lags voltage by an angle $\frac{\pi}{2}$ in an ideal inductor 3 (b) Calculation of inductance and average power dissipation 2		

	(a) 	½	
	induced emf $e = -L\frac{dI}{dt}$	½	
	Hence Net voltage in the circuit $= V - L\frac{dI}{dt}$		
	According to Kirchoff's Rule		
	$V - L\frac{dI}{dt} = 0$	½	
	$V_m \sin\omega t = L\frac{dI}{dt}$		
	$dI = \frac{V_m}{L}\sin\omega t\, dt$	½	
	$I = -\frac{V_m}{\omega L}\cos\omega t$	½	
	$= \frac{V_m}{\omega L}\sin(\omega t - \frac{\pi}{2})$		
	$\therefore \quad i = i_m \sin(\omega t - \frac{\pi}{2})$	½	
	Hence current lags by $\frac{\pi}{2}$		
	(b) Inductance of the inductor $= 100mH$		
	Average power dissipation		
	$P = V_{rms}I_{rms}\cos\varphi$	½	
	$= 10 \times 1 \times \cos\frac{\pi}{4}$	½	
	$= \frac{10}{\sqrt{2}}\mathrm{W} = 5\sqrt{2}\mathrm{watts}(17.07\mathrm{W})$	1	5
Q25	(a) Explanation, how plane polarized light can be produced by scattering 2 (b) Calculation of intensity of light transmitted by A,B and C 3		

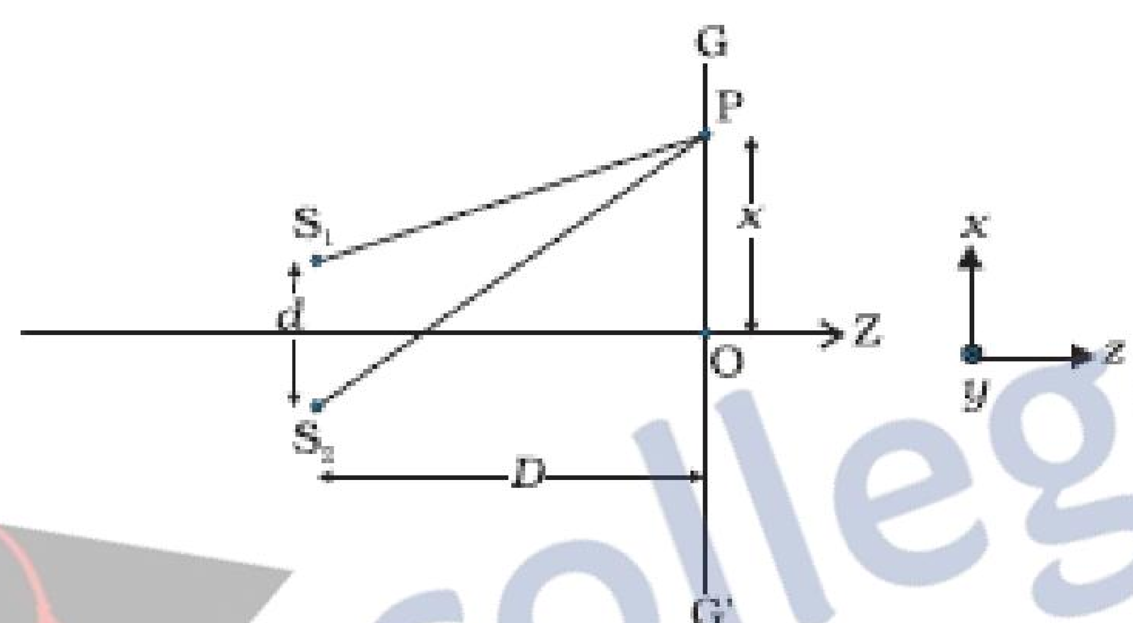
	(a) 	1	
	Unpolarised light, from sun, has Electric field components perpendicular to plane of figure and in the plane of figure. Under the influence of Electric field of the incident wave the electrons in the molecules acquires components of motion in both these directions. As the observer is looking 90° to the direction of sun, hence charges parallel to the plane of figure do not radiate energy towards the observer since their acceleration has no transverse components. Therefore it gets polarized perpendicular to plane of figure.	1	
		1	
	Intensity of light transmitted through $A = \frac{I_0}{2}$	½	
	Transmitted through Polaroid 'C' $$I' = \frac{I_0}{2}\cos^2 45^\circ$$ $$= \frac{I_0}{4}$$	½ ½	
	Transmitted through Polaroid 'B;		

$$I'' = \frac{I_0}{4}\cos^2 45^\circ$$

$$= \frac{I_0}{8}$$ ½ 5

OR

(a) Explanation of formation of dark and bright fringes	2 ½
(b) (i) Calculation of the distance of third bright fringe	1
(ii) Calculation of least distance	1 ½



½

At centre of the screen i.e. at point O, waves from two sources S_1 and S_2 meet in same phase and produce constructive interference, and similarly at all those points on the screen where waves have path difference $n_\lambda, n = 0,1,2,3$ ..., they produce constructive interference hence bright fringes are obtained. 1

At the points on the screen where waves from S_1 and S_2 meet with phase difference of $(2n+1)\pi$ or path difference of $(2n+1)\frac{\lambda}{2}$, the waves will produce destructive interference and dark fringes are obtained. 1

(b) (i)

$$x_n = \frac{n\lambda D}{d}$$ ½

$$= \frac{3\times650\times10^{-9}\times1.2}{4\times10^{-3}}$$

$$= 585\times10^{-6}\text{m}$$

$$= 0.585 \text{ mm}$$ ½

(ii)

$$\frac{n_1\lambda_1 D}{d} = \frac{n_2\lambda_2 D}{d}$$ ½

$$\Rightarrow n_1\lambda_1 = n_2\lambda_2$$

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{520}{650} = \frac{4}{5}$$ ½

Therefore, 4th bright fringe of $\lambda = 650$mm will coincide with 5th bright fringe 520mm.

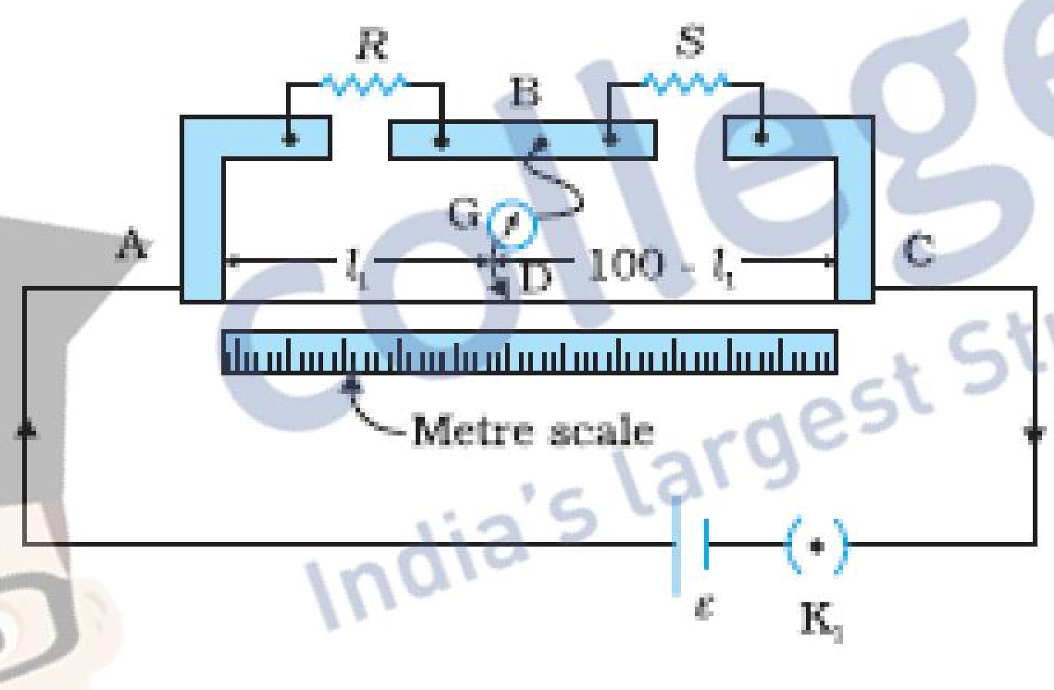
Least distance from central maximum where bright fringes of both wavelength coincide

$$= \frac{4 \times 650 \times 1.2 \times 10^{-9}}{4 \times 10^{-3}}\text{m} = 780 \times 10^{-6}\text{m} = 0.78\text{nm}$$ ½ | 5

Q26

(a) Labelled circuit diagram of meter bridge & derivation of expression of R	3
(b) Meaning of end error and its correction	½ +½
Effect on balancing Length	½
Reason	½

(a)



1

The the bridge is balanced at null point. Therefore

$$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$$ 1

$$\Rightarrow R = S\frac{l_1}{(100 - l_1)}$$ 1

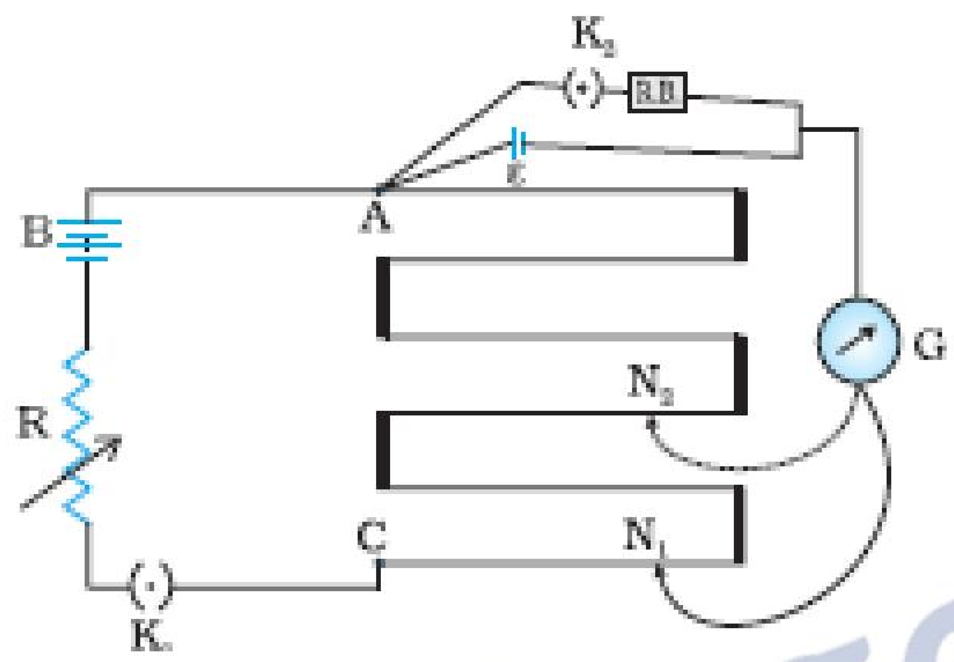
(b) The error which arises on account of resistance of copper strips and the connecting wire at both ends of the meter bridge is called end error. ½

It is minimized by adjusting the balance point near the middle point of the bridge. ½

No effect, as the bridge remains balanced. ½+½ | 5

OR

(a) Statement of working Principle	1
Circuit diagram and determination of internal resistance	3
(b) (i) Effect of internal resistance	½
(ii) Series resistance	½

	(a) Potentiometer principle: When a constant current flows through a wire of uniform cross sectional area, the potential difference, across any length, is directly proportional to the length. $V \propto L$  $E = \varphi l_1$ (i) $V = \varphi l_2$ (ii) $\frac{\varepsilon}{V} = \frac{l_1}{l_2}$ (iii) Since $\varepsilon = I(r + R)$ and $V = IR$ Therefore, $\frac{\varepsilon}{V} = \frac{(r+R)}{R}$ (iv) From (iii)& (iv) $r = R\left(\frac{l_1}{l_2} - 1\right)$ (b) As the question is incomplete, award 1 mark to all candidates who attempt this part.	1 1 ½ ½ ½ ½ 1	5