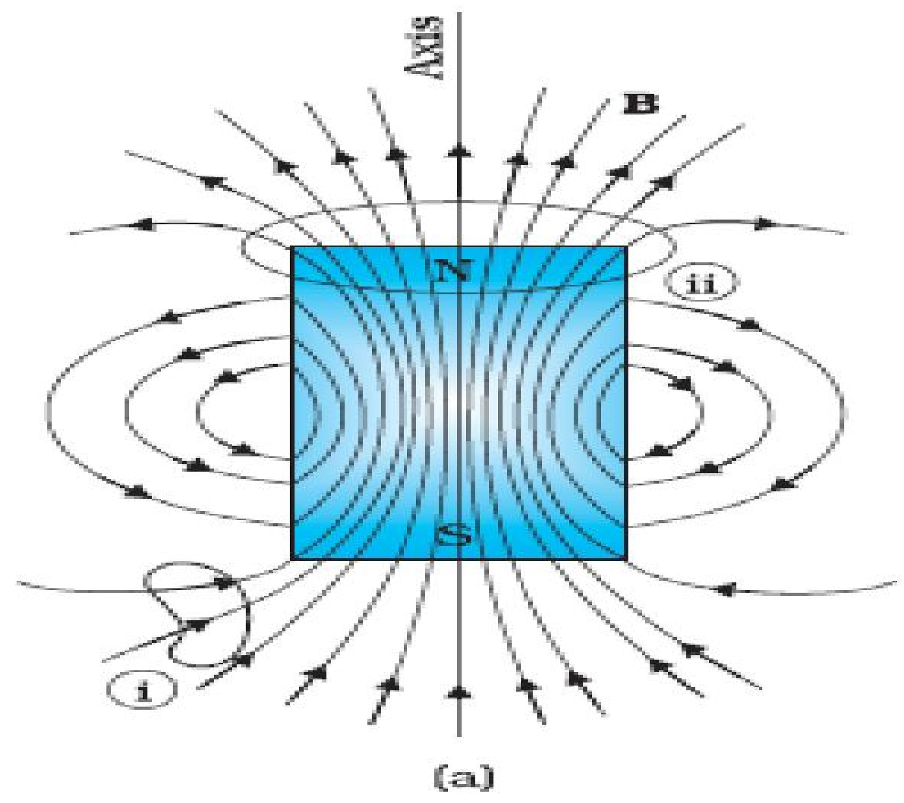
MARKING SCHEME (COMPARTMENT) 2019

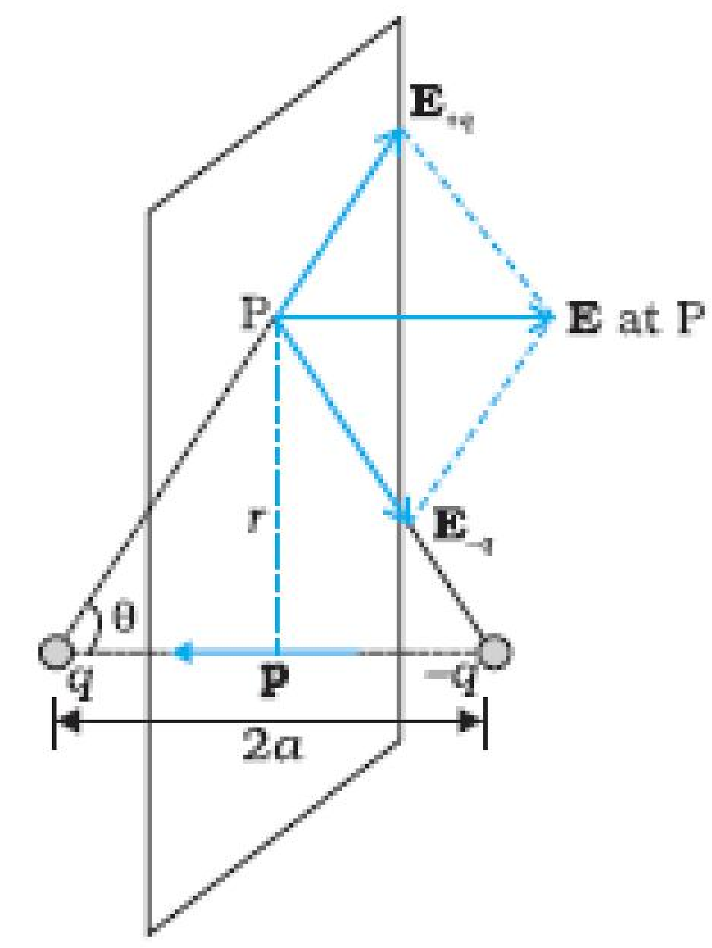
SET: 55/1/3

Q. NO.	VALUE POINTS/ EXPECTED ANSWERS	MARKS	TOTAL MARKS
	SECTION - A		
1.	Most energetic radiation: Gamma rays Frequency range: 10^{18} to 10^{23} Hz **OR** (i) Ultra violet rays (ii) Frequency range: 10^{15} to10^{17} Hz	½ ½ ½ ½	1 1
2.	The three basic units of a communication system are 1. Transmitter 2. Medium (Channel) 3. Receiver (Note : Award ½ mark if the student writes the correct name of one or two of these three basic units)	1	1
3.	Some mass "gets lost" / "gets converted into energy" and this "mass defect" provides the "binding energy" that ensures that stability of the nucleus. [Alternatively: The "lost mass" provides the "binding energy" that ensures the stability of the nucleus.]	1	1
4.	Frequency of photon ν=E/h $= \frac{2eV}{6.63 \times 10^{-34}\ Js}$ $= \frac{2 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}} Hz$ $= 4.8 \times 10^{14}$Hz [Award the last ½ mark even if the student just makes a correct substitution but does not calculate the value of ν] **OR** (i) Yes (ii) The photo electric current is dependent on the intensity of incident radiation Because the change of intensity changes the number of photons incident per second on the photo sensitive surface.	½ ½ ½ ½	 1 1
5.	The (required) magnetic fields lines are shown.  	1	1

SECTION - B

6.

Diagram	½
Electric field due to point charges	½
Net electric field	1



½

$$E_{+q} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2 + a^2)}$$

$$E_{-q} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2 + a^2)}$$ ½

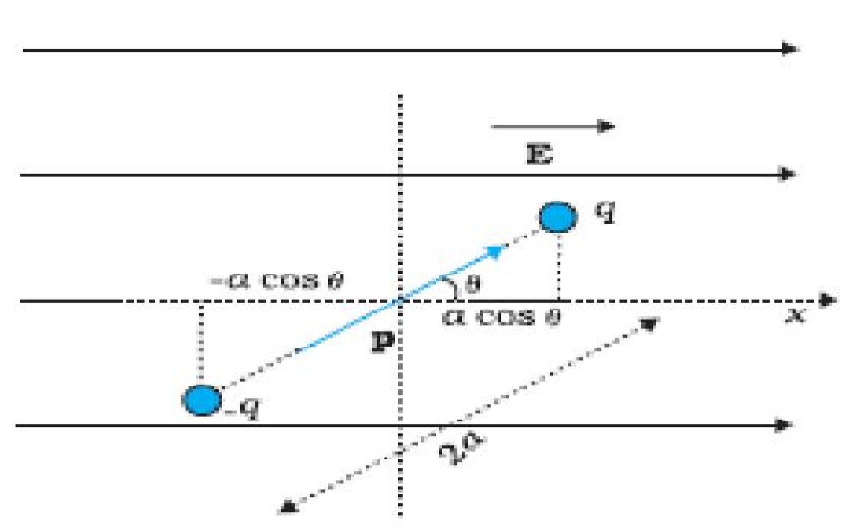
$$E = E_{+q}cos\theta + E_{-q}cos\theta$$

$$= 2E_{+q}cos\theta$$ ½

$$= \frac{2qa}{4\pi\epsilon_0(r^2 + a^2)^{3/2}}$$ ½ | 2

OR

Diagram	½
Expression for torque	½
Expression for P.E.	½
Minimum value of P.E.	½

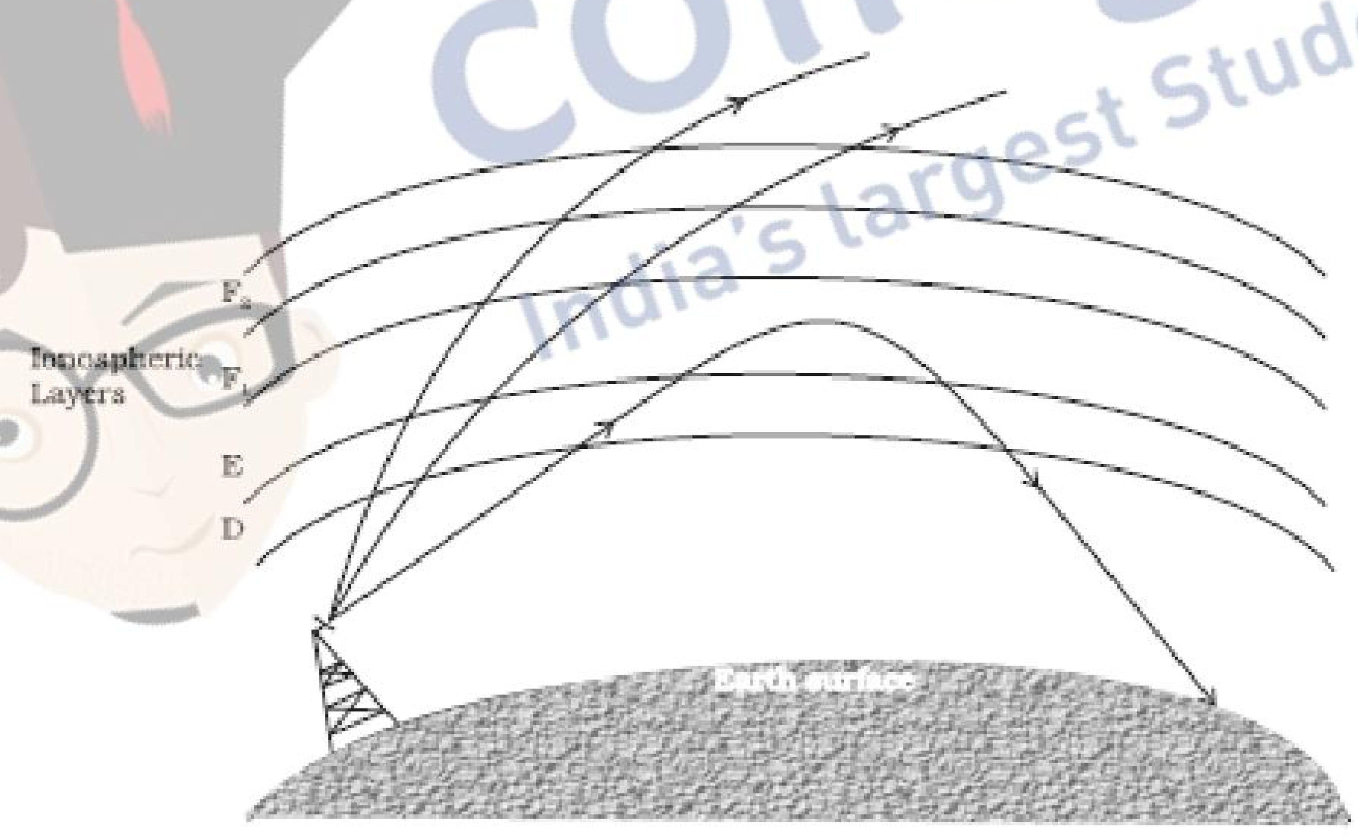


½

Torque $\tau = pEsin\theta$

$$P.E. = W = \int_{\theta_0}^{\theta} pE\ sin\theta\ d\theta$$ ½

$$= -pE\ (cos\theta\ - cos\theta_0)$$ ½

	$= -pE\ cos\theta$ (for θ_0=π/2) ∴ Minimum value of P.E. = - p E [Note: Award the last ½ mark even if the student quotes zero (0) as the minimum value of P.E. which corresponds to the choice $\theta_0 = 0$ (or writes that this cannot be precisely specified as it depends on the choice of θ_0)]	½	2
7.	Estimation of the ratio of wavelengths associated with the electron 2 For standing waves (of de Broglie wavelength λ_n) of electrons revolving in a circular orbit, we have $2\pi r_n = n\lambda_n$ But $r_n = n^2 r_0$ => $2\pi n^2 r_0 = n\lambda_n$ and $\frac{\lambda_1}{\lambda_3} = \frac{1}{3}$	½ ½ ½ ½	2
8.	Sketch 1 Explanation of restriction of frequency range 1 The sketch, showing the sky wave mode of propagation.  The sky wave mode propagation is based on the reflection of e.m. waves by the ionosphere layers. The frequency range, in the sky wave mode, is restricted to about 30 MHz because e.m. waves of frequency higher than 30 MHz, penetrate the ionosphere and escape. (Note : Award the last 1 mark even if the student writes only the second part of the above explanation.)	1 ½ ½	3
9.	Formula for Induced Emf 1 Calculation of Induced Emf 1 $E = \frac{1}{2}B\omega r^2$	1	

$$= \left[\frac{1}{2} \times 8 \times 10^{-5} \times 4\pi \times (0.5)^2\right] V$$ ½

$$= 12.56 \times 10^{-5} V$$ ½ — 2

OR

Formula for Induced Emf	1
Calculation of Induced Emf	1

$$\varepsilon = \frac{-d\phi}{dt}$$ ½

$$= -A\frac{dB}{dt}$$ ½

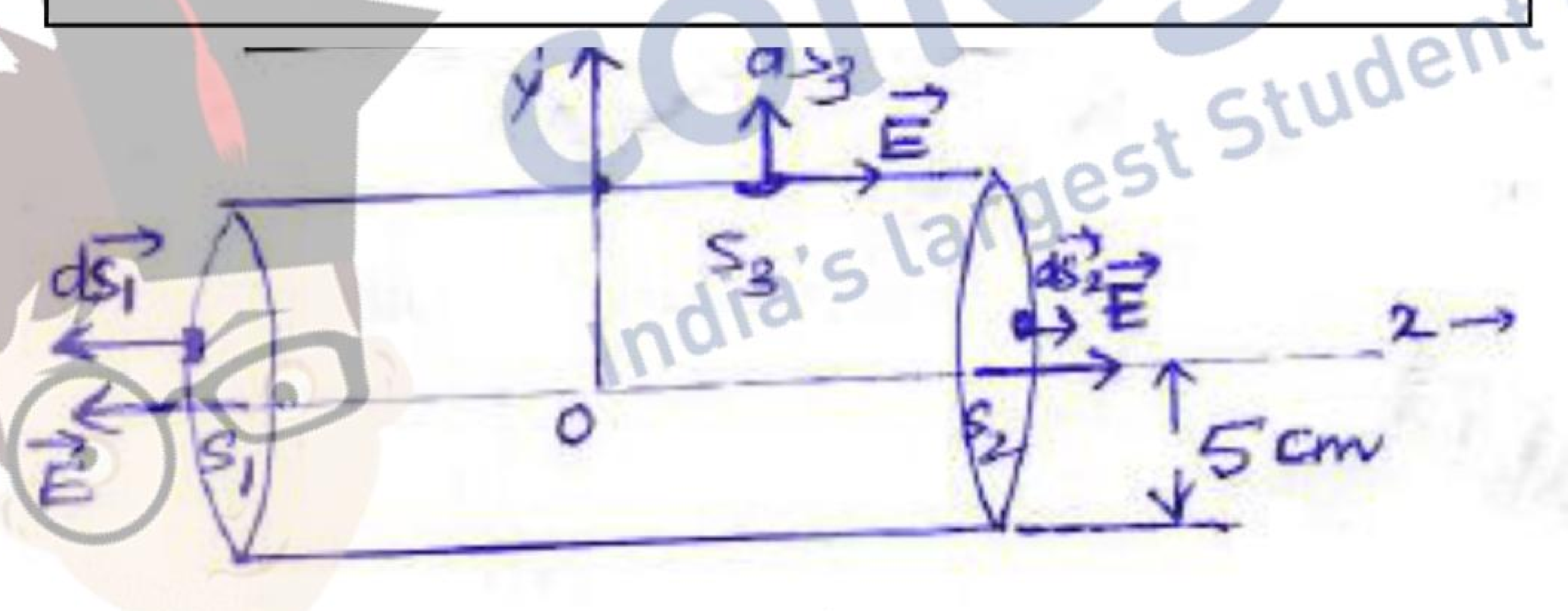
$$= -A\frac{dB}{dx} \times \frac{dx}{dt} = -Av\frac{dB}{dx}$$ ½

$$= -[(0.1)^2 \times (-8 \times 10^{-3})]V$$ ½

$$= 8 \times 10^{-5} V$$ — 2

10.

Diagram	½
Formula of Flux	½
Calculation of the net outward Flux	1



½

$$flux = \oint \vec{E}.\vec{ds}$$ ½

Alternatively $\emptyset = \int Eds \, Cos \, \theta$

$$\emptyset = \int \vec{E}\cdot \vec{ds_1} + \int \vec{E}\cdot \vec{ds_2} + \int \vec{E}\cdot \vec{ds_3}$$

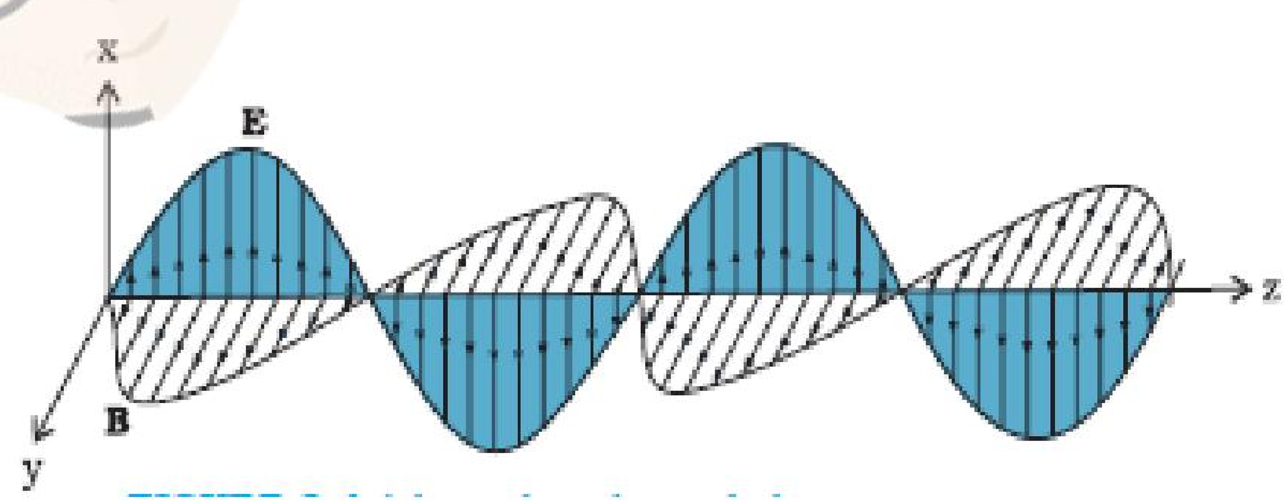
Net outward flux

$$= \left[250 \times \pi \times \left(\frac{5}{100}\right)^2 + 250 \times \pi \times \left(\frac{5}{100}\right)^2 + 0\right] \text{Wb}$$ ½

$$= \left(\frac{5}{4}\pi\right) \text{Wb}$$

$$(\cong 3.93)\text{Wb}$$ ½ — 2

[Note: Award full 2 marks even if the students does a direct (correct) calculation of the net outward flux without drawing the diagram or writing the formula for flux. In

	such a case, award 1 mark for correct substitutions and 1 mark for correct calculations. (Deduct ½ mark if the units for flux are not written)]		
11.	(a) Effect + Reason ½ + ½ (b) Effect + Reason ½ + ½ (a) $I = \frac{V}{\sqrt{R^2+\omega^2L^2}}$ When ω increases, I decreases, $\therefore$ brightness decreases (b) $I = \frac{V}{\sqrt{R^2+\frac{1}{\omega^2c^2}}}$ When ω increases, I increases, $\therefore$ brightness increases Alternatively: (a) Brightness decreases Reason: The impedance of L increases with an increase in angular frequency ω (b) Brightness increases Reason: The impedance of C decreases with an increase in angular frequency ω	½ ½ ½ ½ ½ ½ ½ ½	2
12.	(a) Graph of em wave 1 (b) (i) Relation between c, E_0 and B_0 ½ (ii) Expression for speed of em wave ½ (a)  (b) (i) $c = \frac{E_0}{B_0}$ (ii) $c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$	1 ½ ½	2
	SECTION - C		
13.	(a) Reason for circular motion 1 Expression for radius 1 (b) Path of the particle when $\Theta \neq 90^0$ 1 (a) $\vec{F} = q(\vec{v} \times \vec{B})$ Force $\vec{F}$ on a moving charged particle in a magnetic field acts perpendicular to the	½	

velocity vector at all instants. It therefore, changes only the direction of velocity without changing its magnitude. This results in a circular motion of the particle for which the force $\vec{F}$ provides the needed centripetal force $\left(= \frac{mv^2}{r}\right)$ ½

Here F=qvB sin Θ
= qvB (as Θ = π/2)

$$\therefore \frac{mv^2}{r} = qvB$$ ½

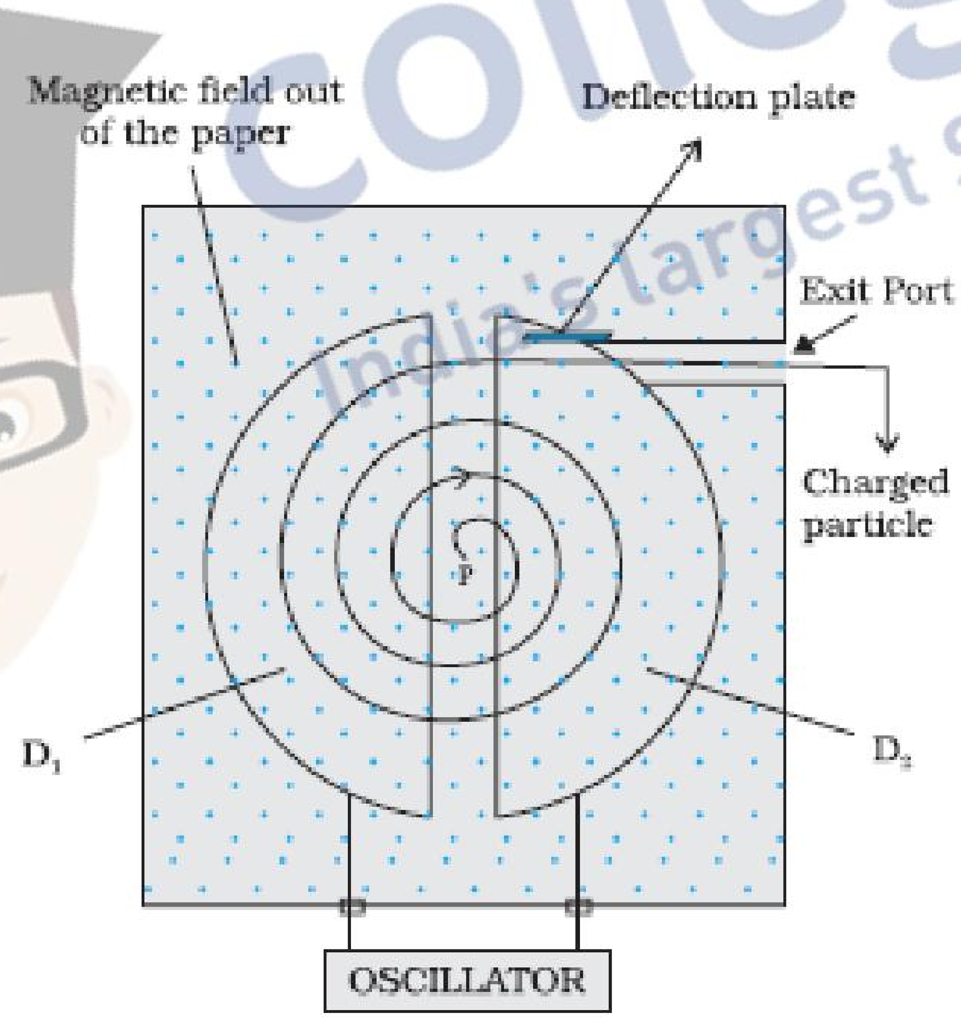
$$\therefore r = \frac{mv}{qB}$$ ½

(b) If Θ ≠ 90^0, then velocity will have a component along $\vec{B}$ also and the charged particle will move along $\vec{B}$ with this component of velocity while describing circular motion in a plane perpendicular to $\vec{B}$. Its motion is, therefore, helical. 1 | 3

[Note: Award this 1 mark even if a student just writes that the charged particle will describe a helical path / motion.]

OR

Diagram	1
Working Principle	1
Two uses	½ + ½



1

Working Principle: Cyclotron uses crossed electric and magnetic fields. Magnetic field makes the charged particle describe a circular path while electric field frequency is so adjusted as to accelerate the particle whenever it crosses the space between the dees. A relatively small electric field can then be used to accelerate particles to very high energy values. 1

Uses: (i) To accelerate charged particles to very high energies ½
(ii) To implant ions into solids to modify their properties. ½ | 3
[or any other use]

14.

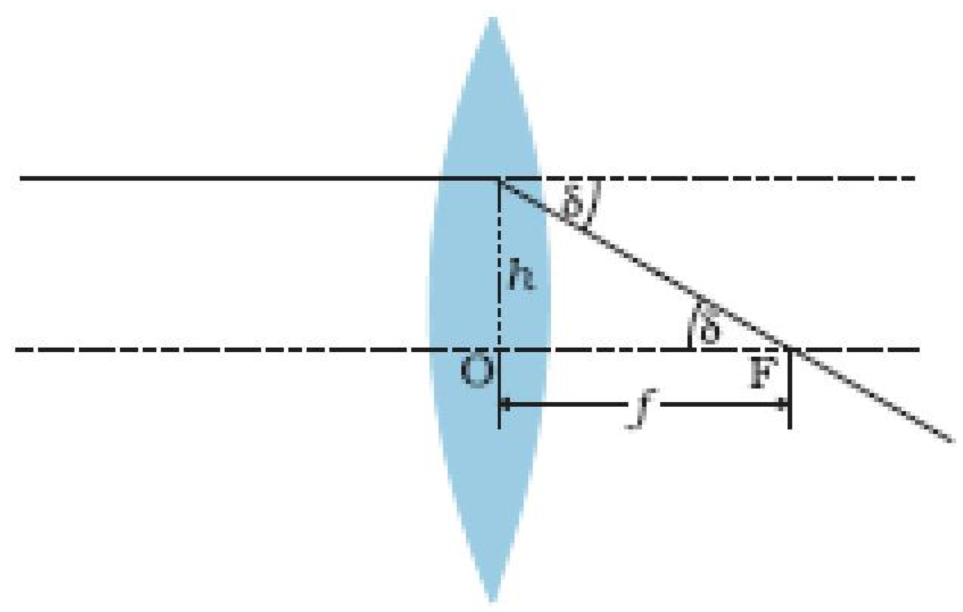
(a) Definition	1
SI Unit	½
(b) Derivation	1 ½

(a) The power of a lens is a measure of its ability to converge or diverge a given beam of light incident on it.

Alternatively

The power of a lens equals the tangent of the angle by which it converges or diverges a beam of light falling at unit distance from its optical centre.

Alternatively



$$\tan\delta = \frac{h}{f}$$, if h=1 and for small angle

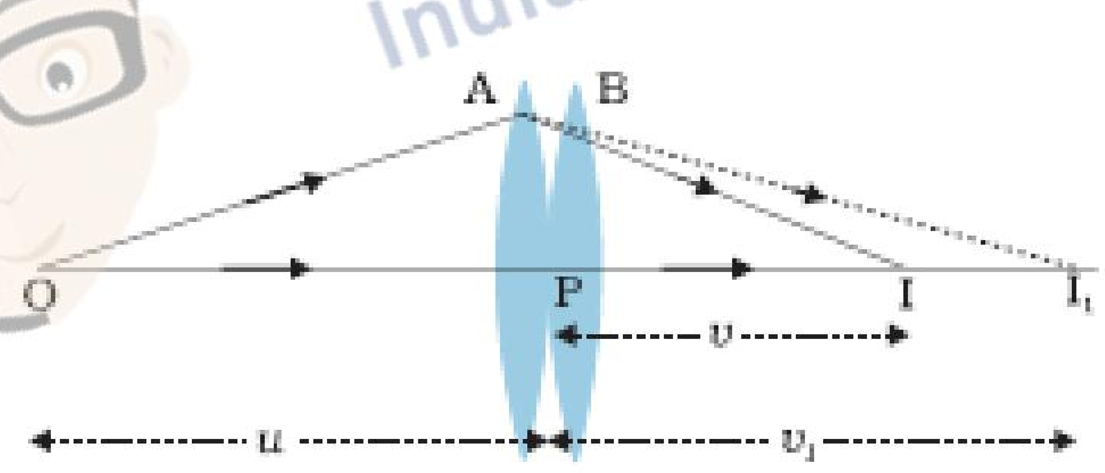
$$\delta = {}^{1}/_{f} \quad \text{thus } P = {}^{1}/_{f}$$

Alternatively

$$Power = \frac{1}{focal\ length}$$ 1

The SI unit of power is the diopter (D) ½

Derivation



½

For the first lens :

$$\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_1}$$

For the second lens:

$$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2}$$

Adding, we get

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$$ ½

∴ The equivalent focal length f, of the combination is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

In terms of power , the relation becomes

$$P = P_1 + P_2$$ ½ 3

Thus the power of two this lens, placed co-axially in contact with each other is the algebraic sum of their individual powers.

15.

(a) Drift Velocity and its significance	½ + ½
Relaxation time and its significance	½ + ½
(b) Change in drift velocity	1

(a)

<u>Drift Velocity:</u> It is the average velocity with which electrons move in a conductor when an external electric field (or potential difference) is applied across the conductor. ½

<u>Significance:</u> The drift velocity controls the net current flowing across any cross section./ There is no net transport of charges across any area perpendicular to the applied field. ½

<u>Relaxation time:</u> It is the average time between successive collisions for the drifting electrons in the conductor. ½

<u>Significance:</u> It is a (very important) factor in determining the electrical conductivity of a conductor at different temperatures. (It is a factor which determines the drift velocity acquired by the electrons under a given applied external electric field) ½

(b)

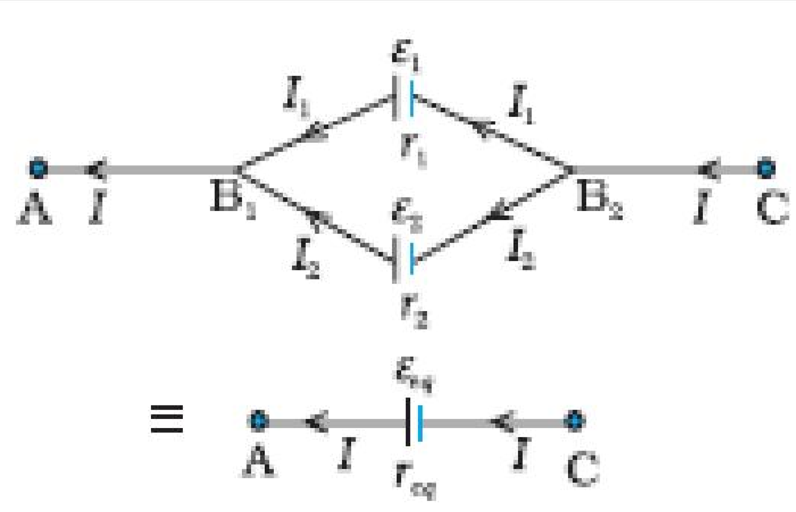
$$v_d = \frac{eV}{mL}\tau$$ ½

$$v_{d'} = \frac{eV}{m \times 5L}\tau$$

$$= \frac{v_d}{5}$$ ½ 3

OR

Diagram	½
Expression for equivalent emf and internal resistance	2 ½



½

	$I = I_1 + I_2$ $= \left(\frac{E_1 - V}{r_1}\right) + \left(\frac{E_2 - V}{r_2}\right)$ $= \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$ Hence $V = \left[\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}\right] - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$ $\therefore E_{eff} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2}$ and $r_{eff} = \frac{r_1 r_2}{r_1 + r_2}$	½ ½ ½ ½ ½	3
16.	(a) Writing the colour band sequence 1 (b) Explanation for transmission of electric power at high voltages. 2 (a) The colour band sequence would be yellow , violet, brown , gold (Note: Award ½ mark if only two of the colours are correctly indicated as per the given sequence) (b) Imagine that a device of resistance R, needs a power P for its working. If V is the voltages across R and I is the current through it, we have $P = VI\,,\ \ i.e.\ \ I = \frac{P}{V}$ Let the transmission cables have a resistance R_c, the power, dissipated in the connecting wires (say P_c) is then given by $P_c = I^2 R_c$ $= \frac{P^2 R_c}{V^2}$ This power gets wasted as heat during transmission. We see that, to operate a device of power P, the power, wasted in the connecting wires is inversely proportional to V^2, therefore at high voltage, less power well get wasted in the transmission cables. It follows that by transmitting power from power stations to homes/factories, via transmission cables, at high voltages, we can bring about a very significant reduction in the power wasted during transmission.	1 ½ ½ ½ ½	3

17.

(a) Name and Principle of the device	½ + ½
(b) Circuit diagram	1
Working	½
(c) I- V characteristics	½

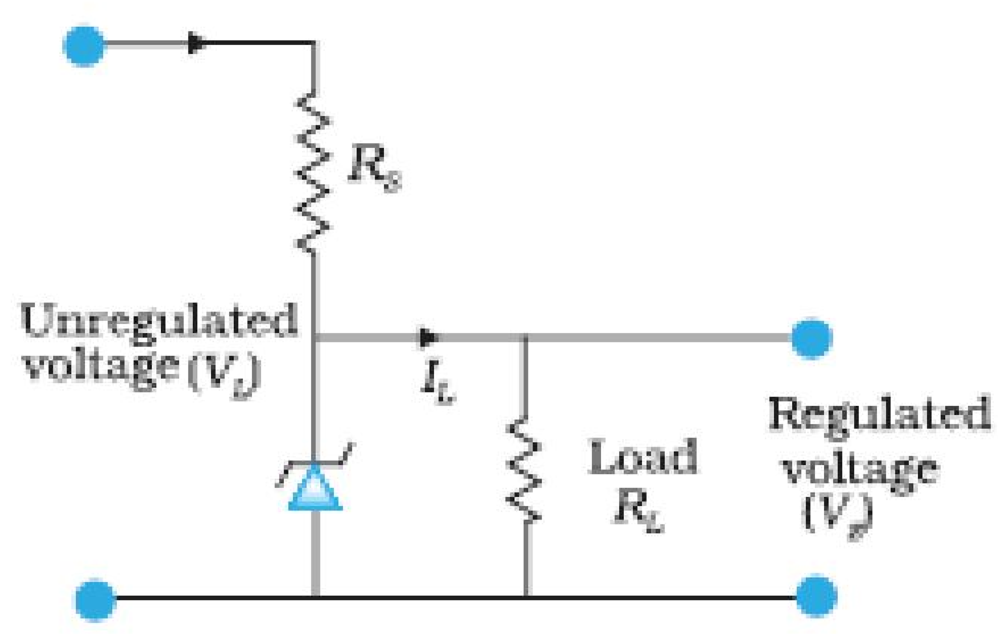
(a)

Zener diode is used as a voltage regulator

It works on the principle that after the breakdown voltage V_Z, a large change in the reverse current can be produced by an almost insignificant change in the reverse bias voltage ½

Alternatively: The Zener Voltage remains constant, even when the current through the Zener diode varies over a wide range. ½

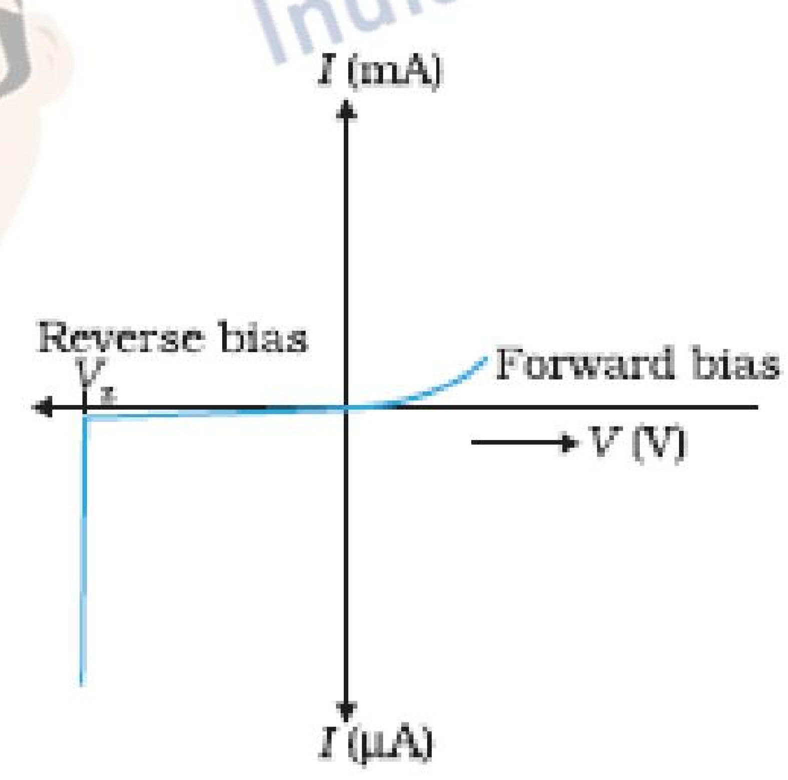
(b)



1

If the input voltage increases the current through R_S and Zener diode also increases. This increases the voltage drop across R_S without any change in the voltage across the Zener diode. If input voltage decreases, the current through R_S and Zener diode decreases. The voltage across R_S decreases without any change in voltage across the Zener diode. ½

(c)



½

3

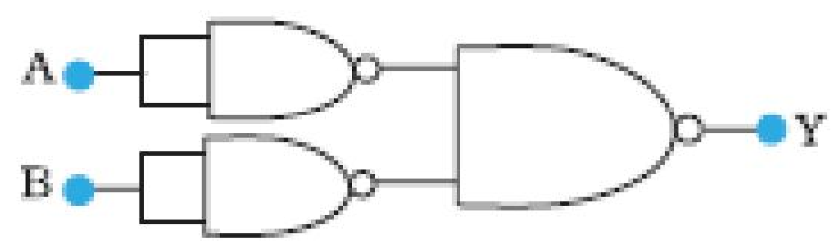
OR

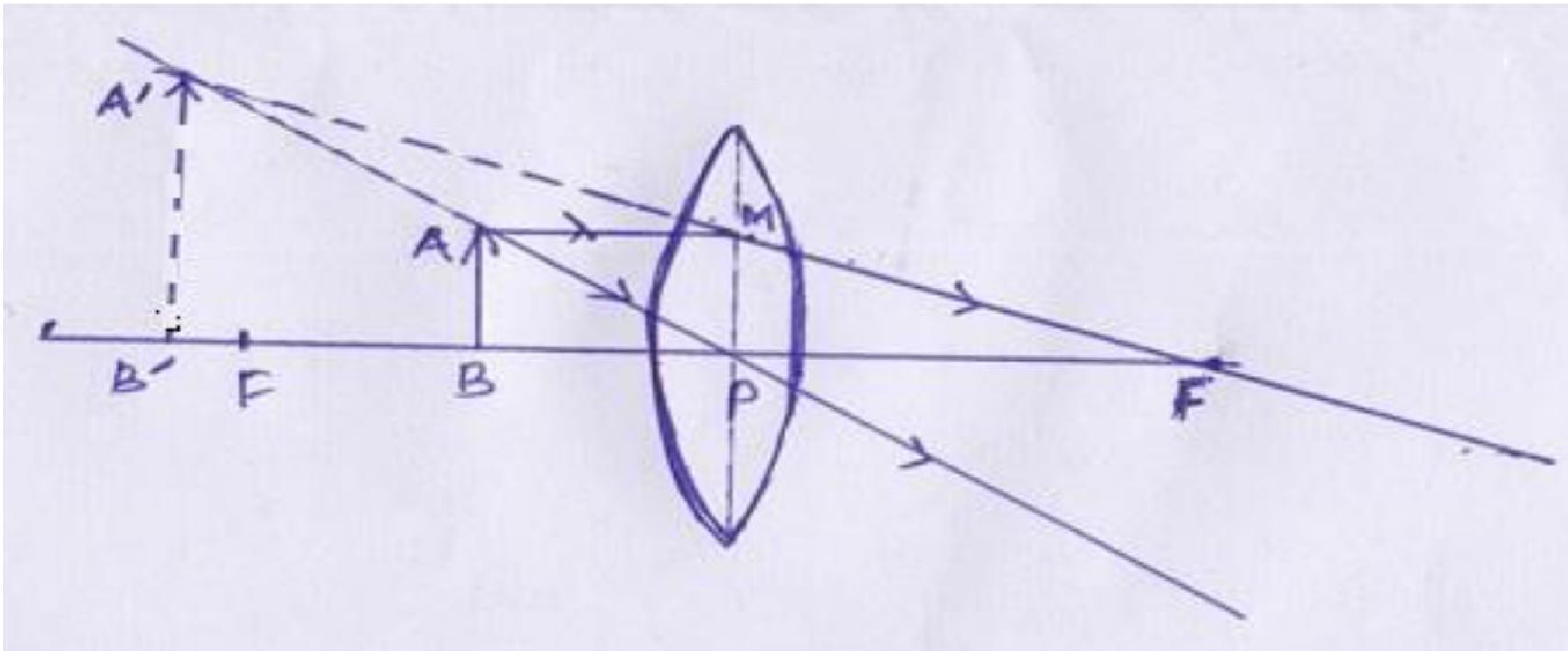
(a) Truth tables of AND and NOT gates	1+ ½
(b) Obtaining OR gate from NAND gates	1 ½

(a) AND gate

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

1

	NOT gate A | B 0 | 1 1 | 0	½	
	(b)  [Note: Award ½ mark if the student just writes the truth table of NAND gate without drawing any diagram]	1 ½	3
18.	(a) Need for radial magnetic field 1 (b) (i) Magnetic field at the centre 1 (ii) Magnetic Moment 1 (a) We need a radial magnetic field to ensure that the deflection of the galvanometer needle is directly proportional to the current flowing through its coil. <u>Alternatively :</u> A radial magnetic field ensures a linear(proportionality) relation between the deflection (θ) and the current flowing (I) in a moving coil galvanometer. <u>Alternatively :</u> The cylindrical soft iron core, used for making the field radial , increases the strength of the magnetic field and brings about a linear relation between the deflection (θ) and the current (I) for a moving coil galvanometer.	1	
	(a) (i) Magnetic field at the centre $B_o = \frac{\mu_0}{2r} NI$	½	
	$= \frac{4\pi\times10^{-7}\times100\times3.2}{2\times10\times10^{-2}}$ T		
	$\cong 2\times10^{-3}\,T = 2\,m\,T$	½	
	(ii) Magnetic Moment = NIA $100\times3.2\times\pi\times(10^{-1})^2$ ampere (meter)^2	½	
	$\cong 10Am^2$	½	3
19.	Ray diagram 1 Derivation of lens formula 2		



1

$\Delta A'B'P \sim \Delta ABP$

$\frac{A'B'}{AB} = \frac{B'P}{BP}$ --------------------------(i) ½

$\Delta A'B'F \sim \Delta MPF$

$\frac{A'B'}{MP} = \frac{B'F}{PF}$

or $\frac{A'B'}{AB} = \frac{B'F}{PF}$ --------------------------(ii) ½

From (i) and (ii)

$\frac{B'P}{BP} = \frac{B'F}{PF}$

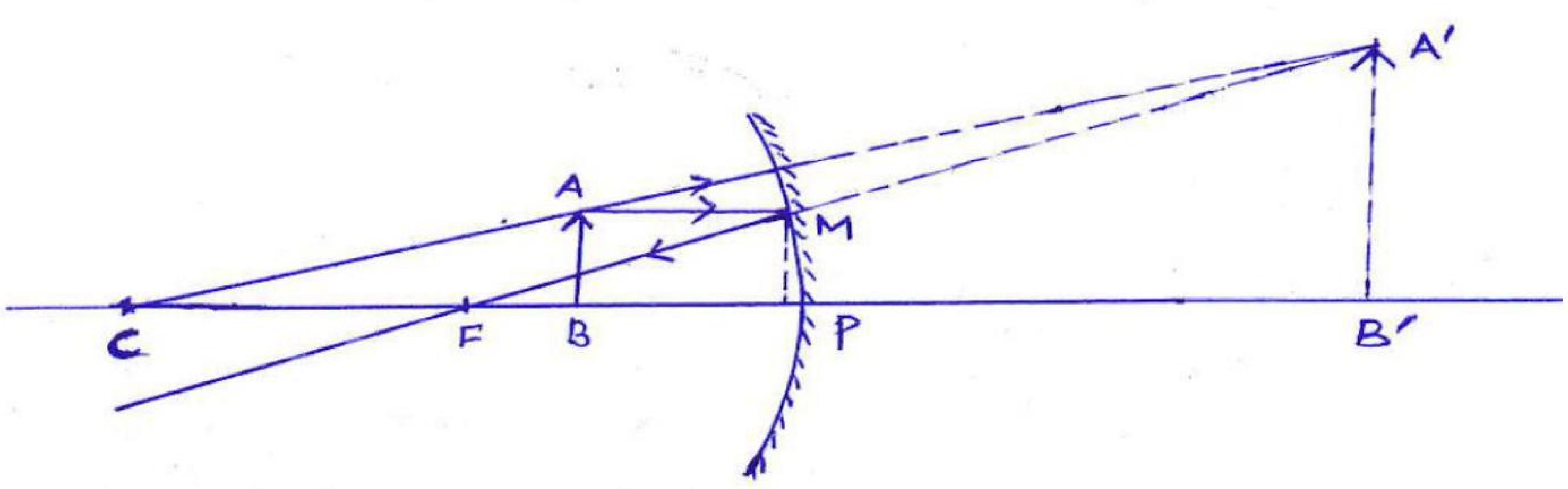
or $\frac{-v}{-u} = \frac{B'P+PF}{PF} = 1 + \frac{B'P}{PF}$

or $\frac{v}{u} = 1 - \frac{v}{f}$

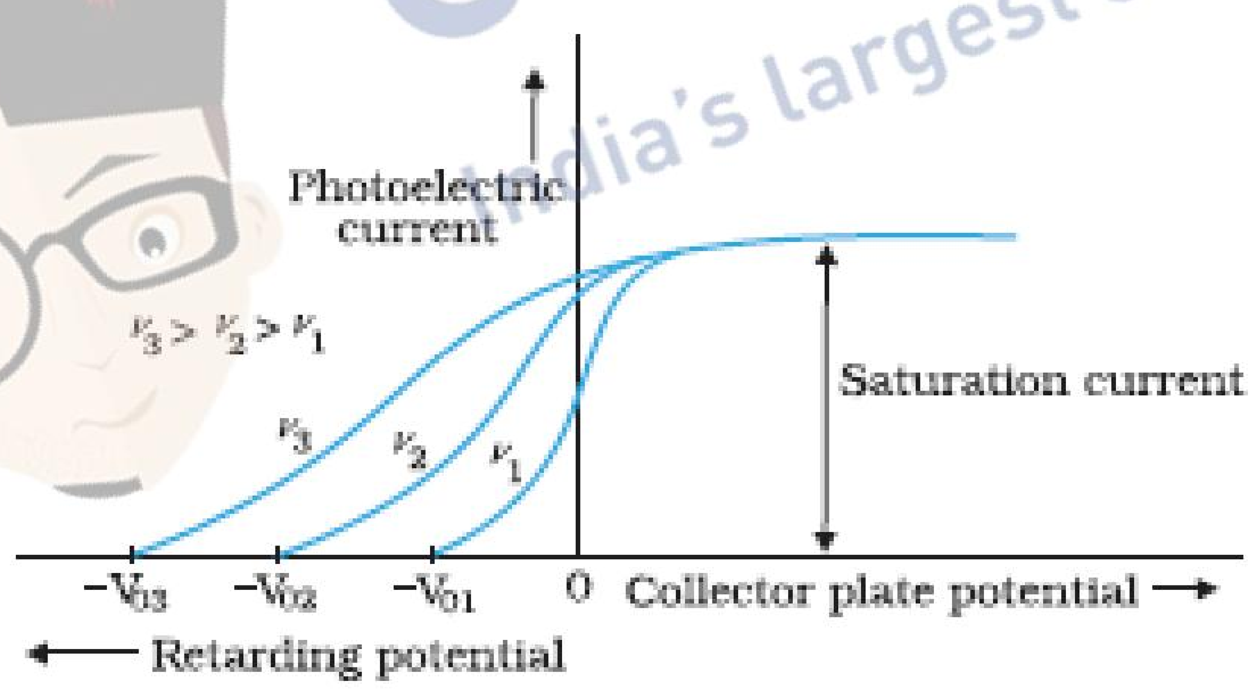
or $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ 1 3

OR

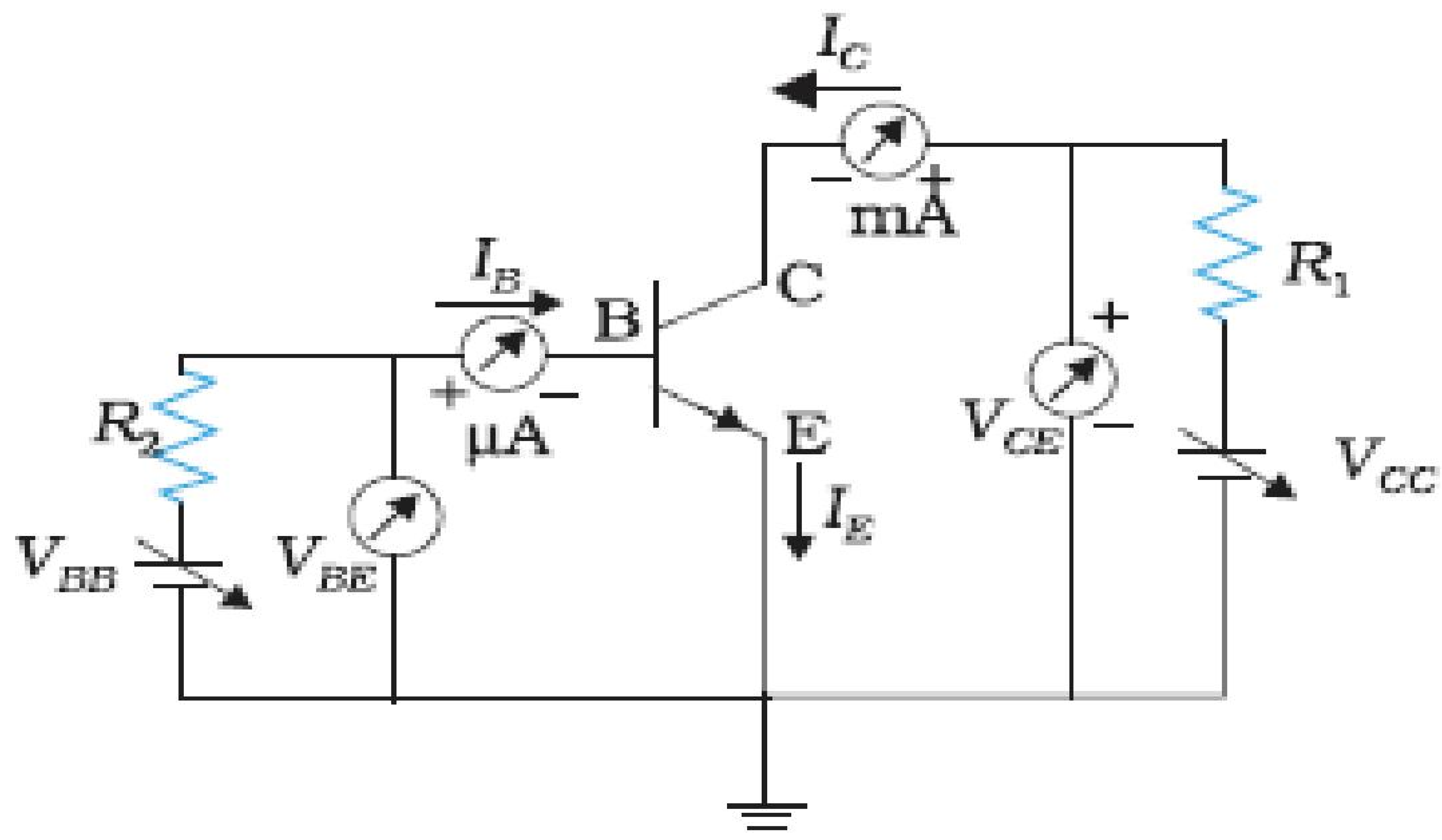
Ray diagram	1
Derivation of mirror formula	2



1

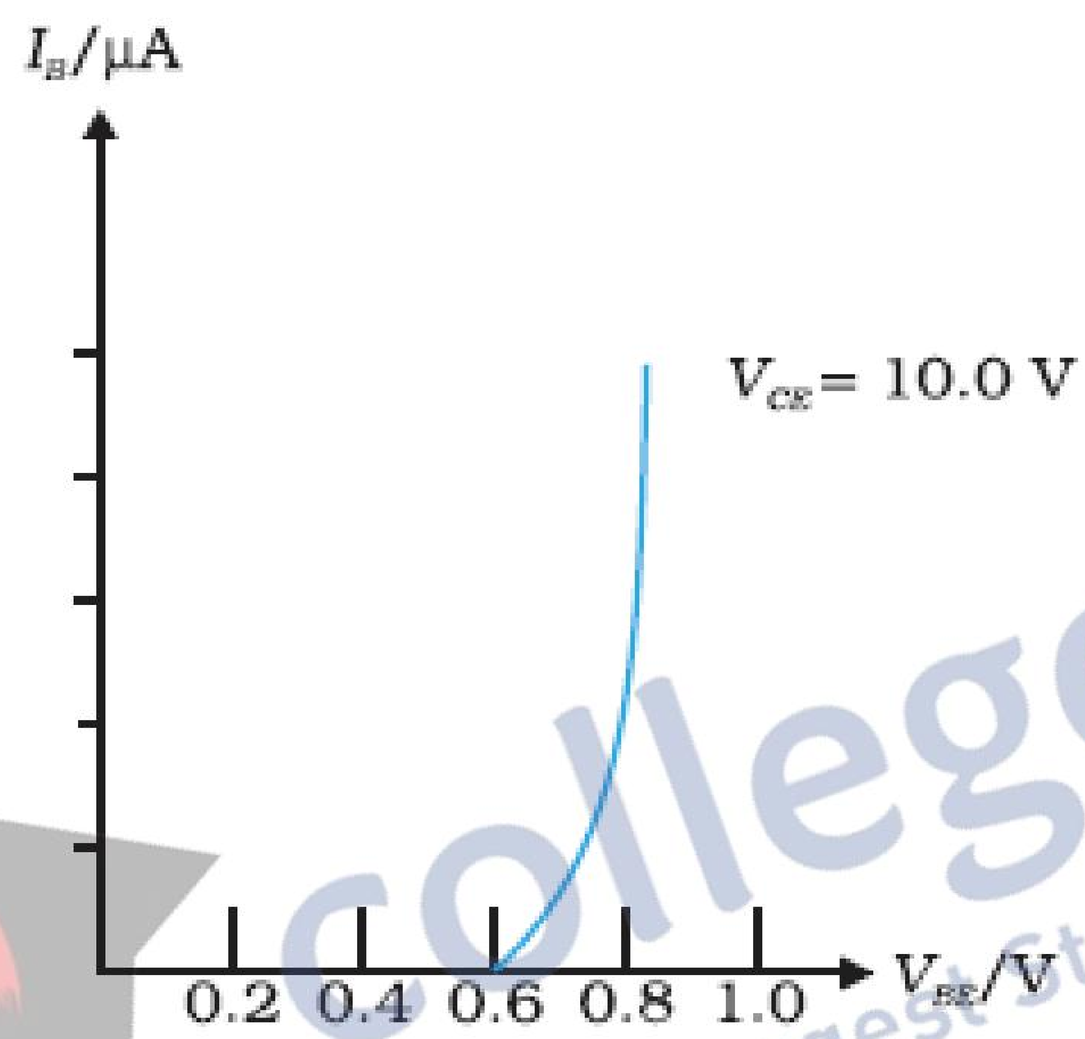
	$A'B'F \sim \Delta MPF$ $\frac{A'B'}{MP} = \frac{B'F}{PF} = \frac{B'P+PF}{PF}$ or $\frac{A'B'}{AB} = \frac{B'P+PF}{PF}$ --------------------------(i) $\Delta A'B'C \sim \Delta ABC$ $\frac{A'B'}{AB} = \frac{B'C}{BC} = \frac{B'P+PC}{PC-PB}$ --------------------------(ii) or $\frac{B'P+PF}{PF} = \frac{B'P+PC}{PC-PB}$ or $\frac{v-f}{-f} = \frac{v-2f}{-2f+u}$ Cross multiply and divide by uvf : $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$	½ ½ 1	3
20.	(a) Plotting the graph 1 (b) Identification and justification in each case 2 X (½ + ½) (a) The required graph is as shown below  (b) (i) Blue light will emit photo electrons having greater kinetic energy . **Reason:** The frequency of blue light (/ the energy of a photon of blue light) is more than the frequency of green light (/ the energy of photon of green light) (ii) The photo current will be (nearly) equal for both the lights. **Reason :** For a given intensity the saturation value of the photo electric effect is (nearly) independent of the frequency of the incident light. [Alternatively : This has been shown in the graph drawn in part (a) of this question]	1 ½ ½ ½ ½	3
21.	(a) Circuit diagram for studying the characteristics of an npn transistor 1 (b) Finding the input resistance and current gain 1+1		

(a)



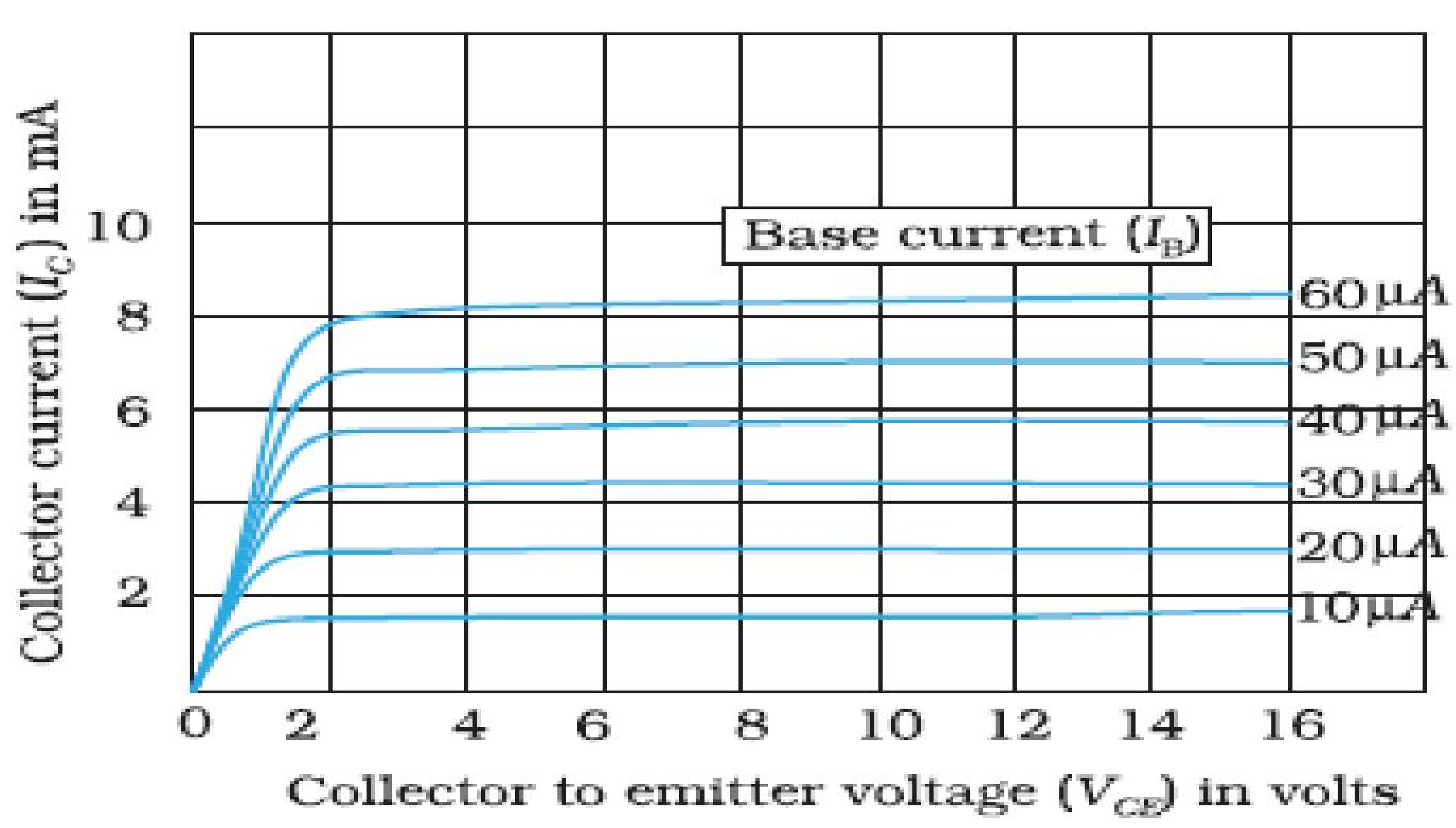
1

(b)



½

Input Resistance $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$ ½

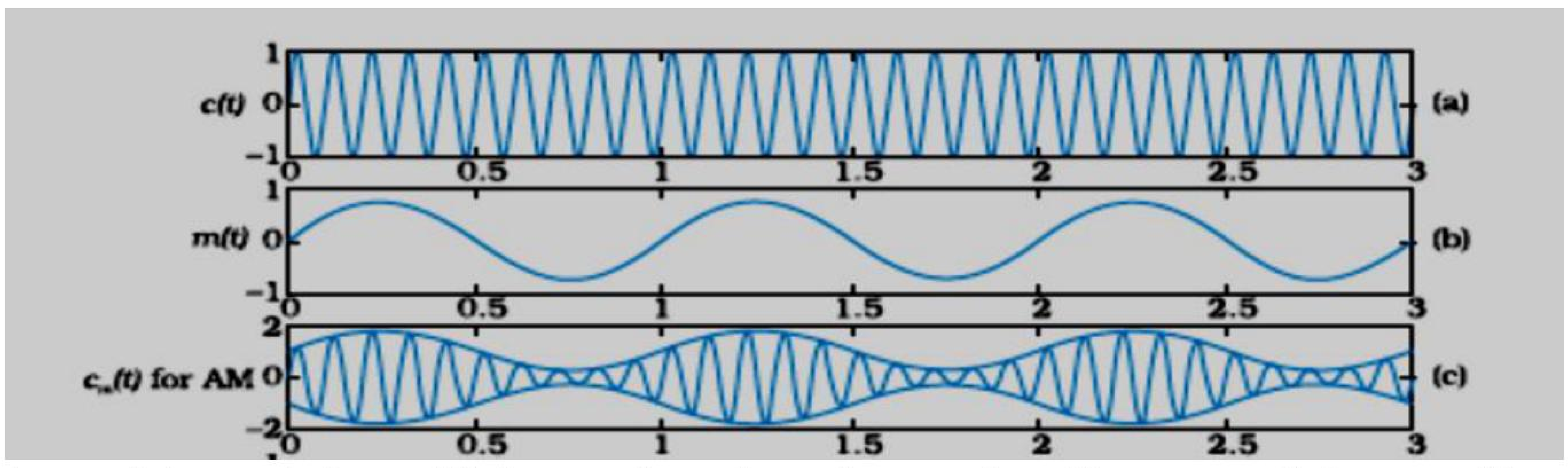


½

$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$ ½ 3

22.

(a) Explanation of amplitude modulation	1 ½
(b) Calculation of modulation index	1 ½



½ ½ ½

[Note: Award 1 mark here if the student just draws the diagram of the amplitude, modulated wave without drawing the 'carrier wave' and the 'message signal' diagrams]

(b)

$$a_m + a_c = 20\ V$$

$$a_c - a_m = 5\ V$$

$$=> a_c = 12.5\ V$$ ½

$$a_m = 12.5\ V$$

Modulation index $\mu = \frac{a_m}{a_c}$ ½

$= \frac{7.5}{12.5} = 0.6$ ½ 3

23.

(a) Highest energy level to which atom will be excited	1
(b) Calculation of longest Lyman wavelength	1
(c) Calculation of longest Balmer wavelength	1

(a) Maximum Energy that the excited hydrogen atom can have is

E=-13.6eV + 12.5eV=-1.1 eV ½

Now $E_3 = \frac{-13.6}{3^2} eV = -1.5eV \quad (< (-1.1eV))$

$E_4 = \frac{-13.6}{4^2} eV = -0.85eV \quad (> (-1.1eV))$

It follows that the electron can only be excited up to the n=3 state. ½

(b) Longest wavelength of Lyman series:

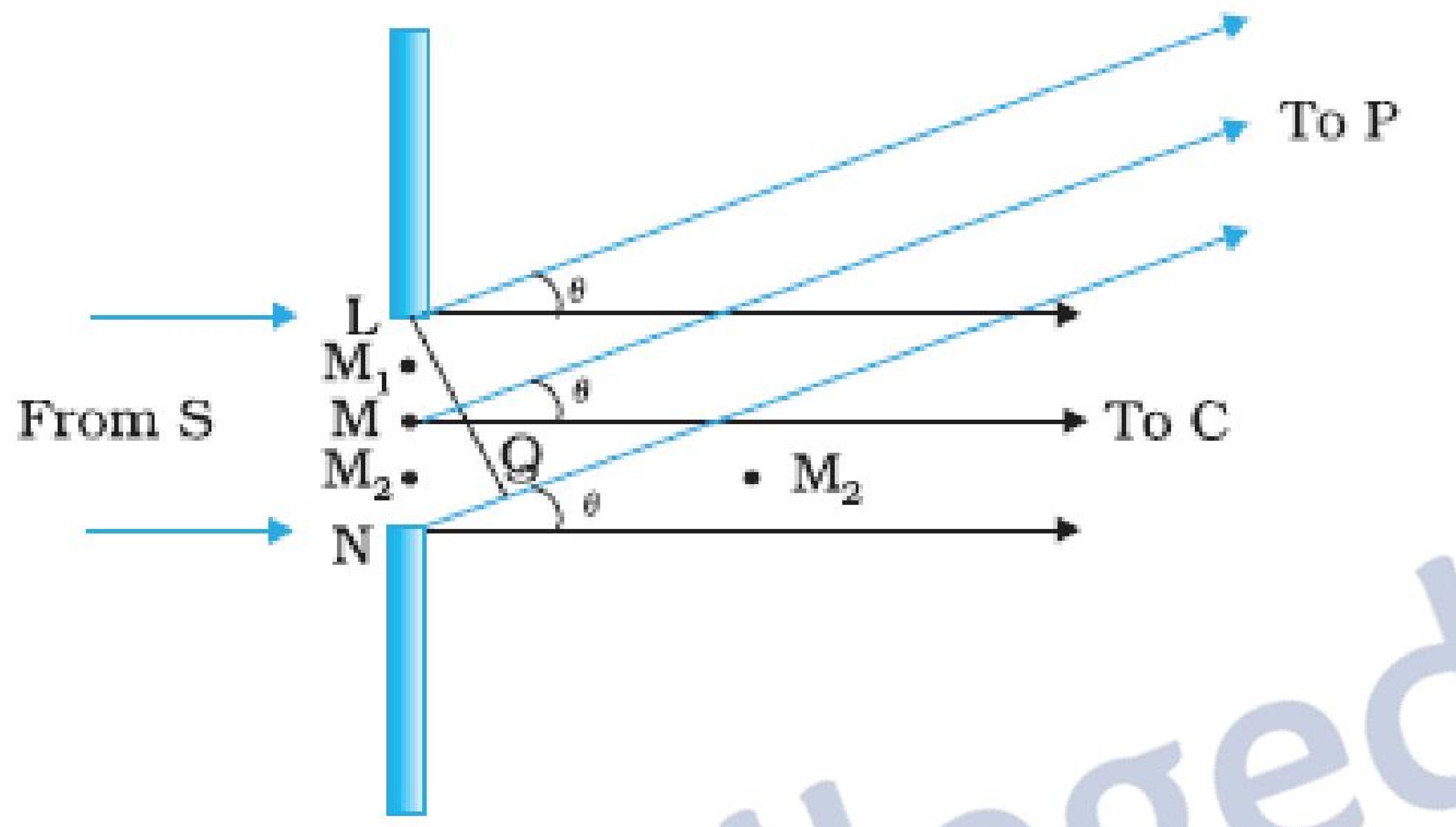
$$\frac{1}{\lambda_L} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R.\frac{3}{4}$$ ½

$$\therefore \lambda_L = \frac{4}{3} \times \frac{1}{R}$$

$$= \frac{4}{3 \times 1.1 \times 10^7} m \cong 1218\ A^0$$ ½

Longest wavelength of Balmer series:

$$\frac{1}{\lambda_B} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$ ½

	$= \frac{5R}{36}$ $\lambda_B = \left(\frac{36}{5 \times 1.1 \times 10^7}\right) m \approx 6560 A^0$	½	3
24.	(a) Explanation for formation of diffraction pattern 2 (b) Calculation of separation 1 (a)  	½	
	Path difference, NP-LP=NQ =a sinθ $\approx a\theta$	½	
	At C on the screen, $\theta = 0^0$. All path differences are zero and hence all wavelets meet in phase and produce a maxima at C. At points P on the screen for which path difference is $\lambda, 2\lambda, 3\lambda, \ldots\ldots n\lambda$; the wavelets will cancel each other in pairs and produce minima. $\therefore a\theta = n\lambda$ --------- condition for minima (n=1,2,………)	½	
	At points P on the screen for which path difference is $\frac{\lambda}{2}$, $3\frac{\lambda}{2}$, …………....., $(2n+1)\frac{\lambda}{2}$ The wavelets produce a maxima due to one uncancelled part of the wavefront. $\therefore a\theta = (2n+1)\frac{\lambda}{2}$--------- condition for maxima (n=1,2,………)	½	
	(b) separation between 1st secondary maxima of the two wavelengths $= \frac{3D}{2d}(\lambda_2 - \lambda_1)$ $= \frac{3\times1.5}{2\times2\times10^{-4}} \times 60 \times 10^{-10}$ m	½	

	$=67.5 \times 10^{-6}$ m $=67.5\ \mu$m	½	3

SECTION - D

25.

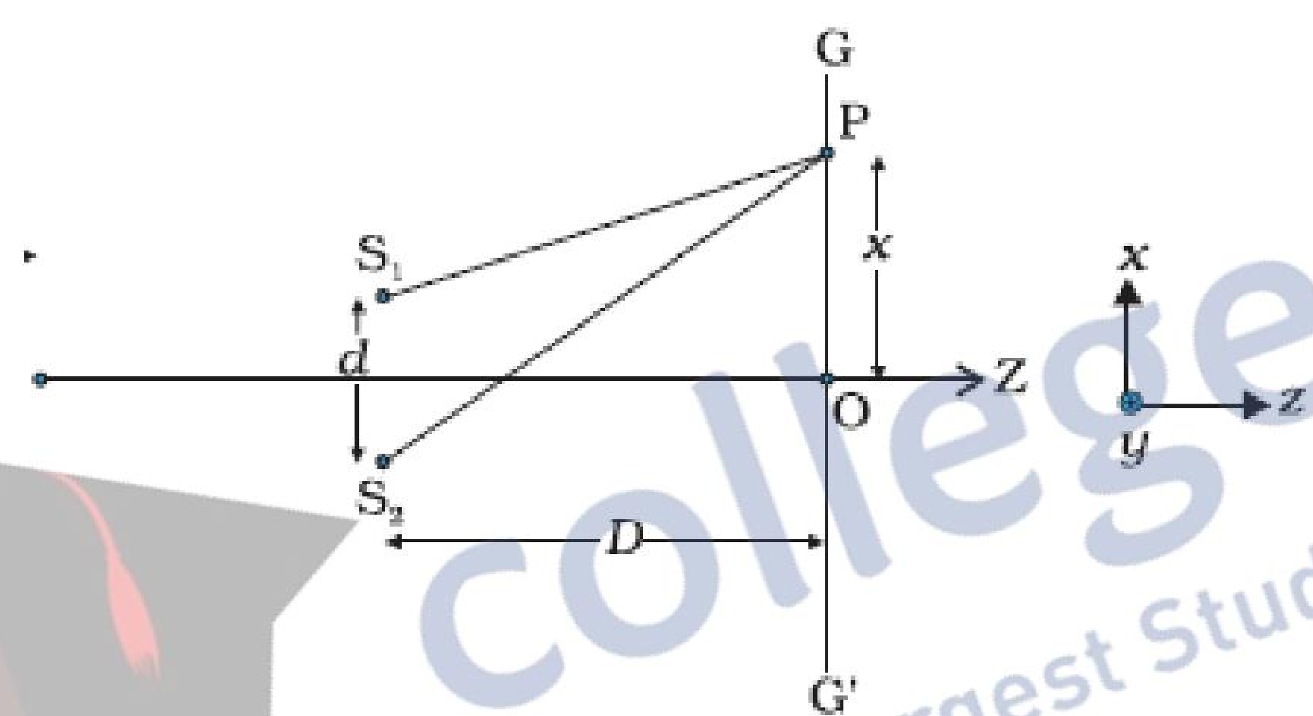
(a) Answer and justification	½ + ½
(b) Explanation of the formation of interference fringes and derivation of expression of fringe width	1 + 2
(c) Finding the intensity of light	1

(a) No, ½

Because to obtain the steady interference pattern, the phase difference between the waves should remain constant with time, two independent monochromatic light sources cannot produce such light waves. ½

(b)

When light waves from two coherent sources, in Young's double slit experiment, superpose at a point on the screen, they produce constructive/ destructive interference, depending on the path difference between the two waves. 1



½

Path difference between the waves reaching at point P from two sources S_1 and S_2

$$S_2P - S_1P \approx \frac{xd}{D}$$ ½

For constructive interference (i.e for nth bright fringe on the screen)

$$\frac{xd}{D} = n\lambda \qquad \text{where } n = 0, \pm 1, \pm 2, \ldots\ldots\ldots$$

$$\therefore x_n = \frac{n\lambda D}{d}$$ ½

Similarly for (n+1)th bright fringe

$$x_{n+1} = \frac{(n+1)\lambda D}{d}$$

Fringe width $\beta = x_{n+1} - x_n$

$$= \frac{\lambda D}{d}$$ ½

[Alternatively

Path difference for nth dark fringe on the screen

$$\frac{xd}{D} = (n + \frac{1}{2})\lambda$$

$$x_n = \frac{(n + \frac{1}{2})\lambda D}{d}$$

For (n+1)th dark fringe

$$x_{n+1} = \frac{(n + \frac{3}{2})\lambda D}{d}$$

Fringe width $\beta = x_{n+1} - x_n$

$= \frac{\lambda D}{d}$]

(c) The intensity at a point on the screen where waves meet with a phase difference (ϕ), is given by

½

$$I = 4I_0 cos^2 \phi/_2$$

Phase difference (φ) when path difference is 'x'

$$\phi = \frac{2\pi}{\lambda}.x$$

∴ for x= λ , we have

$$\phi = 2\pi$$

∴ Intensity $I = 4I_0 cos^2\pi = K$

$$\therefore \ 4I_0 = K$$

$$\therefore \ I_0 = K/_4$$

Phase difference, when path difference is λ/4, is

$$\phi' = \frac{2\pi}{\lambda}.\lambda/_4 = \pi/2$$

$$\therefore I' = 4I_0 cos^2 \pi/_4$$

½ 5

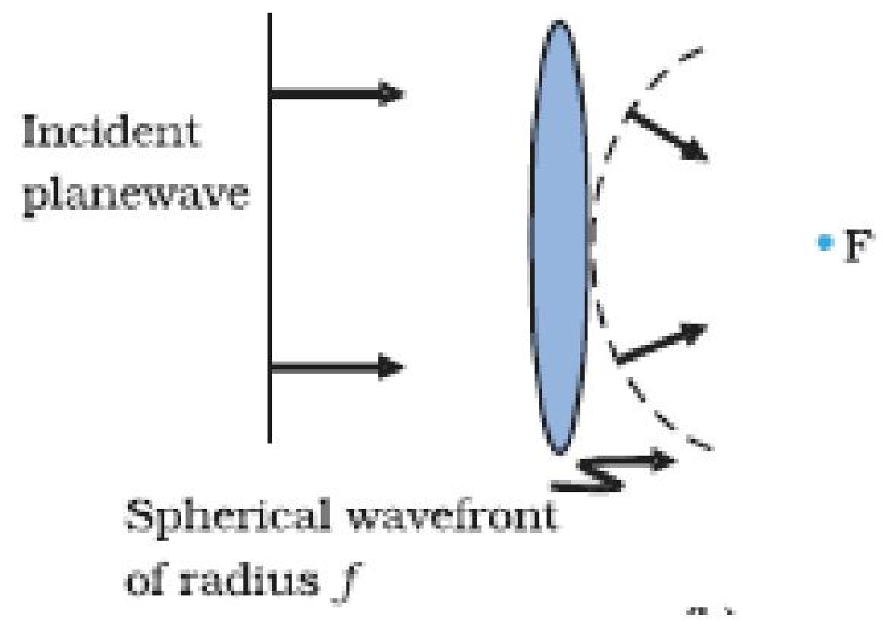
$=2I_0$

$$= 2\frac{K}{4} = K/_2$$

OR

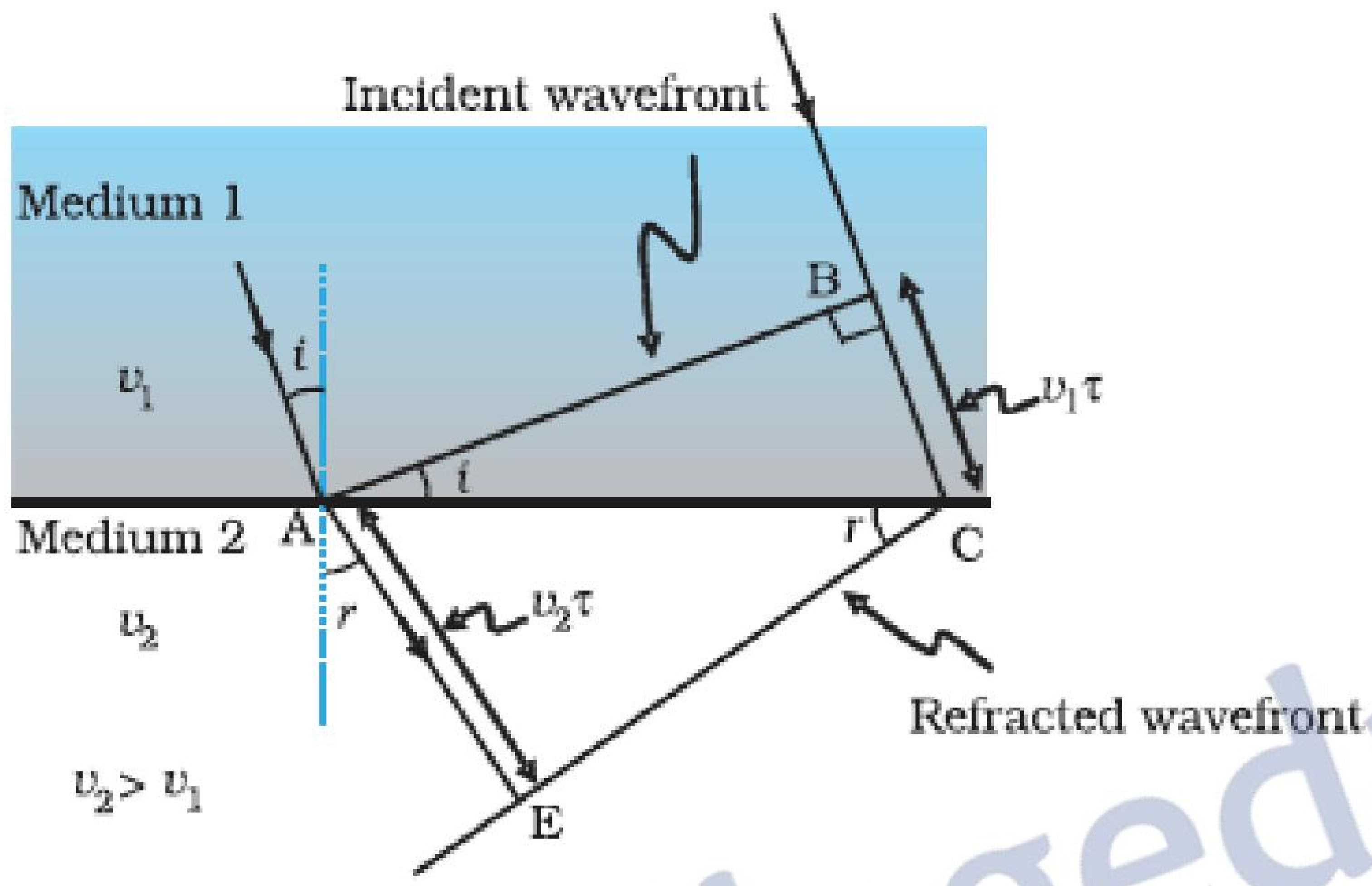
(a) Sketch of the refracted wave front	1
(b) Verification of laws of refraction	2
(c) Estimation of speed and wavelength	1+1

(a)



1

(b)



½

In right triangle ABC

$$\sin i = \frac{BC}{AC}$$ ½

In ΔAEC

$$\sin r = \frac{AE}{AC}$$ ½

$$\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v_1\tau}{v_2\tau} = \frac{v_1}{v_2} = \mu$$ ½

(c) Speed of yellow light inside the glass slab

$$v = \frac{c}{\mu}$$ ½

$$= \frac{3 \times 10^8}{1.5} m/s$$

$$= 2 \times 10^8 \, m/s$$ ½

Wavelength of yellow light inside the glass slab

$$\lambda' = \frac{\lambda}{\mu}$$ ½

$$= \frac{590}{1.5} nm$$

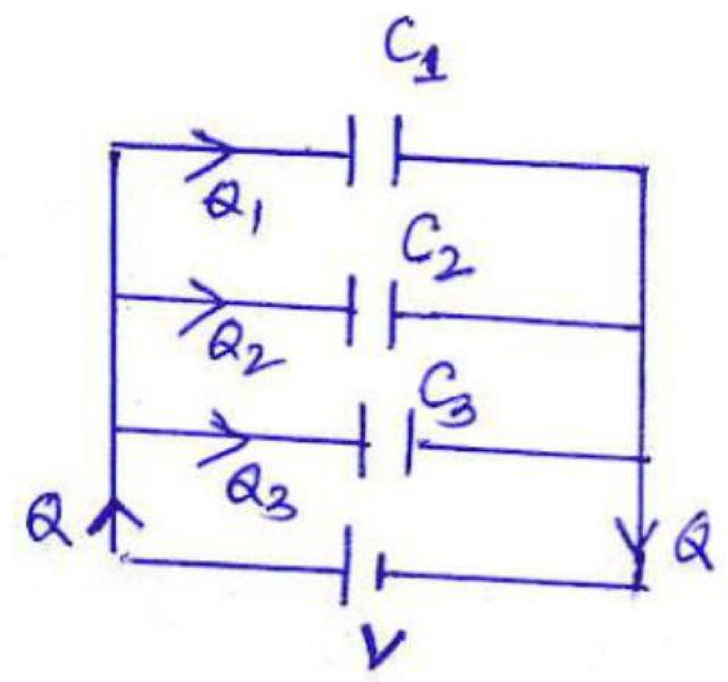
$$=393.33 nm$$ ½

5

26.

(a) Derivation of expression for the resultant capacitance in
(i) parallel (ii) series 1 ½ + 1 ½
(b) Calculation of energy stored in the 12µf capacitor 2

(a) (i) <u>Parallel</u>



½

$$Q_1 = C_1V,$$
$$Q_2 = C_2V,$$
$$Q_3 = C_3V,$$

½

But $Q = Q_1 + Q_2 + Q_3$

$$\therefore\ Q = C_1V + C_2V + C_3V$$
$$\therefore\ CV = C_1V + C_2V + C_3V$$
$$C = C_1 + C_2 + C_3$$

½

(ii) <u>Series</u>

½

Potential difference across the plates of the three capacitors are:

$$V_1 = \frac{Q}{C_1}$$
$$V_2 = \frac{Q}{C_2}$$
$$V_3 = \frac{Q}{C_3}$$

But $V = V_1 + V_2 + V_3$

$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

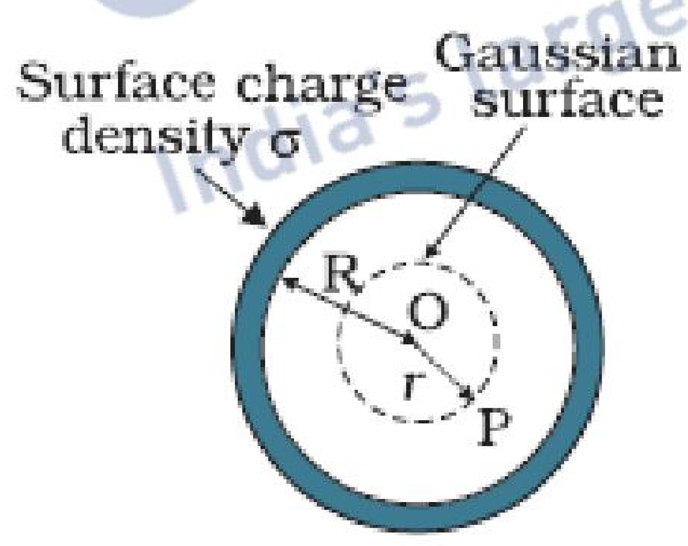
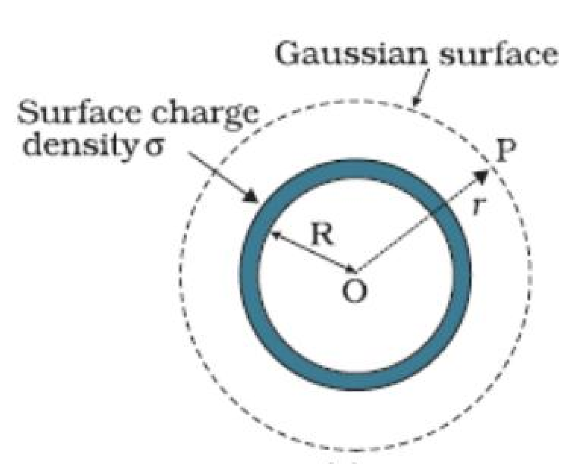
½

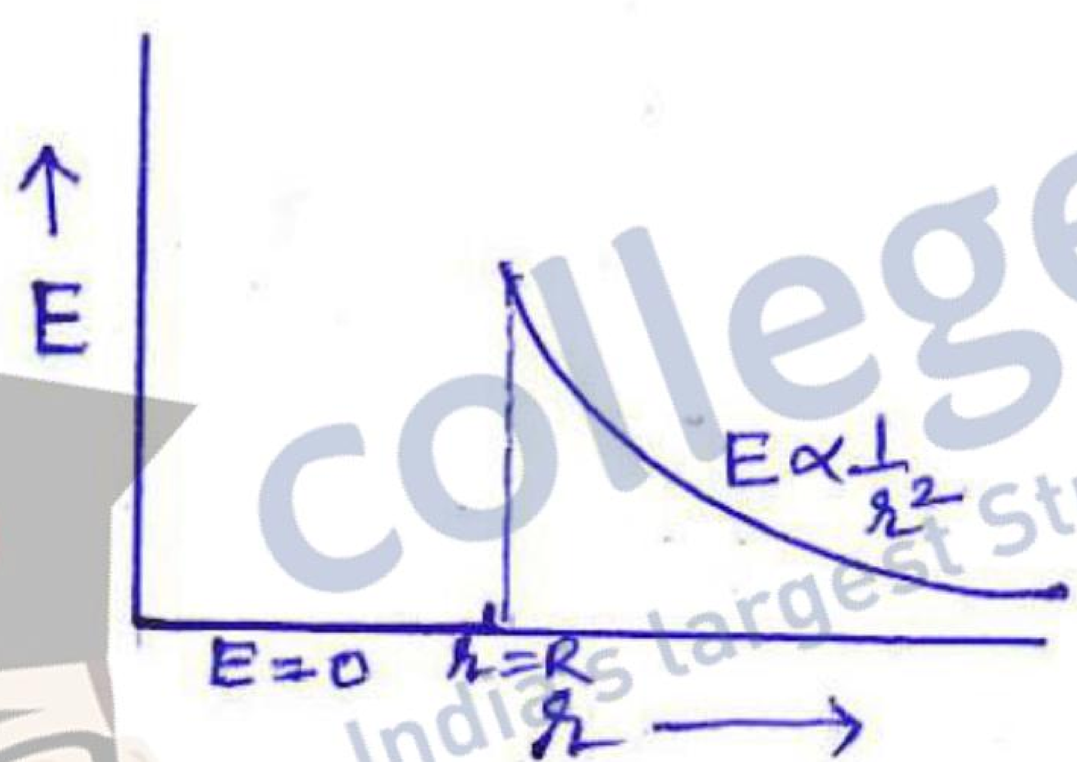
$$\therefore \frac{Q}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

½

$$\therefore \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

(b) Potential difference across the capacitor of 4µf capacitance

	$$V = \frac{Q}{C} = \frac{16\mu C}{4\mu F}$$	½	
	$=4V$		
	Potential across 12µf capacitor $=12\ V - 4V$ $=8V$	½	
	Energy stored on this capacitor $$U = \frac{1}{2}CV^2$$	½	
	$$= \frac{1}{2}(12 \times 10^{-6})8^2 \text{ joule}$$		
	$=6 \text{ X } 64 \times 10^{-6}$ joule $=384 \times 10^{-6}$ J $=384\ \mu$J	½	5
	OR		
	(a) Derivation of expression for the Electric field (i) inside (ii) outside — 1 + 2 (b) Graphical variation of the Electric field — 1 (c) Calculation of Electric flux — 1		
	(a) (i) <u>Inside</u>		
			
	The point P is inside the spherical shell. The Gaussian surface is a sphere through P centered at 'O'		
	Flux through this surface= $E \times 4\pi r^2$ However there is no charge enclosed by this Gaussian surface. Hence using Gauss's Law	½	
	$$E \times 4\pi r^2 = 0$$ $\Rightarrow E=0$	½	
	<u>Outside</u>		
	 (a)	½	

	To calculate Electric Field $\vec{E}$ at the outside point P, we take the Gaussian surface to be a sphere of radius ‘r’ and with center O, passing through P.		
	Electric Flux through the Gaussian surface $\varphi = E \times 4\pi r^2$	½	
	Charge enclosed by this the Gaussian surface = $\sigma \times 4\pi R^2$	½	
	By Gauss’s Law $$E \times 4\pi r^2 = \frac{\sigma \times 4\pi R^2}{\epsilon_0} = {}^{q}/_{\epsilon_0}$$ Where q= total charge on the spherical shell. $$\therefore E = \frac{q}{4\pi\epsilon_0 r^2}$$		
	$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$	½	
	(b)  	1	
	(c) Electric flux passing through the square sheet $$\phi = \int \vec{E}.\vec{ds}$$	½	
	=EA cosΘ =200 × 0.01 × cos 60^0 =1.0 Nm^2/C	½	
	[Note: The student may do the calculation by taking Θ=30^0 and get $\sqrt{3}Nm^2/C$ as the answer. In that case award ½ mark only for part (c)]		5
27.	(a) Derivation of the expression for the average power — 3 (b) Definition of terms (i) watt less current (ii) Quality factor — 1 + 1		
	(a) Power at any instant ‘t’ $$P = Vi$$ $$= (V_m \sin wt)(i_m \sin(wt + \varphi))$$	½	

	$= \frac{V_m i_m}{2}\,(2\sin wt \sin(wt+\varphi))$	½	
	$= \frac{V_m i_m}{2}\,[\cos\varphi - \cos(2wt+\varphi)]$	½	
	The term $\cos(2wt+\varphi)$ is time dependent and its average over a cycle is zero. Therefore average power	½	
	$\bar{P} = \frac{V_m i_m}{2}\cos\varphi$	½	
	$\bar{P} = \frac{V_m i_m}{\sqrt{2}\sqrt{2}}\cos\varphi$		
	$\bar{P} = V_{rms} i_{rms}\cos\varphi$	½	
	(b) (i) When no power is dissipated even through a current is flowing in the circuit, the current is then called a wattles current. <u>Alternatively</u> The net power dissipation in a circuit containing an ideal inductor or a capacitor is zero. Therefore, the associated current is wattless current.	1	
	(ii) Q factor of LCR circuit is defined as the ratio of its resonant angular frequency (ω_0) to the band width $(2\Delta\omega)$ of the circuit. <u>Alternatively</u> $Q = \frac{\omega_0}{2\Delta\omega}$ <u>Alternatively</u> $Q = \frac{\omega_0 L}{R}$ <u>Alternatively</u> Quantity factor is the ratio of rms voltage drop across inductor or the capacitor, in resonance condition, to the rms voltage applied to the circuit. $Q = \frac{(V_{rms})_L\ [/(V_{rms})_C]}{(V_{rms})_R}$ <u>Alternatively</u> Quantity factor is measure of the sharpness of the resonance in LCR circuit. <u>Alternatively</u> $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	1	5
	OR		

(a) Statement of Faraday's Laws	1
(b) Derivation of the expression for the emf induced across the ends of a straight conductor	2
(c) Derivation of Magnetic energy stored	2

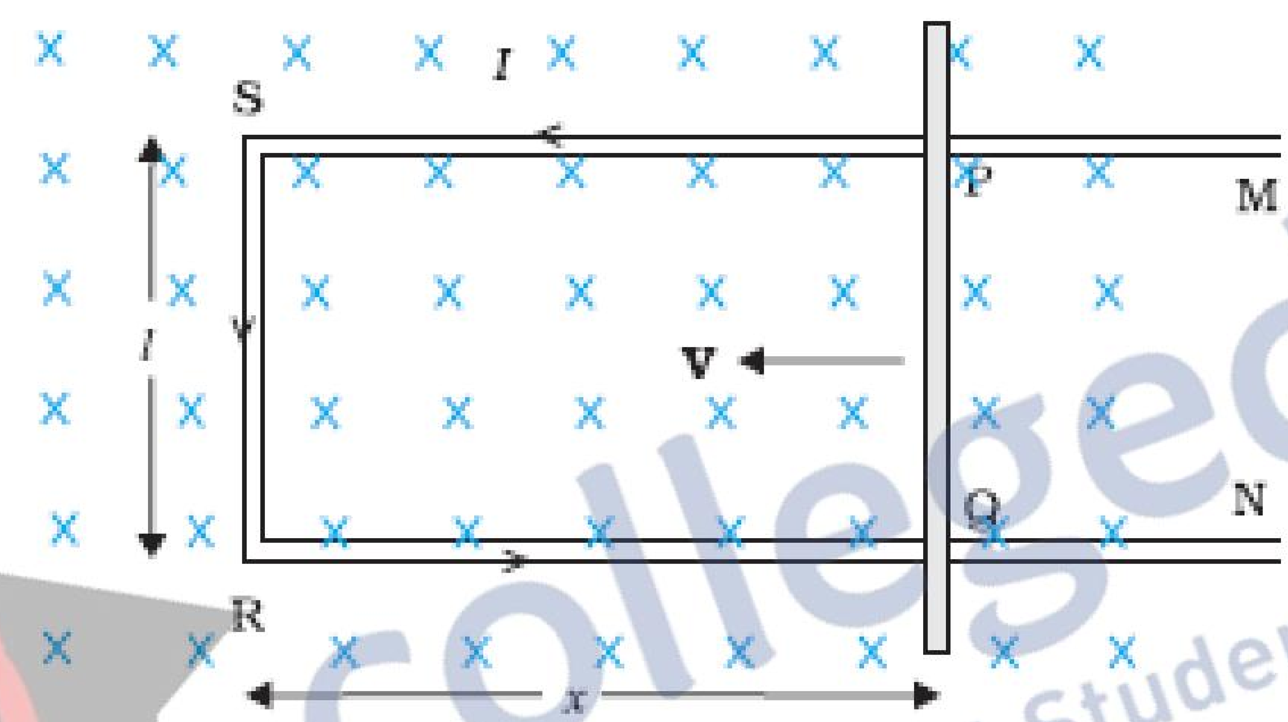
(a) (i) Whenever there is a change in magnetic flux linked with a coil, an emf is induced in the coil, however it lasts so long as magnetic flux keeps on changing.

(ii) The magnitude of the induced emf is equal to the rate of change of magnetic flux through the circuit 1

Alternatively

$$\varepsilon = \frac{-d\phi}{dt}$$

(b)



½

Straight conductor PQ of length 'l' is moving with velocity 'v' in uniform magnetic field B, which is perpendicular to the plane of the system.

Length RQ=x, RS=PQ=l

Instantaneous flux= (normal) field × area

The magnetic flux (ϕ_B) enclosed by the loop PQRS,

½

$$\therefore\ \phi_B = Blx$$

Since 'x' is changing with time, there is a change of magnetic flux. The rate of change of this magnetic flux determines the induced emf

$$\therefore e = \frac{-d\phi}{dt} = \frac{-d}{dt}(Blx)$$

$$= -Bl\frac{dx}{dt}$$

½

$$e = Blv$$

$$\text{as } \frac{dx}{dt} = -v$$

½

(c) Work done (that gets stored as the magnetic potential energy) when current 'I' flows in the solenoid.

	$dW = (e)(I\text{dt})$ $\therefore dW = \left(L\frac{dI}{dt}\right).(Idt)$ $\therefore dW = LIdI$ Total work done $W = \int dW = \int LI\, dI$ $W = \frac{1}{2}L\, I^2$ For the solenoid, we have $L = \mu_0 n^2 Al$ and $B = \mu_0 nI$ $\therefore\ W = \frac{1}{2}(\mu_0 n^2 Al)[\frac{B}{\mu_0 n}]^2$ $= \frac{B^2 Al}{2\mu_0}$	½ ½ ½ ½	5