MARKING SCHEME
SET 55/1/C

<table>
<tr><th>Q. No.</th><th>Expected Answer / Value Points</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td colspan="4">Section - A</td></tr>
<tr><td>Set-1, Q1
Set-2, Q5
Set-3, Q2</td><td>Power factor = 1</td><td>1</td><td>1</td></tr>
<tr><td>Set-1, Q2
Set-2, Q4
Set-3, Q5</td><td>i) Width of depletion layer will decrease
ii) potential barrier will decrease
iii) junction will conduct
(Any one point)</td><td>1</td><td>1</td></tr>
<tr><td>Set-1, Q3
Set-2, Q2
Set-3, Q4</td><td>$\vec{P} = \epsilon_0 \ X_e \vec{E}$
(Also accept if the student writes $\vec{P} \propto \vec{E}$ or $\vec{P} = X_e \vec{E}$)</td><td>1</td><td>1</td></tr>
<tr><td>Set-1, Q4
Set-2, Q3
Set-3, Q1</td><td>Mobility is defined as drift velocity per unit electric field
or $\mu = \frac{v_d}{E}$
S.I. Unit - m^2/Vs or Cm/Ns</td><td>½
½</td><td>1</td></tr>
<tr><td>Set-1, Q5
Set-2, Q1
Set-3, Q3</td><td>$\frac{1}{f} = (\mu - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
∴ μ = 1.5
(Award 1 mark even if direct answer is written)</td><td>½
½</td><td>1</td></tr>
<tr><td colspan="4">Section - B</td></tr>
<tr><td>Set-1, Q6
Set-2, Q7
Set-3, Q10</td><td>
Two differences between Interference and Diffraction pattern 2
<table>
<tr><th></th><th>Interference</th><th>Diffraction</th></tr>
<tr><td>1</td><td>All the bright bands are of same intensity.</td><td>Intensity of bright bands goes on decreasing with increasing order.</td></tr>
<tr><td>2</td><td>All the bright bands are of same width.</td><td>Not of same width.</td></tr>
<tr><td>3</td><td>Dark bands may be completely dark.</td><td>Not completely dark.</td></tr>
<tr><td>4</td><td>Number of fringes are more.</td><td>Less in number.</td></tr>
</table>
(Any two)
[Award only 1 mark if student draws intensity distribution curves for both without writing points]
Or
</td><td>1×2</td><td>2</td></tr>
</table>

<table>
<tr>
<td></td>
<td>Difference in Construction - 1
Difference in Working – 1
<table>
<tr><td></td><td>Microscope</td><td>Telescope</td></tr>
<tr><td>Construction</td><td>Objective is of very short focal length and short aperture and eye piece of short focal length and large aperture. $[f_e > f_o]$</td><td>Objective is of large focal length and large aperture but eye piece of short focal length and short aperture.</td></tr>
<tr><td>Working</td><td>It will form magnified image of a small nearby object.
(Object is placed close to focus of objective which forms real and magnified image.)</td><td>It will form magnified image of distant object.
(Objective will form the image of distant object at its focus and image is diminished.)</td></tr>
</table></td>
<td>½+ ½
½+ ½</td>
<td>2</td>
</tr>
<tr>
<td>Set-1, Q7
Set-2, Q10
Set-3, Q8</td>
<td>Postulate - 1
Formula for H'_α line – ½
Substitution and calculation- ½

Postulate- Energy is radiated when an electron jumps from a (permitted) higher to lower orbit and it equal to the difference in energy in the two orbits.
$hv = E_i - E_f$
$\frac{1}{\lambda_\propto} = R_H[\frac{1}{2^2} - \frac{1}{3^2}]$
$= 1.03 \times 10^7 \times \frac{5}{36}$ $\because \lambda_\alpha = 6.99 \times 10^{-7}$ m = 699 nm
[Award ½ mark if student only writes $\frac{1}{\lambda} = R_H[\frac{1}{n_f{}^2} - \frac{1}{n_i2}]$</td>
<td>1
½
½</td>
<td>2</td>
</tr>
</table>

Set-1, Q8 Set-2, Q6 Set-3, Q9	Kirchhoff's laws ½+½ To justify them ½+½ Kirchhoff's I Law: (JUNCTION LAW) Sum of the incoming currents at a junction = Sum of outgoing currents [**Alternatively** Algebraic sum of all the currents meeting at a junction in the electrical circuit is zero] 2nd Law : (LOOP LAW) The algebraic sum of the changes in potential around any closed loop involving resistors and cells in the loop is zero [**Alternatively** In any closed electrical part of circuit, sum of the e.m.f s is equal to sum of products of various currents and resistances through which currents pass.] To justify First law is based on the law of conservation of charge. Second Law is based on the law of conservation of energy.	½ ½ ½ ½	2
Set-1, Q9 Set-2, Q8 Set-3, Q7	Formula for de Broglie wavelength – 1 Calculation and result – 1 Formula used $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$ $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}}$ since $E_n \propto \frac{1}{n^2}$ For $n = 2$ $E_2 = \frac{E_1}{4}$ $\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{1}{4}} = \frac{1}{2}$ [Award ½ mark if the student only writes $\lambda = \frac{h}{mv}$] Also accept any other correct alternative answer.	1 ½ ½	2
Set-1, Q10 Set-2, Q9 Set-3, Q6	(a) Difference between Analog and Digital signal 1 (b) Any two uses of internet 1		

<table>
<tr>
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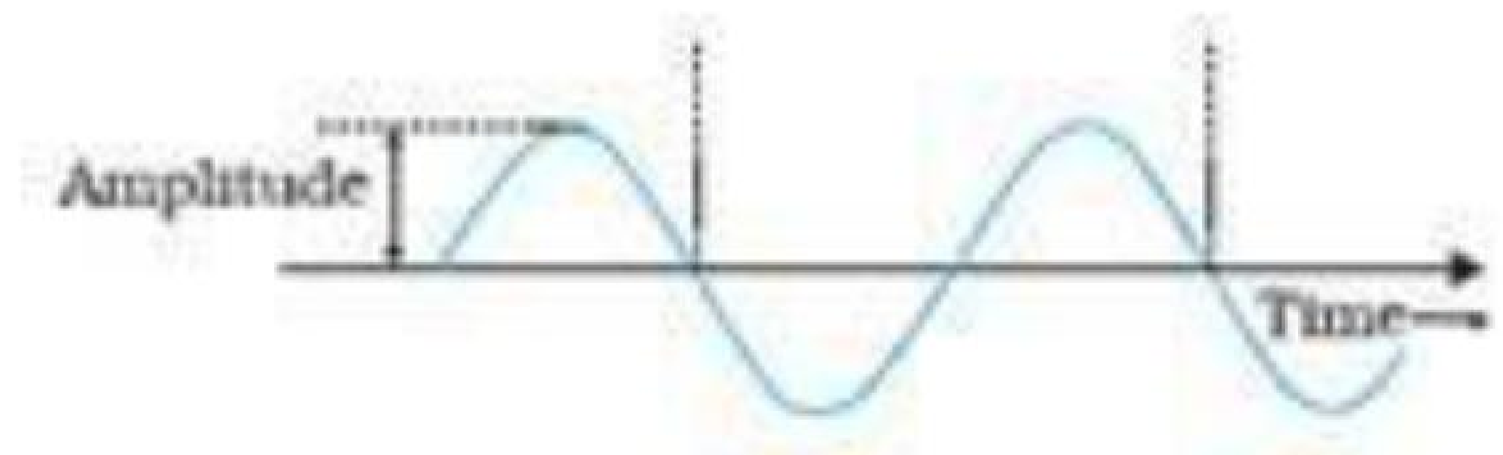
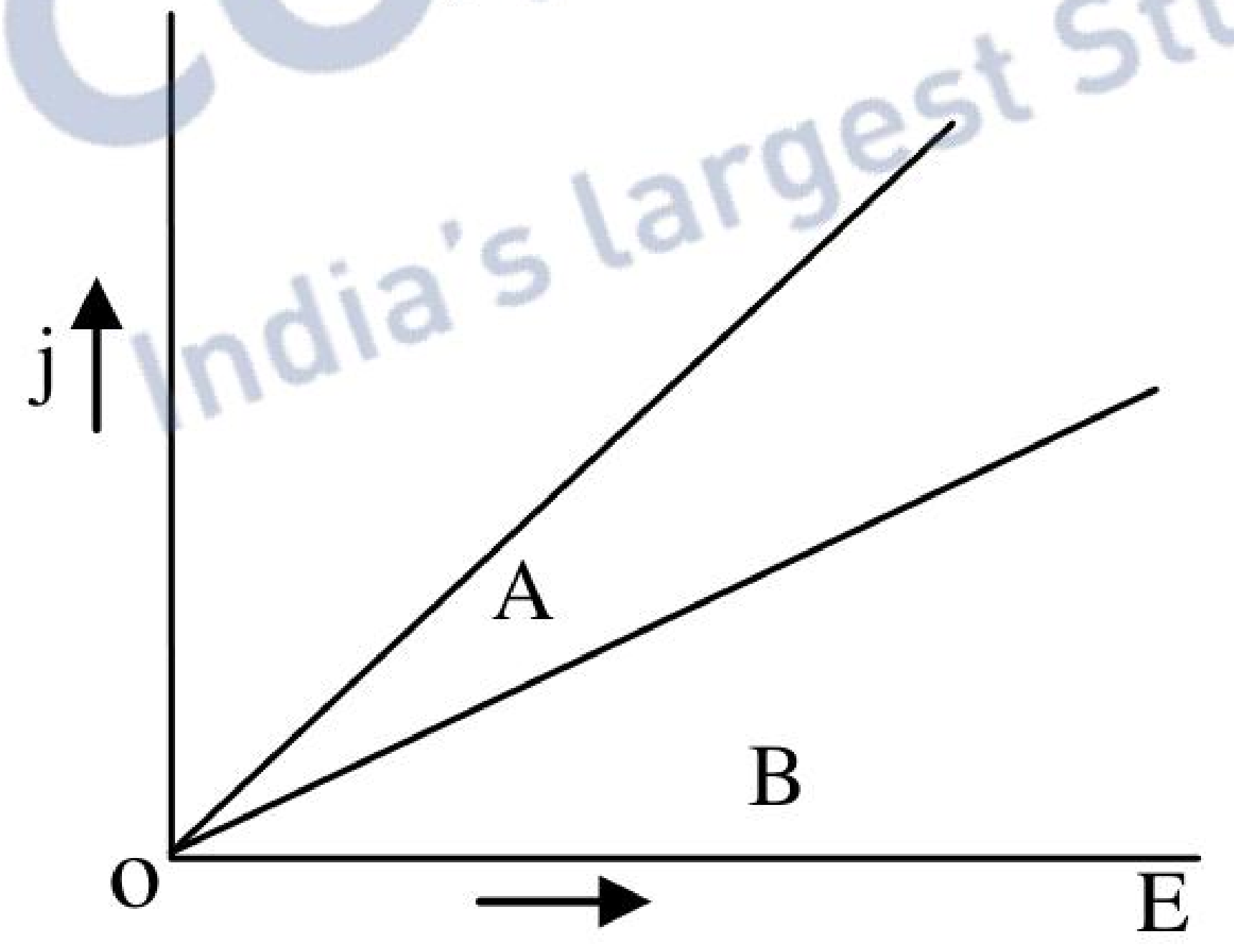
(a)
<table>
<tr><th>Analog signal
(Any one of the two)</th><th>Digital Signal
(Any one of the two)</th></tr>
<tr><td>It is single valued function of time or varies continuously with time</td><td>These signals take only discrete set of values i.e. 0 or 1</td></tr>
<tr><td>alternatively
 </td><td>alternatively
</td></tr>
</table>
(b) Uses of Internet : Any two
(E mail, E- banking, chatting, file transfer, e-shopping, e-ticketing, surfing etc)
</td>
<td>1

½ +
½</td>
<td>2</td>
</tr>
<tr>
<td colspan="4">Section - C</td>
</tr>
<tr>
<td>Set-1, Q11
Set-2, Q20
Set-3, Q15</td>
<td>
<table>
<tr><td>Formula</td><td>½</td></tr>
<tr><td>Graph</td><td>1</td></tr>
<tr><td>Information from the graph</td><td></td></tr>
<tr><td>Selecting the materials</td><td>1</td></tr>
<tr><td>Explanation for large current</td><td>½</td></tr>
</table>
$j = \sigma E$

Slope of the graph= conductivity (σ)
Material with less slope (smaller conductivity) is used for making standard resistances and material with greater slope (higher conductivity) for making connecting wires

We have $I = nAev_d$

Although v_d is small but n (electron number density) is very large. Hence the current can be large.
</td>
<td>½
1
½
½
½</td>
<td>3</td>
</tr>
<tr>
<td>Set-1, Q12
Set-2, Q21
Set-3, Q16</td>
<td>
<table>
<tr><td>Statement</td><td>½ mark</td></tr>
<tr><td>Derivation of magnetic field on axis</td><td>2 marks</td></tr>
<tr><td>Magnetic field at centre</td><td>½ mark</td></tr>
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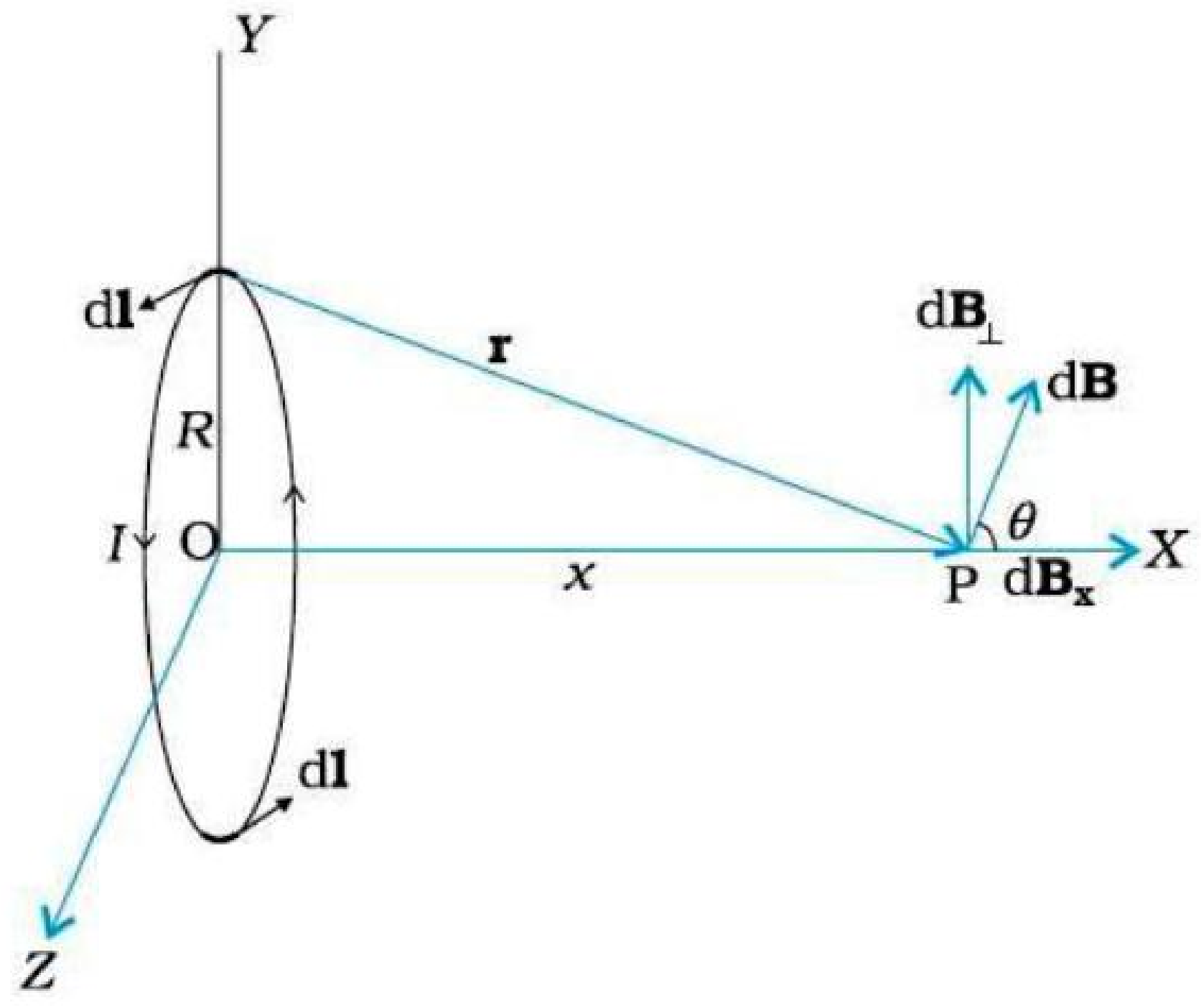
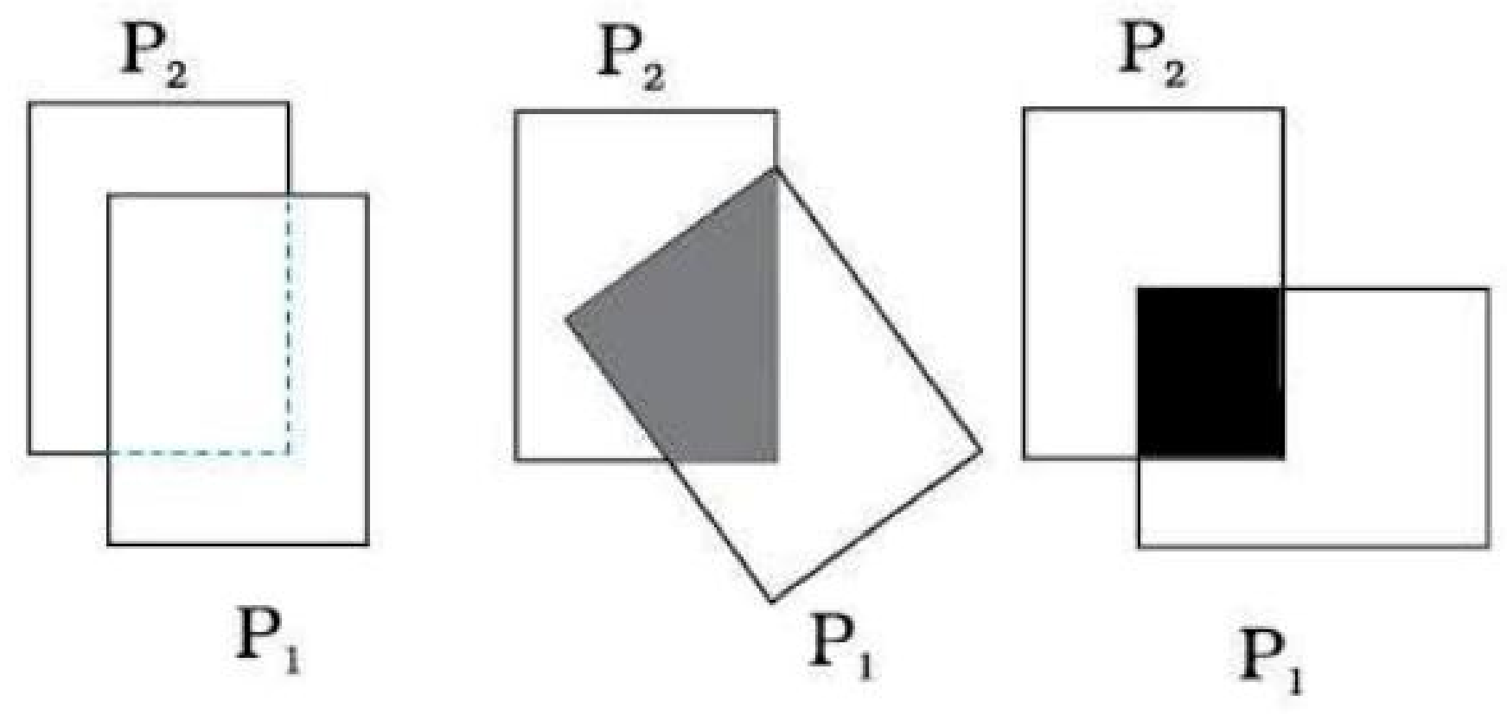
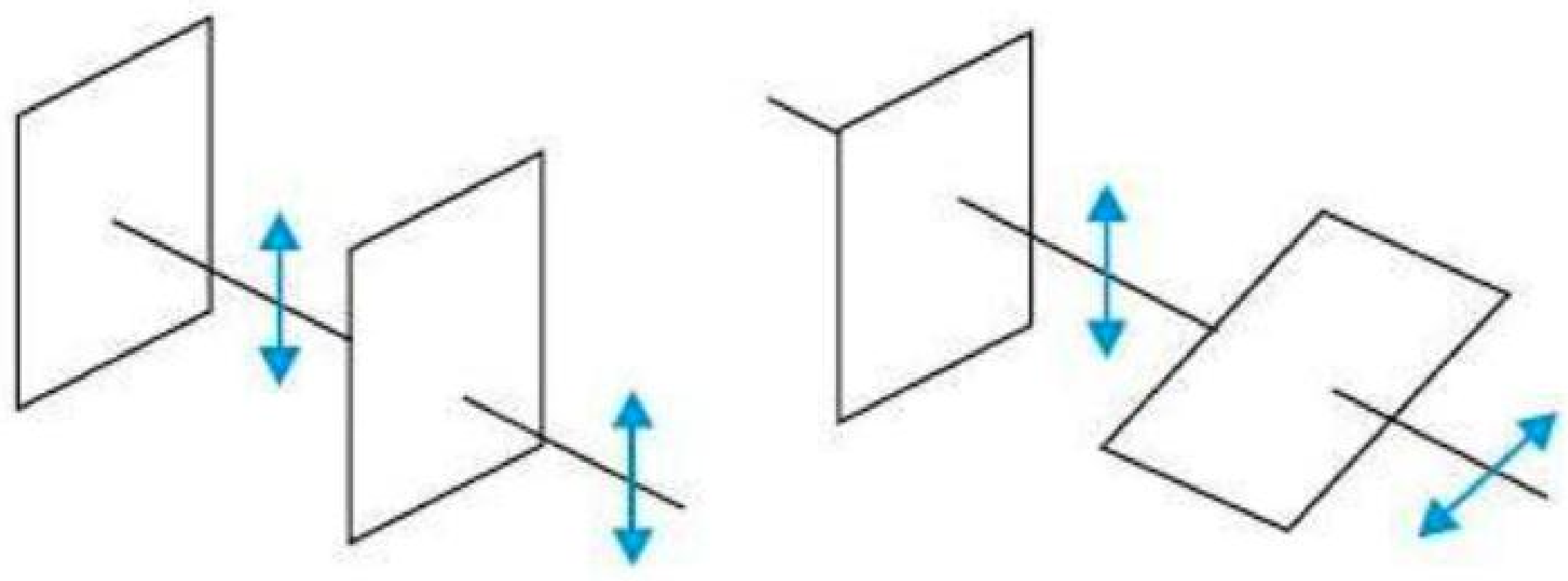
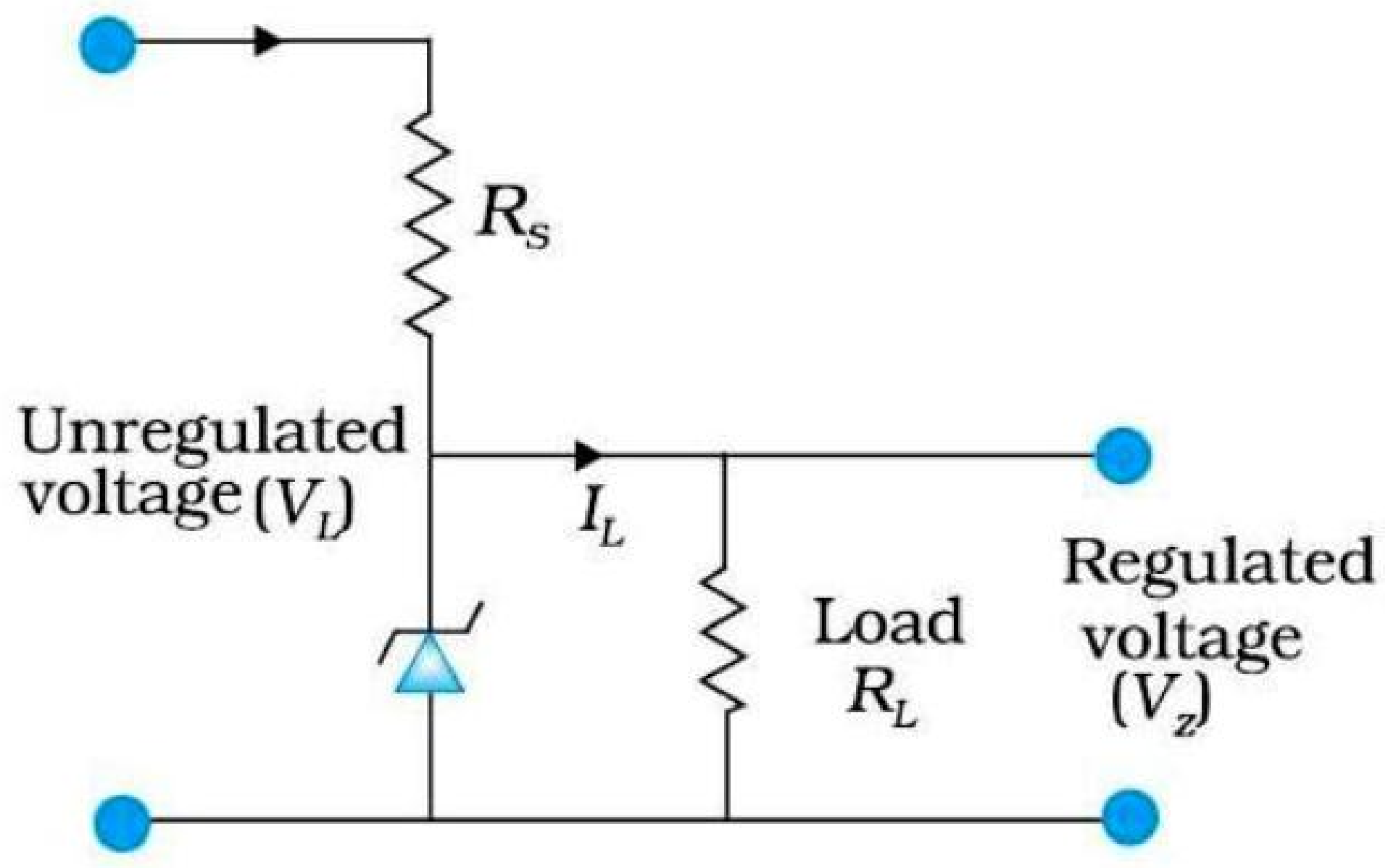
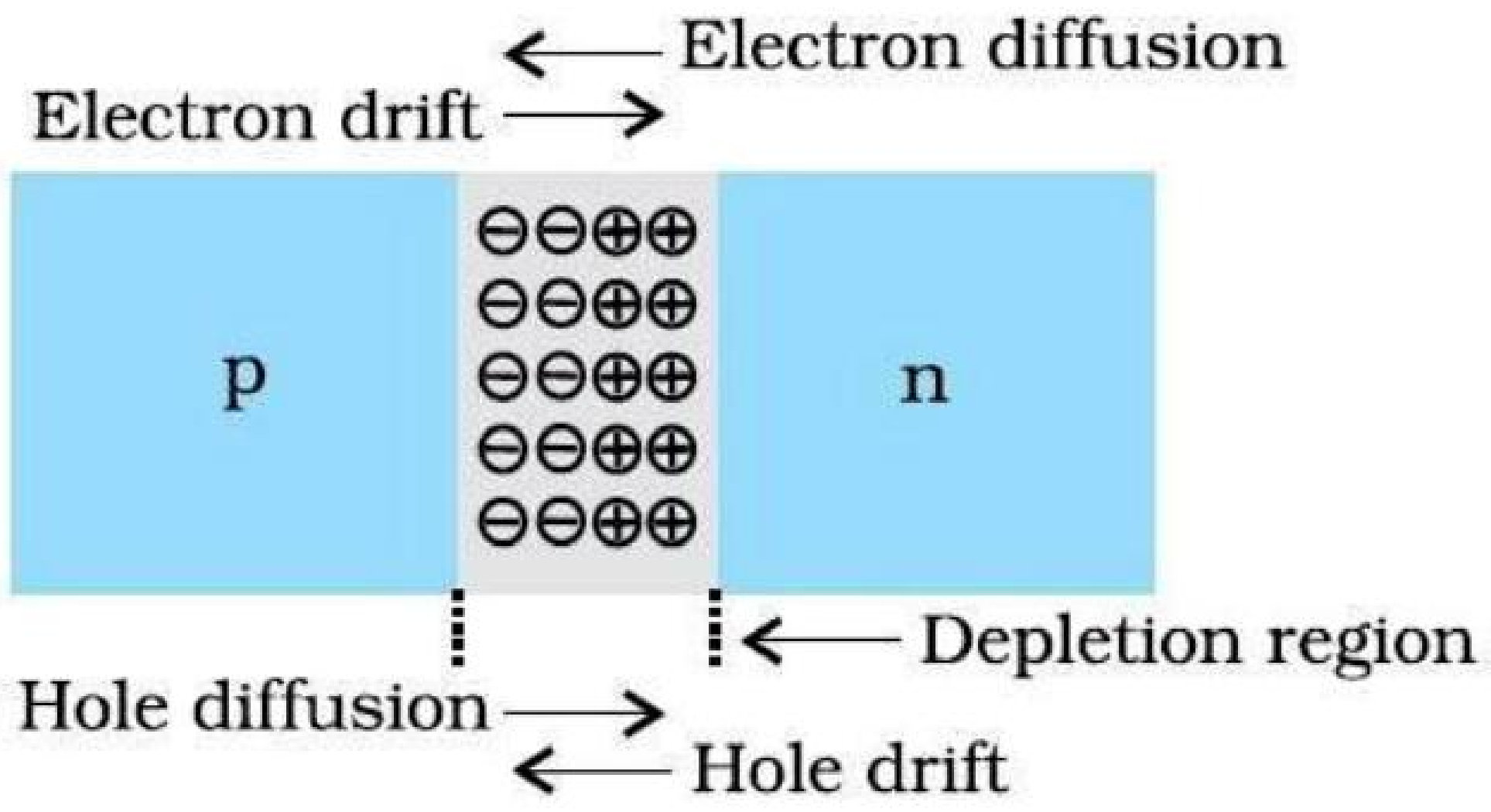
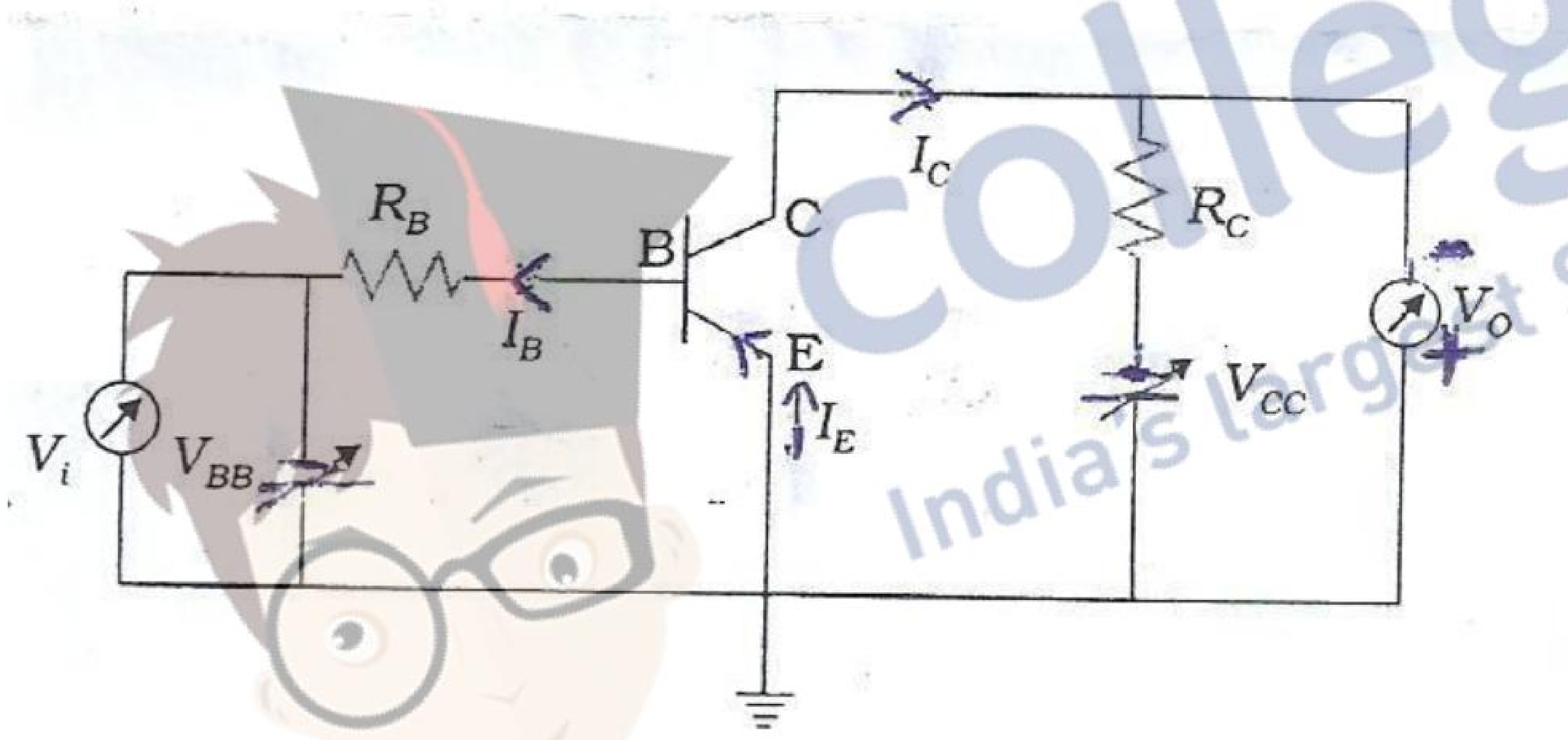
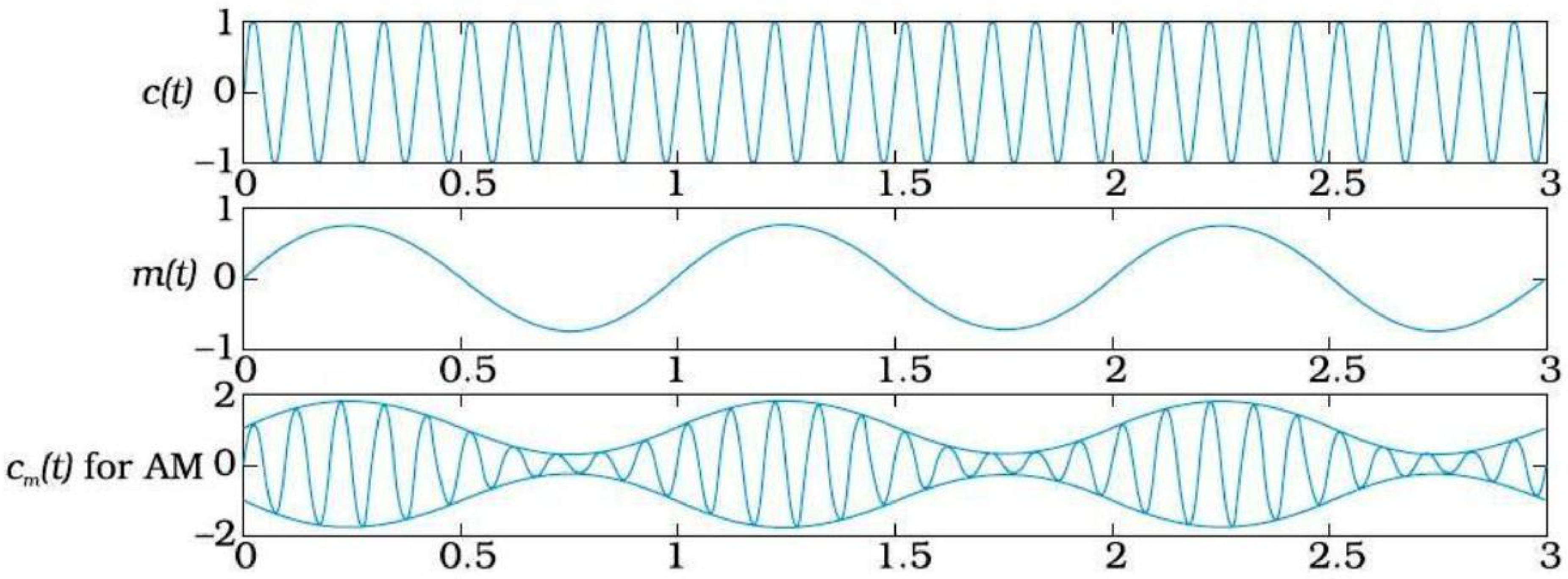
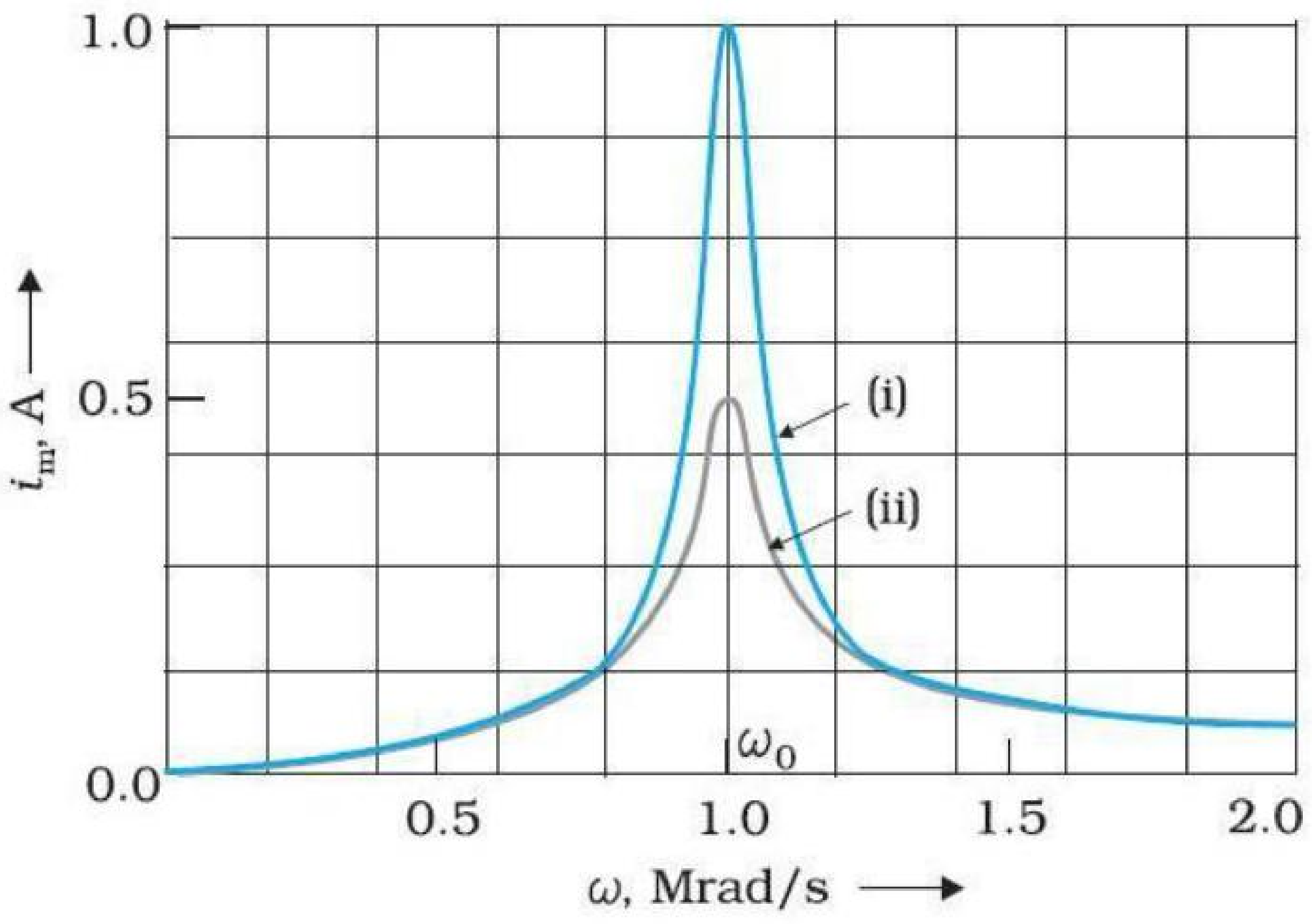
</table>

	Biot Savart's law $\overrightarrow{dB} \propto I \frac{\overrightarrow{dl}\times\vec{r}}{r^3}$	½	
	Or $\overrightarrow{dB} = \frac{\mu_o}{4\pi} I \frac{\overrightarrow{dl}\times\hat{r}}{r^2}$ [Also accept if the student writes $dB \propto I, dB \propto dl \; and \; dB \propto \frac{1}{r^2}$]		
		½	
	Derivation The resultant magnetic field will be along the axis as the perpendicular (to the axis) components cancel out in pairs. $B = \int_o^{e\pi R} dB \; \cos\theta$	½	
	$= \int_o^{2\pi R} \frac{\mu_0}{4\pi} \frac{Idl}{(R^2+x^2)} \; \frac{R}{(R^2+x^2)^{1/2}}$ $= \frac{\mu_0 I}{4\pi} \; \frac{2\pi R^2}{(R^2+x^2)^{3/2}} \; = \; \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$	½	
	At centre, x= 0	½	
	$\therefore B_0 = \frac{\mu_0 I}{2R}$	½	3
Set-1, Q13 Set-2, Q22 Set-3, Q17	Polaroid 1 Transverse nature of light 1 Required Explanation 1		
	Polaroid consists of long chain molecules aligned in a particular direction Transverse nature of light.	1	

		½	
	Alternatively 		
	Explanation: Unpolarised light incident on a polaroid, gets linearly polarized with electric vector oscillating along the pass axis of Polaroid.	½	
	It will pass out with same intensity from P_2, if pass axis of P_2 is parallel to that of P_1. On rotating P_2 intensity of light reduces to zero when their pass axes are perpendicular to each other showing transverse nature of light.	½	
	Explanation for intensity of light Unpolarised light incident on a Polaroid, gets polarized and its intensity is reduced to half and it does not depend on the orientation of the Polaroid.	½	3
Set-1, Q14 Set-2, Q16 Set-3, Q18	Fabrication of Zener Diode ½ Cause of high Electric field ½ Diagram for Zener Diode as Voltage Regulator 1 Working 1		
	Zener diode is fabricated by heavy doping of its p and n sections.	½	
	Since doping is high, depletion layer becomes very thin. Hence, electric field $(=\frac{V}{d})$ becomes high even for a small reverse bias.	½	
		1	
	Working : If input voltage increases/ decreases, current through Zener diode will also increase/ decreases. It increases/ decreases voltage drop across R_s without any change in voltage across R_L as potential across Zener diode does not change in	1	3

	breakdown region giving the regulated output voltage.		
	OR		
	(a) Diagram ½ Formation of depletion region 1 Potential barrier ½ b) Effect on barrier potential 1		
	a) 	½	
	Explanation Due to concentration gradient across p and n sides, holes from p diffuse into n section and leave behind ionized acceptor (negatively) ions which are immobile. As holes continue to diffuse from p to n, a layer of negative charge on p side of junction is formed. Similarly, the diffusion of electrons from n to p will form a positive charge space region on the n side.	1	
	The space charge region on either side of the junction which gets devoid of mobile charge carrier is known as the **depletion layer**.		
	The loss of electrons from n side and holes from p side cause a potential difference across the junction. This is known as the called barrier potential .	½	
	b) Barrier potential decreases in forward bias .	½	
	Barrier potential increases in reverse bias.	½	3
Set-1, Q15 Set-2, Q17 Set-3, Q11	Effect in each case 1½ Justification in each case 1½		
	i) Anode current will increase with increase of intensity	½	
	More is intensity of light, more is the number of photons and hence more number of electrons are emitted	½	
	ii) No effect	½	

	Frequency of light affects the maximum K.E. of the emitted photoelectrons. iii) Anode current will increase with anode potential More anode potential will accelerate the electrons more till it attains a saturation value and get them collected at the anode at a faster rate.	½ ½ ½	3
Set-1, Q16 Set-2, Q18 Set-3, Q12	Active state ½ Circuit diagram 1 Working ½ Reasons in each case 1 <u>Active State :</u> When the emitter base junction is forward biased and the base collector junction is reverse biased with $V_i > 0.6V \ or \ V_i > 0.3V$. (Also accept any other correct answer) <u>Diagram</u> :  $= V_{CE}$ <u>Explanation</u> : If V_i is +ve or –ve , changes in V_{BE} will produce changes in I_c and hence changes in V_{CE} which will appear in amplified form <u>Base</u> is thin so that there are few majority carriers in it. <u>Emitter</u> is heavily doped so that it supplies more number of majority charge carriers. (Note: Award 1 mark if the student writes the reason for any one case)	½ 1 ½ ½ ½	3
Set-1, Q17 Set-2, Q19 Set-3, Q13	Factors for need of modulation 1½ Sketch of carrier wave, modulating wave and AM wave 1½ <u>Need of Modulation:</u> 1. To have smaller height of antenna $[h \sim \frac{\lambda}{4}]$	½	

	2. So that more power is radiated by the antenna, $P \propto \frac{1}{\lambda^2}$	½	
	3. To avoid mixing up of signals from different ransmissions.	½	
		½ ½ ½	3
Set-1, Q18 Set-2, Q11 Set-3, Q14 .	Identification of circuit elements 1½ Impedance value ½ Plot of circuit vs frequency ½ Significance of plot ½		
	Identification of elements		
	X- Resistor	½	
	Y- Inductor	½	
	Z- Capacitor	½	
	Impedence Z=R Since $X_L = X_C$ (Also accept if the student writes $Z = \sqrt{R^2 + (X_L - X_C)^2}$ = R	½	
	Plot of current vs frequency 	½	
	(Only one curve is expected) Significance, at $w = \omega_o$ (resonance frequency) current is maximum (Alternatively: Gives information about sharpness of resonance or quality factor of the circuit)	½	3

Set-1, Q19 Set-2, Q12 Set-3, Q21	Equation of β^{+} decay 1 Identification ½ Calculation of mass defect ½ Calculation of Q value 1		
	Equation ${}^{11}_{6}C \rightarrow {}^{11}_{5}X + i^{e} + v + Q$	1	
	(Also accept if the student does not write v or Q on the R.H.S.)		
	X is an isobar	½	
	Mass defect (Δm) = $m({}^{11}_{6}C) - m({}^{11}_{5}X)$	½	
	= (11.011434 – 11.009305)u		
	= 0.002129 u	½	
	Q= Δm ×931.5 MeV		
	= 0.002129 × 931.5 MeV	½	3
	= 1.98 MeV		
Set-1, Q20 Set-2, Q13 Set-3, Q22	Calculation to find image formed by lens 1½ Nature of image ½ Distance of mirror from lens 1		
	For lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$	½	
	$\frac{1}{v} - \frac{1}{-15} = \frac{1}{+10}$	½	
	$\frac{1}{v} + \frac{1}{15} = \frac{1}{10}$	½	
	$\therefore v = 30$ cm		
	Nature of image- real, magnified	½	
	Final image formed will be at the object itself only if image formed by lens is at the position of centre of curvature of mirror	½	
	$\therefore D = (30 + R)cm = (30 + 20)cm = 50\ cm$ (Distance of mirror from lens)	½	3

Set-1, Q21 Set-2, Q14 Set-3, Q19	Arranging in order 1½ Production of infrared waves ½ Role of infrared waves in Earth's warmth and physical therapy 1		
	Gamma(γ) rays, X-rays, Microwaves, Radiowaves	1½	
	Infrared rays are produced by hot bodies / vibration of atoms and molecules	½	
	Infrared rays: (i) Maintain Earth's warmth through green house effect	½	
	(ii) Produce heat	½	3
Set-1, Q22 Set-2, Q15 Set-3, Q20	Process of charging capacitor 1 Effect of dielectric on (i) Electric field and justification ½+½ (ii) Energy stored and justification ½+½		
	Process of charging		
	The electrons, from the plate of the capacitor, which is connected to the positive terminal of the battery, move towards the battery. The reverse	½	
	happens at the other plate. Hence, the plates get positively and negatively charged respectively.	½	
	Effect of dielectric		
	(a) Electric fields decreases	½	
	Justification	½	
	Because initially $E_1 = \frac{\sigma}{\varepsilon_0}$ and finally $E_2 = \frac{1}{K} \cdot \frac{\sigma}{\varepsilon_0}$, $E = \frac{E_1}{K}$		
	(b) Energy stored increases	½	
	New capacitance $C = \left(\frac{\varepsilon_0 A}{2d}\right) k$ $= \frac{K}{2} C_o, \quad \therefore C < C_o$ Initially Energy $= \frac{Q^2}{2C}$ and Energy $= \frac{Q^2}{C} \cdot \frac{2}{K}$ as $1 < K < 2$	½	3
	Section – D		
Set-1, Q23 Set-2, Q23 Set-3, Q23	Necessity 1 Explanation; low power factor implies large power loss? 1 Two values each displayed by Ajit and his uncle 1+1		

<table>
<tr><td></td><td>a) For the same power at high voltage, current in the transmission wires becomes smaller.
∴ power loss is less</td><td>½
½</td><td></td></tr>
<tr><td></td><td>[Award ½ mark if the student just writes $P = I^2R$]</td><td></td><td></td></tr>
<tr><td></td><td>b) If power factor is less, current in the cables is more so power loss is more
[Alternately $P_{av} = E_v I_v \cos\theta$</td><td>1</td><td></td></tr>
<tr><td></td><td>If $\cos\theta$is less, I_v is more so power loss is more]
(Award ½ mark if the student just writes $P = E_E I_v \cos\theta$</td><td></td><td></td></tr>
<tr><td></td><td>c) Values displayed
By Ajit (Any two) – Social Awareness, understanding nature, concern for society</td><td>½ +½</td><td></td></tr>
<tr><td></td><td>By Uncle- Knowledgeable, professional honesty, concern for society.
(Also accept other suitable values)</td><td>½ +½</td><td>4</td></tr>
<tr><td colspan="4">Section - E</td></tr>
<tr><td>Set-1, Q24
Set-2, Q26
Set-3, Q25</td><td><table>
<tr><td>Definition of self-inductance</td><td>1</td></tr>
<tr><td>Expression for energy stored</td><td>2</td></tr>
<tr><td>Direction of induced current</td><td>½</td></tr>
<tr><td>Duration of induced current</td><td>½</td></tr>
<tr><td>Graphs of magnetic flux and induced e.m.f</td><td>1</td></tr>
</table></td><td></td><td></td></tr>
<tr><td></td><td>a) Self inductance of a coil is numerically equal to magnetic flux linked with the coil when unit current passes through it. $L = \frac{\varphi}{I}$
Alternately
Self inductance of a coil is numerically equal to induced e.m.f. produced in it when rate of change of current is unity in it.</td><td>1</td><td></td></tr>
<tr><td></td><td>Expression for energy
Induced e.m.f. produced in coil, $\varepsilon = -L\frac{dI}{dt}$</td><td>½</td><td></td></tr>
<tr><td></td><td>∴ work done by the source, dw= $+\varepsilon Idt = LIdI$</td><td>½</td><td></td></tr>
<tr><td></td><td>$W = \int_O^I LIdI = \frac{1}{2}LI^2$</td><td>½+½</td><td></td></tr>
<tr><td></td><td>b) Direction of induced current – clockwise (MNOP)
[A student can also show the direction in the diagram itself]</td><td>½</td><td></td></tr>
<tr><td></td><td>Duration of induced current - 1s</td><td>½</td><td></td></tr>
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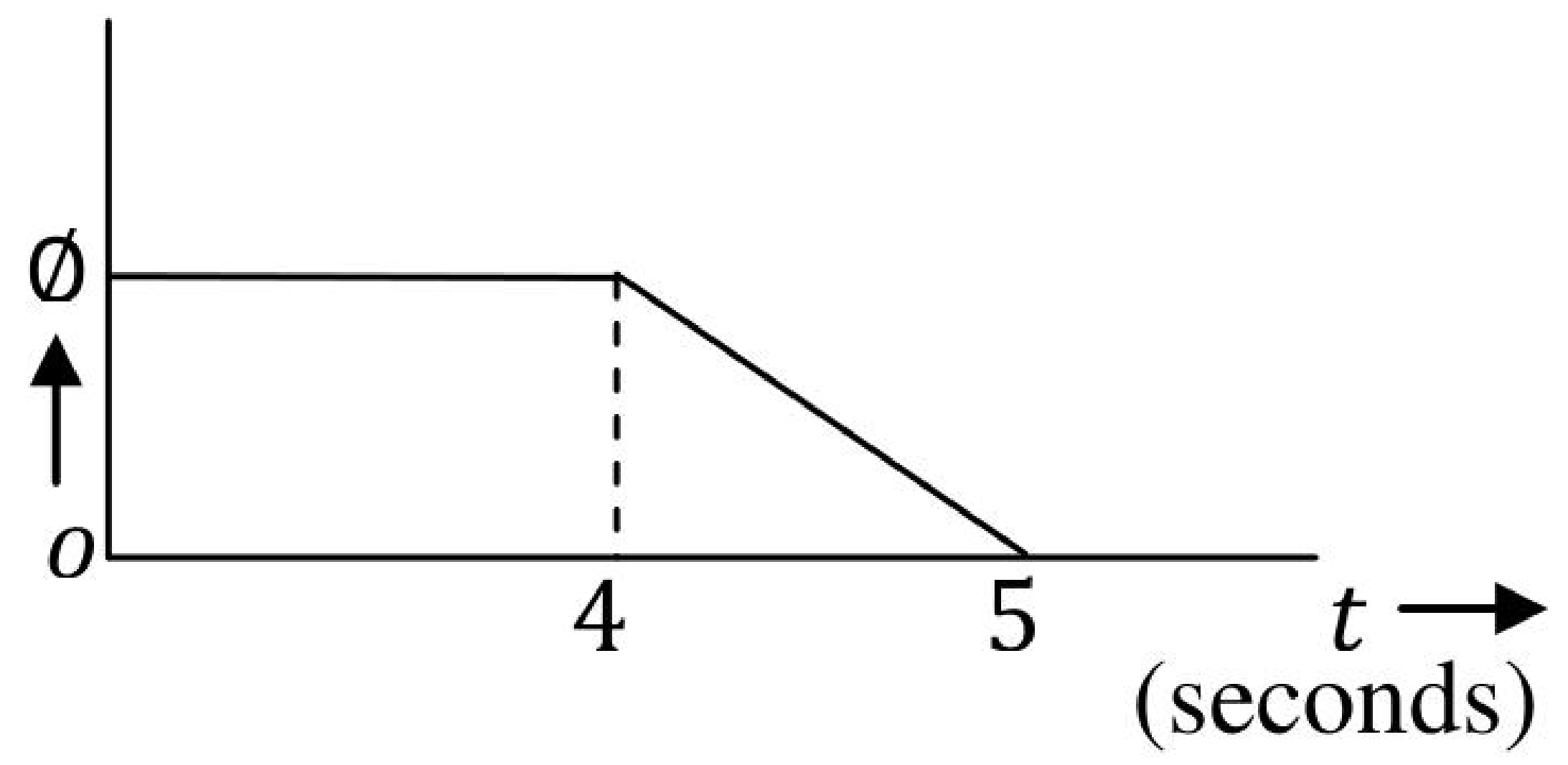
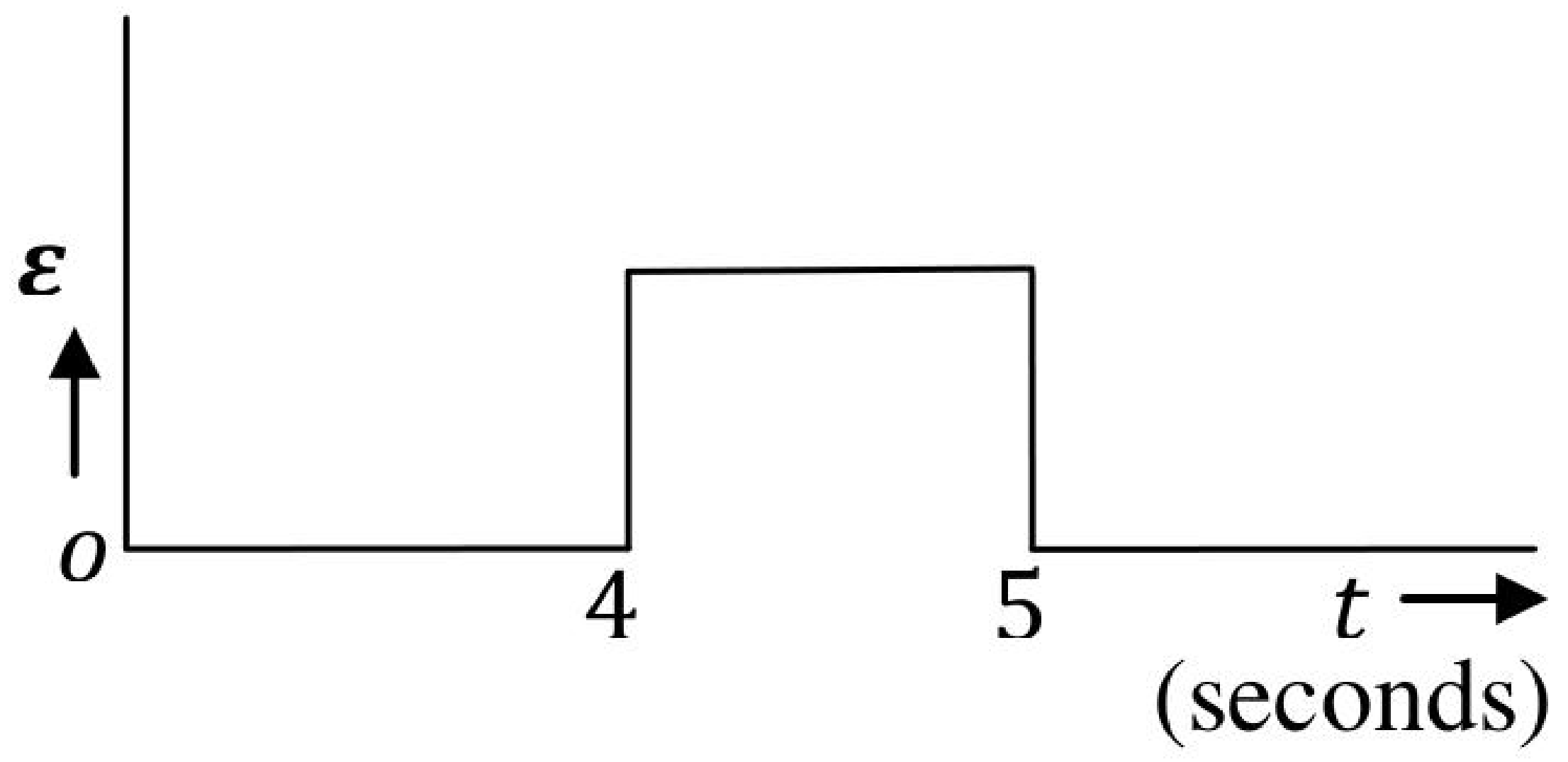
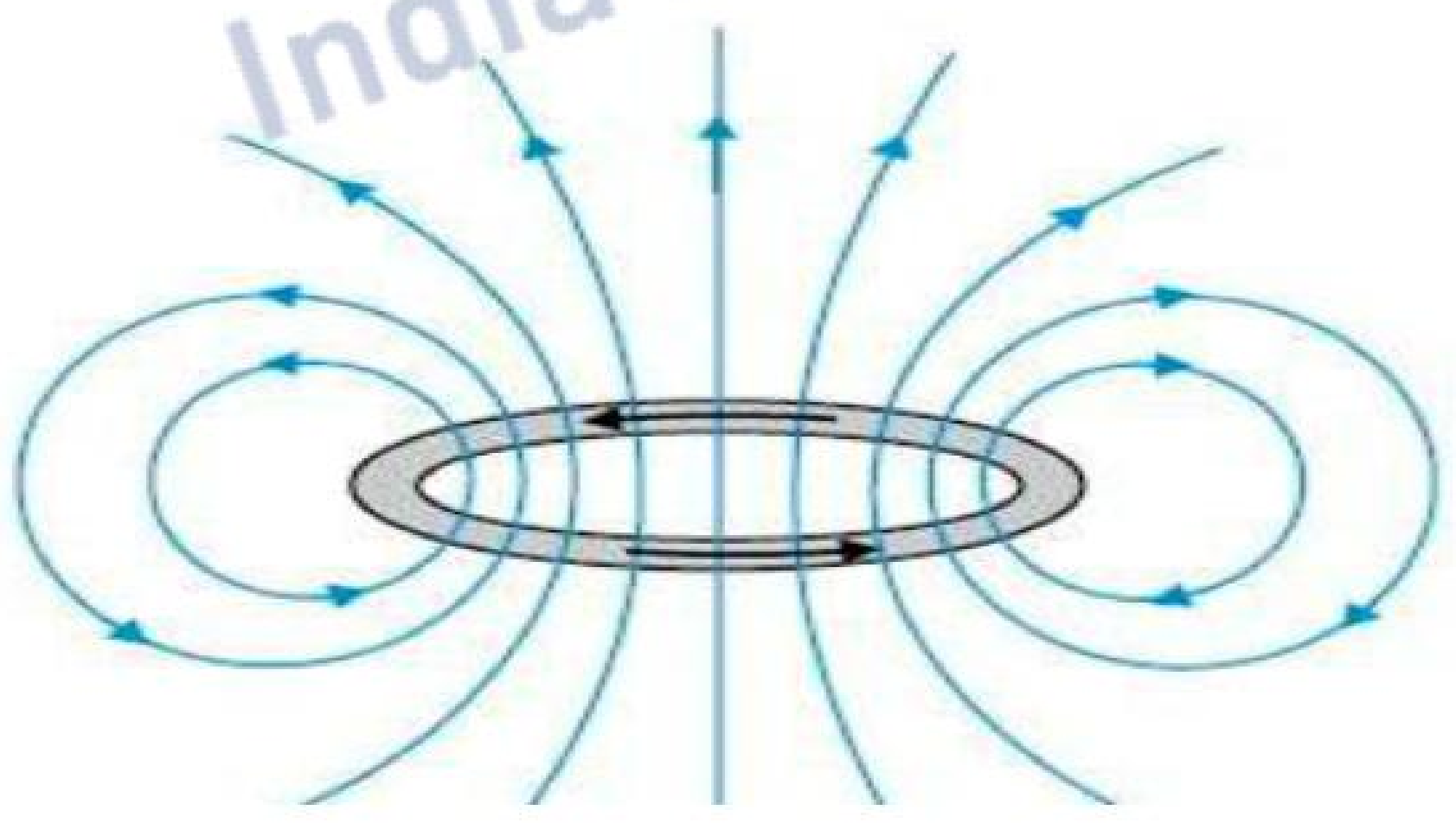
	Plot of graph  	½	
	 	½	5
	(Award this 1 mark even if the student draw the two graphs correctly without mentioning the values on the time axis)		
	OR		
	Plot of magnetic field lines 1 To show, $\vec{m} = I\vec{A}$ 1 Expression for magnetic field due to finite solenoid and comparison with bar magnet 3		
	(a) 	1	
	Magnetic field due to circular loop on its axis for far off points		
	$B = \frac{\mu_0}{4\pi}\frac{2IA}{x^3}$	½	
	Magnetic field due to bar magnet at an axial point		
	$B = \frac{\mu_0}{4\pi}\frac{2m}{x^3}$	½	
	By comparison m = IA		
	[**Alternatively:** Students can also get this equality by comparing the torque values in the two cases]		

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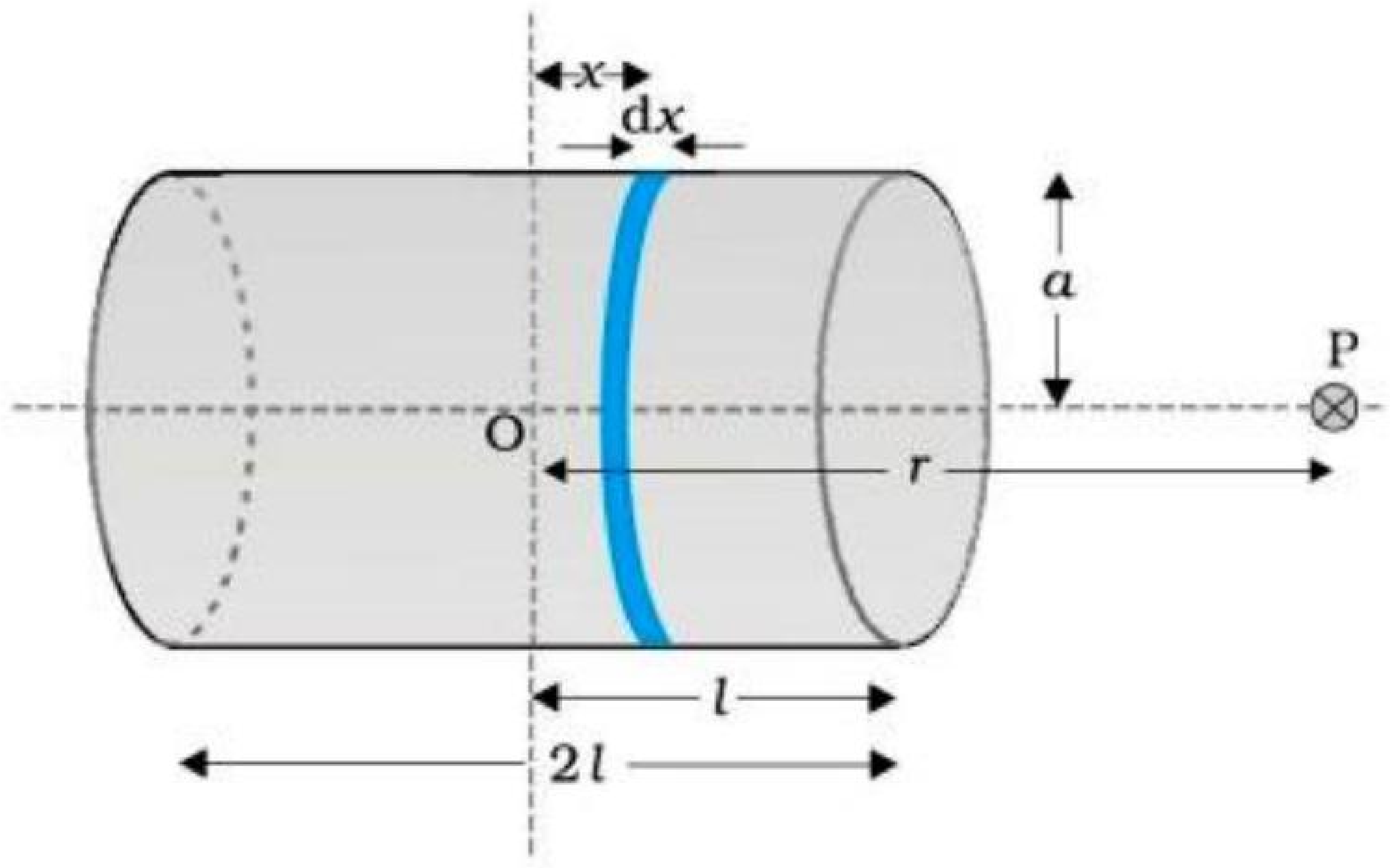
a) Magnetic field on the axis of a finite solenoid



</td><td>1</td><td></td></tr>
<tr><td></td><td>

Magnetic field due to element dx at point P

$$dB = \frac{\mu_0 n dx I\, a^2}{2[(r-x)^2 + a^2]^{3/2}}$$

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

$$\therefore B = \int dB = \frac{\mu_0 I a^2 \times n}{2} \int_{-l}^{+l} \frac{dx}{[(r-x)^2 + a^2]^{3/2}}$$

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

For r >> a, (r >> l)

</td><td>½</td><td></td></tr>
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$$\therefore B = \frac{\mu_0 I a^2 n}{2 \times r^3} \int_{-l}^{+l} dx = \frac{\mu_0 n I}{2} \frac{2la^2}{r^3}$$

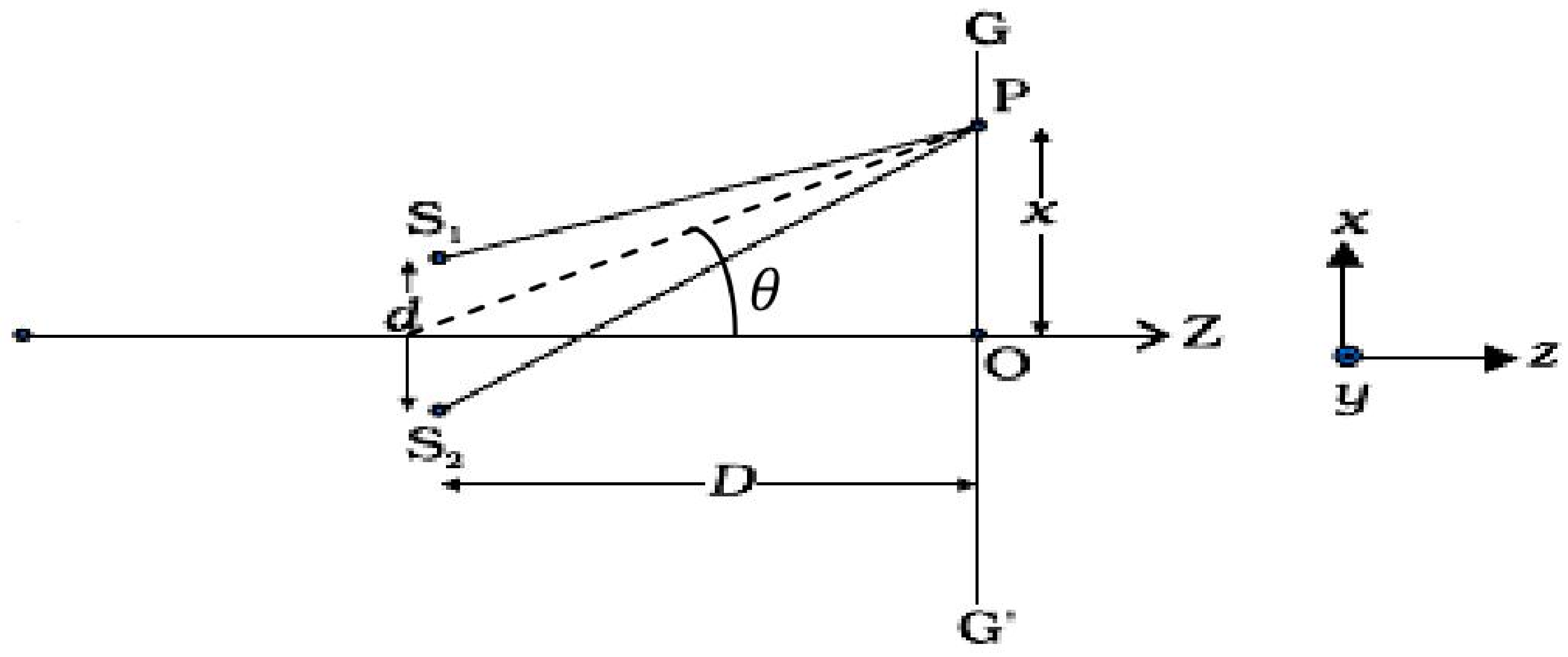
Magnetic moment of solenoid, $m = (n \times 2l)I(\pi a^2)$

$\therefore B = \frac{\mu_o}{4\pi} \frac{2m}{r^3}$ same as that of a bar magnet

</td><td>½</td><td>5</td></tr>
<tr><td>Set-1, Q25
Set-2, Q24
Set-3, Q26</td><td>

Conditions for constructive and destructive interference 1½
Expression for fringe width 2
Fringe pattern in double slit related to diffraction pattern ½
Numerical 1

Diagram



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

(a) Path difference $(\Delta) = S_2P - S_1P = d\ \sin\theta = \frac{dx}{D}$ ½

For constructive interference, $\Delta = n\lambda\ [n = 0,1,2..]$ ½

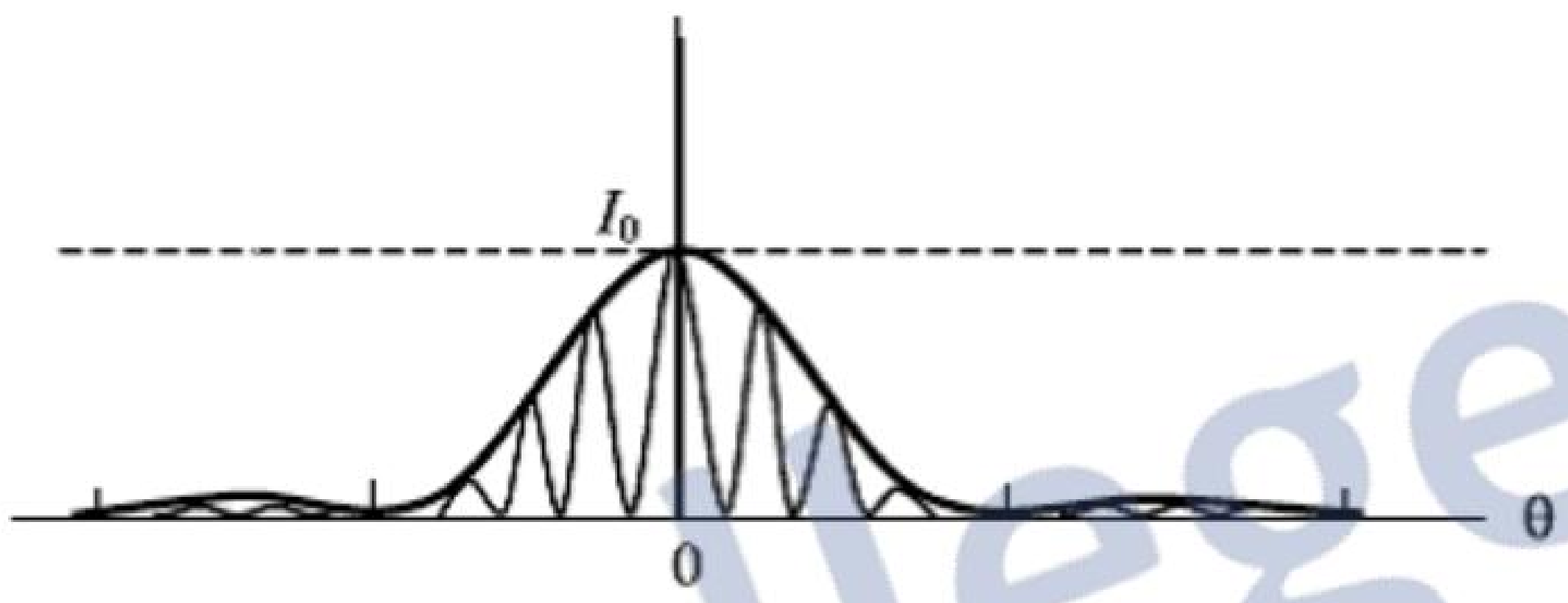
Destructive interference, $\Delta = (2n-1)\frac{\lambda}{2}[n = 1,2..]$ ½

For bright bands, $\Delta = n\lambda = \frac{x_n d}{D}\ or\ x_n = \frac{n\lambda D}{d}$ ½

For dark bands, $\Delta = (2n-1)\frac{\lambda}{2} = \frac{x_n d}{D}\ or\ x_n = (2n-1)\frac{\lambda D}{2d}$ ½

Fringe width $\beta = X_n - X_{n-1} = \frac{\lambda D}{d}$ ½

b)



½

[Alternately
It is a broader diffraction peak in which there appears several fringes of smaller width due to double slit interference pattern]

(c) 10 β= width of central maxima

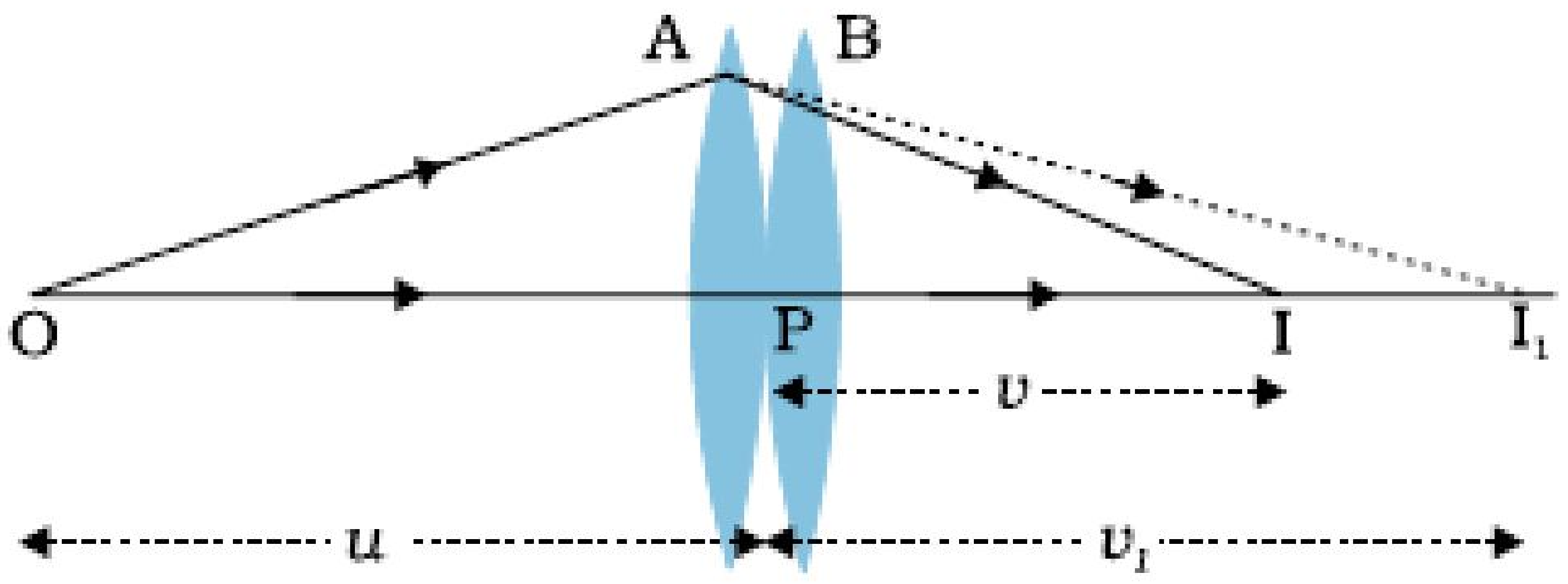
$$10\frac{D\lambda}{d} = 2\frac{D\lambda}{a}$$ ½

$$a = \frac{d}{5} = \frac{1}{5}mm = 0.2\ mm$$ ½

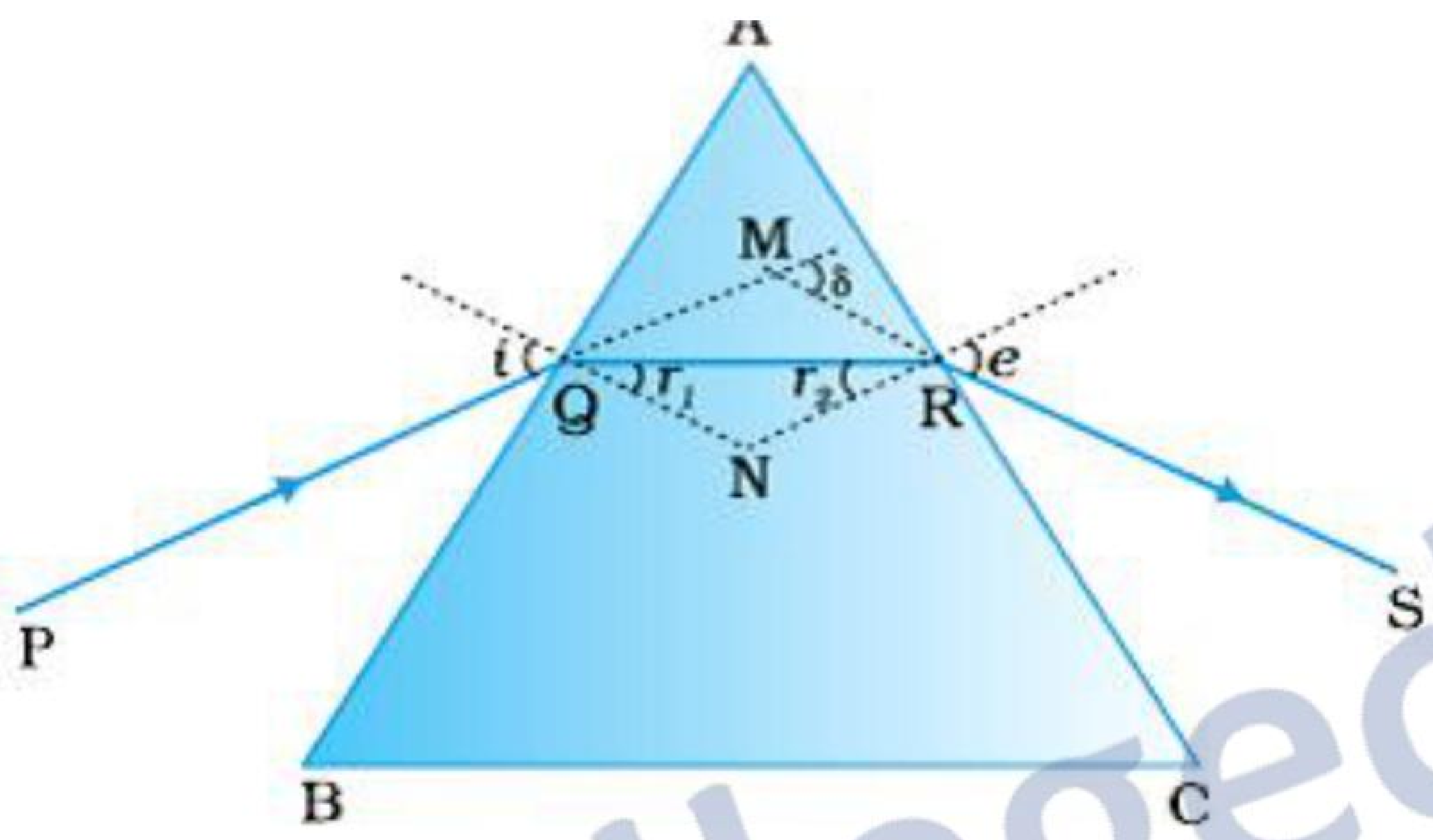
5

OR

Diagram for image formation	½
Derivation for combines focal length	1½
Ray diagram through prism	1
Calculation of angle of incidence and angle of deviation	2



½

	For First lens $\frac{1}{v_1}-\frac{1}{u}=\frac{1}{f_1}$ (i) For Second lens $\frac{1}{v}-\frac{1}{v_1}=\frac{1}{f_2}$ (ii) By adding i) and ii) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f_1}+\frac{1}{f_2}$ Or $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$ b) Ray Diagram  Given A=60°, $\mu=\sqrt{3}$ It is minimum deviation position of prism, $\therefore r=\frac{A}{2}=30°$ $\mu=\frac{\sin i}{\sin r}$ $\therefore \sqrt{3}\times\sin 30=\sin i$ $\Rightarrow i=60°$ $\therefore e=60°$ $i+e=A+D$ $60+60=60+D \therefore D=60°$ Alternately $[i=\frac{A+D_m}{2} \quad \therefore D_m=60°]$	½ ½ ½ 1 ½ ½ ½ ½	5
Set-1, Q26 Set-2, Q25 Set-3, Q24	Expression for potential energy 2 Numerical 3 a) Expression for potential energy i) To bring charge q_1 from ∞ to point$(\overrightarrow{r_1})$ Work done = $W_1 = q_1V(r_1)$	½	

ii) To bring charge q_2 from ∞ to point$(\overrightarrow{r_2})$

Work done = $W_2 = q_2 V(r_2) + \frac{1}{4\pi\varepsilon_o} \cdot \frac{q_1 q_2}{r_{12}}$ ½

∴ Potential energy $U = W_1 + W_2 = q_1 V(r_1) + q_2 V(r_2) + \frac{K q_1 q_2}{r_{12}}$ 1

b) $U_i = \frac{1}{4\pi\varepsilon_o}\left[\frac{Q\times 2Q}{l} + \frac{Q(-3)Q}{l} + \frac{2Q\times(-3)Q}{l}\right]$ 1

$= - \frac{1}{4\pi\varepsilon_o}\frac{7Q^2}{l}$

$$U_f = \frac{1}{4\pi\varepsilon_o}\left[\frac{Q \times 2Q}{\frac{l}{2}} + \frac{Q(-3)Q}{\frac{l}{2}} + \frac{2Q \times (-3)Q}{\frac{l}{2}}\right]$$

$= - \frac{1}{4\pi\varepsilon_o}\frac{14Q^2}{l}$ 1

$W = U_f - U_i = - \frac{1}{4\pi\varepsilon_o}\frac{7Q^2}{l}$ 1 5

(If a student writes $U_i = \frac{1}{4\pi\varepsilon_o}\left[\sum\sum\frac{q_i q_j}{r_{ij}}\right]$, award ½ mark)

Or

Definition of electric flux	1
S.I. unit	½
State and explain Gauss's law	1½
Outward flux	1
Flux is independent of shape and size	1

Electric flux through a given area is defined as the number of electric field lines crossing normally through that area 1

[Alternately,
Electric flux is the surface integral of electric field over the surface

$\Phi = \oint \vec{E}.\overrightarrow{ds}$]

S.I. unit - Nm^2C^{-1} or Vm ½

Gauss Law: Electric flux through a given closed surface is $\frac{1}{\varepsilon_o}$ times the charge enclosed by the closed surface 1½

$[Alternatively: \phi = \frac{q}{\varepsilon_o}]$

Flux of a point charge placed at the centre of cube = $\frac{q}{\varepsilon_o}$ 1

	As the Electric field is radial and inversely proportional to the square of distnce. Therefore, it is independent of shape and size. The number of electric field lines, crossing normally through a closed surface depends only on the charge enclosed by it.	1	5