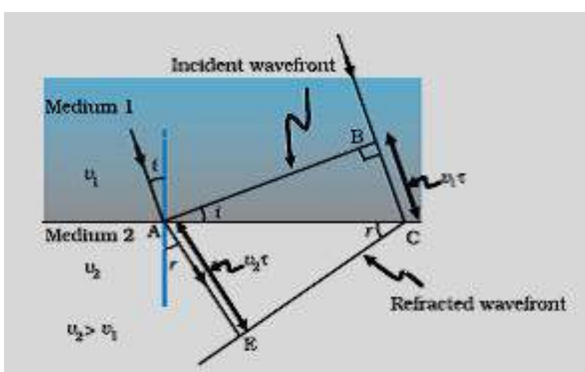
Set1,Q15 Set2,Q22 Set3,Q18	Production of e.m. waves ½ Source of energy ½ Expressions for electric and magnetic fields ½ + ½ Any two properties ½ + ½ ε.M. waves are produced by accelerated /oscillating charges. Source of energy is the source that accelerates the charges Expression for the electric and magnetic fields (for an e.m. wave propagating along the z – axis) can be $E_x = E_0 \sin(kz - wt)$ $B_y = B_0 \sin(kz - wt)$ **<u>Properties (any two)</u>** (i) Transverse nature (ii) Have a definite speed (for all frequencies) in vaccum (iii) Can be polarized (iv) Can show the phenomenon of interference and diffraction (v) Can transport energy from one point to another (vi) Have oscillating electric and magnetic fields along mutually perpendicular directions (vii) Have a momentum associated with them. (viii) Their speed , in a medium , depends upon the values of μ and ε for that medium.	½ ½ ½ ½ ½ + ½	3
Set1,Q16 Set2,Q15 Set3,Q17	(i) Derivation of Snell's law 2 (ii) Sketches to differentiate between plane wavefront and spherical wavefront 1 (i)  We have BC=$\vartheta_1\tau$ and $AE = \vartheta_2\tau$ Also $\sin i = \frac{BC}{AC}$ and $\sin r = \frac{AE}{AC}$	½ ½ ½	

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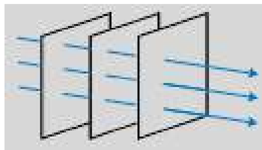
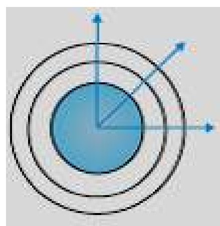
$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{\vartheta_1}{\vartheta_2} = \frac{n_2}{n_1}$$

= a constant
This is Snell's law.

(ii) Plane wavefront


Spherical wavefront

</td>
<td>½

½

½</td>
<td>3</td>
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<tr>
<td>Set1,Q17
Set2,Q11
Set3,Q16</td>
<td>
Two properties of Photon ½ + ½
Writing Einstein's equation ½
Definition of stopping potential (V_0) ½
Definition of Threshold frequency (υ_0) ½
Plot between V_0 and υ ½

Properties of Photon
(i) For a radiation of frequency υ, each photon has an energy, $E = h\upsilon$, associated with it
(ii) The energy of a photon is independent of the intensity of incident radiation.
(iii) During the collision of a photon, with an electron, the total energy of the photon gets absorbed by the electron.
(Any two)

Einstein's photoelectric equation is
$K_{max} = h\upsilon - \phi_0$
or $eV_0 = h\upsilon - \phi_0$

(a) Stopping potoential, V_0, equals that value of the negative potential for which
$|eV_0| = K_{max}$
</td>
<td>½ + ½

½

½</td>
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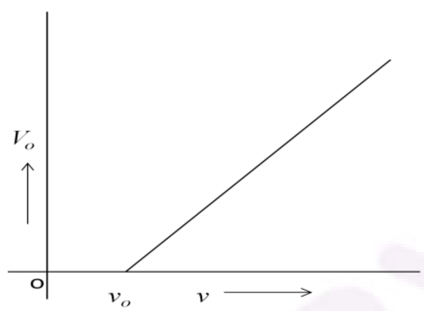
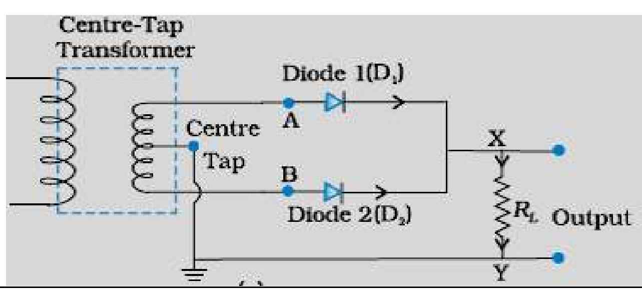
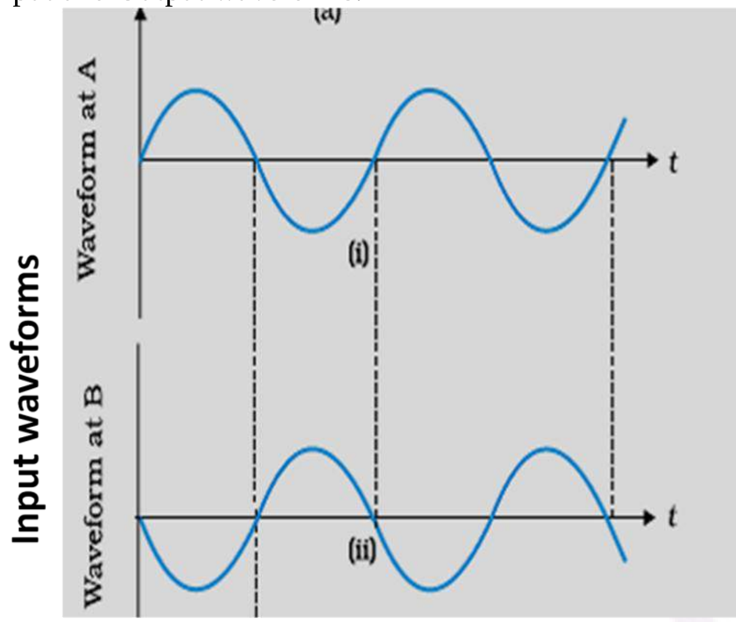
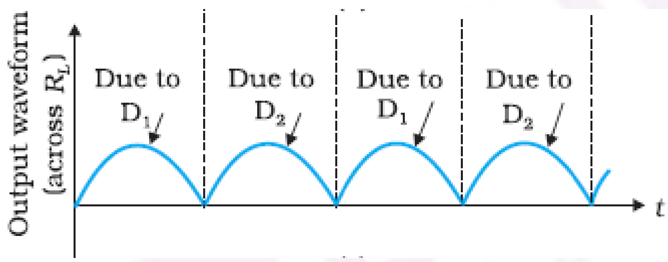
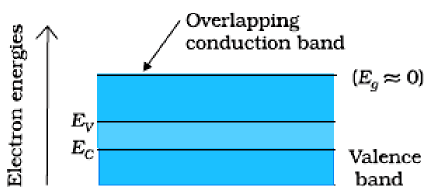
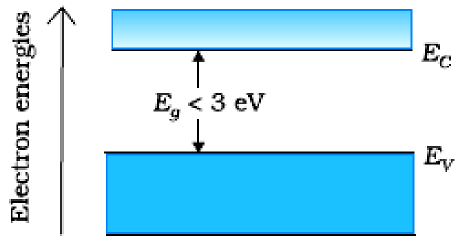
</table>

	(**Alternatively:** The stopping potential (V_0) equals that (least) value of the (negative) plate potential that just stops the most energetic emitted photoelectrons from reaching the plate.) (b) Threshold frequency (ϑ_0) equals that value of the frequency of incident radiation for which $K_{max} = 0$. (**Alternatively:** For a given photosensitive surface, its threshold frequency is the minimum value of the frequency of incident radiation for which photoelectrons can be just emitted from that surface or that maximum frequency of incident radiation below which no photo emission takes place.) The plot, between V_0 and ϑ, has the form shown: 	1 ½	 3
Set1,Q18 Set2,Q20 Set3,Q15	(i) Naming the two processes — ½ + ½ (ii) Circuit diagram — 1 Input and output waveforms — ½ Unidirectional nature of output voltage/current — ½ (i) Diffusion and Drift [Also accept if the student writes a) Appearance of a BARRIER POTENTIAL across the junction. b) Formation of a DEPLETION REGION on either side of the junction.] (ii) Circuit diagram 	½ + ½ 1	

	Input and Output waveforms.   [Note: Award this ½ mark even if the student draws the output waveform only.] Because of (i) the use of the centre tap transformer and (ii) the manner in which the load is connected, the voltage across/current through, the load has the same direction during both halfs of the input wave.	½ ½	3
Set1,Q19 Set2,Q12 Set3,Q14	(i) Distinguishing on the basis of energy band diagram ½+½ (ii) Identifying the gate 1 Truth Table ½ Logic symbol ½ (i)  Conductor	½	



Semiconductor ½

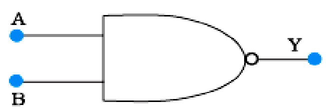
(i) The gate is a NAND gate 1

Truth Table of NAND gate

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

½

Logic Symbol



½ 3

Set1,Q20
Set2,Q18
Set3,Q13

Space wave propagation	1
Factors that limit the range of propagation	½
Derivation of the expression	1½

Space Wave Propagation

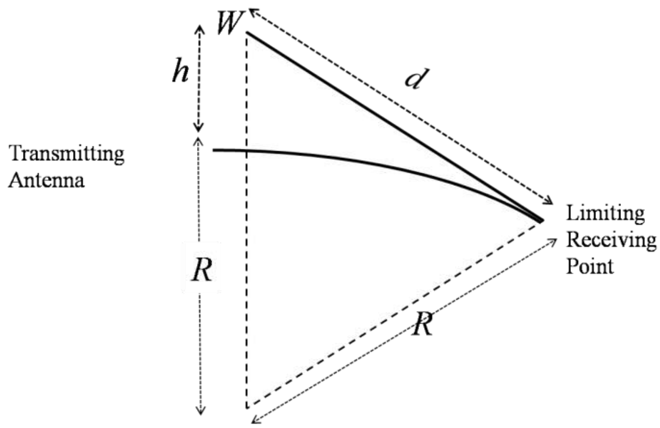
The mode of propagation in which radio waves travel, along a straight line, from the transmitting to the receiving antenna. 1

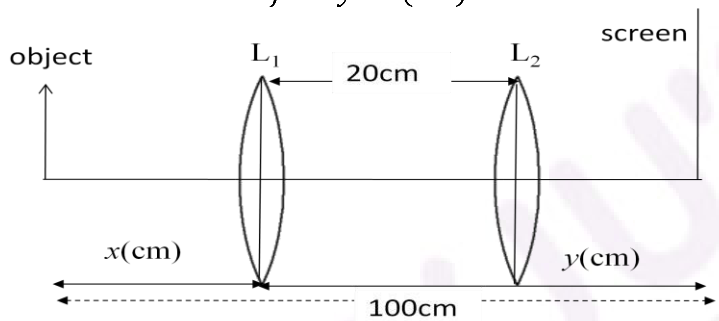
Limiting Factors

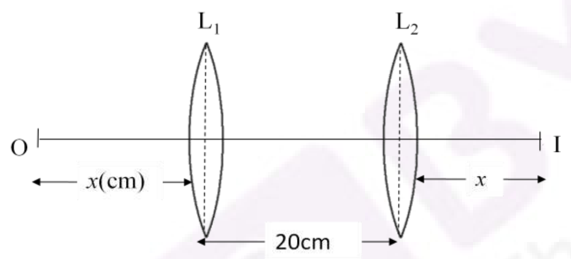
(i) Curvature of the earth

(ii) Insufficient height of the receving antenna ½

(Award this ½ mark if the student writes any one of these two factors)

	<u>Derivation</u>  From the figure, we have $$(R+h)^2 = R^2 + d^2$$ Or $$2Rh \cong d^2 (\ as\ h^2 << 2Rh)$$ $$\therefore, d = \sqrt{2Rh}$$ For a transmitting antenna of height h_T, and a receiving antenna of height h_R, the maximum line of sight distance becomes $$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$ **[NOTE:** Give 1 mark if the student writes the expression for d_M]	½ ½ ½	 3
Set1,Q21 Set2,Q13 Set3,Q12	(i) Derivation of the mathematical expression 2½ (ii) Relation between mean life and decay constant ½ (i) Let there be N_0 radioactive nuclei at t =0. If N is the number of nuclei left over at t=t, we have $$\frac{-dN}{dt} \propto N$$ $$or\ \frac{-dN}{dt} = \lambda N\ \ (\lambda = decay\ constant)$$ $$\therefore\ \frac{dN}{N} = -\lambda\, dt$$ $$or\ lnN = -\lambda t + constant$$ $\therefore$ At t=0, we have $$lnN_0 = constant$$	 ½ ½ ½ ½	

	$lnN = -\lambda t + lnN_0$ $or\ ln\left(\frac{N}{N_0}\right) = -\lambda t$ $\therefore N = N_0 e^{-\lambda t}$ (ii) Mean life$= \frac{1}{decay\ constant}$ (Alternatively, $\tau = \frac{1}{\lambda}$)	½ ½	3
Set1,Q22 Set2,Q16 Set3,Q11	(i) Calculating the focal length of the lens 2 (ii) Calculating the focal length of the combination 1 (i) For first position of the lens , we have $$\frac{1}{f} = \frac{1}{y} - \frac{1}{(-x)}$$  For second position of the lens , we have $$\frac{1}{f} = \frac{1}{y-20} - \frac{1}{(-(x+20))}$$ $\frac{1}{y} + \frac{1}{x} = \frac{1}{(y-20)} + \frac{1}{(x+20)}$ $\frac{x+y}{xy} = \frac{(x+20)+(y-20)}{(y-20)(x+20)}$ $\therefore xy = (y-20)(x+20)$ $= xy - 20x + 20y - 400$ $\therefore x - y = -20$ Also , x + y =100 ∴ x = 40 cm and y = 60 cm $\therefore \frac{1}{f} = \frac{1}{60} - \frac{1}{-40} = \frac{2+3}{120} = \frac{5}{120}$ $\therefore f = 24\ cm$	½ ½ ½ ½	

	Alternatively , We have $f = \frac{D^2 - d^2}{4D}$ $= \frac{100^2 - 20^2}{4 \times 100}$ $= \frac{120 \times 80}{400}$ = 24 cm **Alternatively,** For the two positions of the lens , the values of the magnitudes of u and v , get interchanged. Hence , $\|u + v\| = 100$ $\|u - v\| = 20$, This gives $\|u\| = 60$ $\|v\| = 40$ $\therefore f = 24\,cm$ **Alternatively ,**  $2x + 20 = 100$ $\therefore x = 40$cm For lens at position L_1 ; u = - x = -40cm v = 20 + 40 = 60cm This gives f = 24 cm (i) For combination of two lenses in contact . Net Power of combination , P = P_1 + P_2 $P_1 = +P$, $P_2 = -P$ So P= 0 and F= infinite **Alternatively ,** $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$	1 ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½	

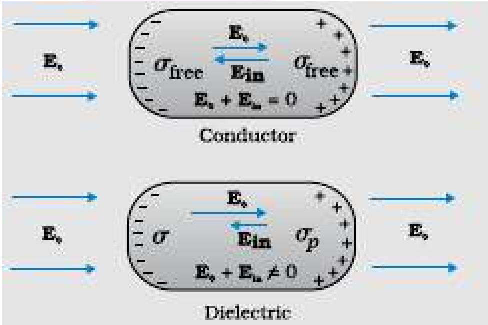
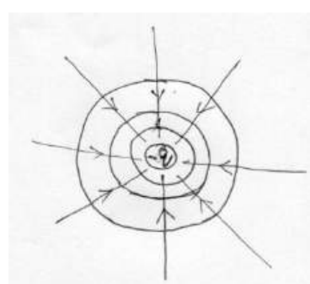
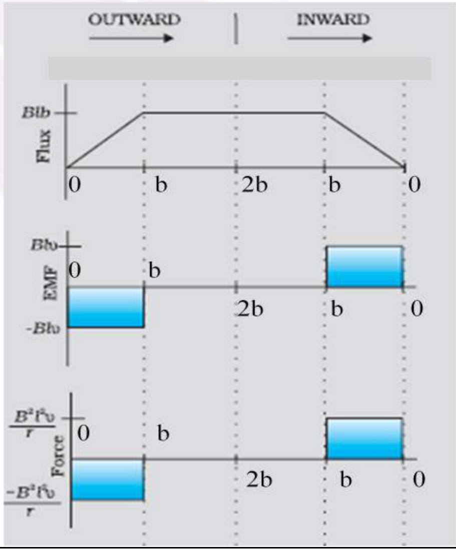
	$= \frac{1}{f} + \left(\frac{-1}{f}\right) = 0$ F = infinite	½	
Set1,Q23 Set2,Q23 Set3,Q23	(a) Values displayed ½ + ½ + ½ (b) Possible reason ½ (c) Formula for force ½ Max. value 1 Min. value ½ a) Value displayed by Seema : Helpful , considerate Family : Concerned , Affectionate Doctor : Humane nature (any one in all three cases) b) Expensive machinery/technique c) $F = qvB\sin\theta$ $F_{max} = qvB = 1.6 \times 10^{-19} \times 10^{4} \times 0.1$ $= 1.6 \times 10^{-16}$N F_{min}=zero (for $\theta = 0^{0}$)	 ½ ½ ½ ½ ½ 1 ½	 4
Set1,Q24 Set2,Q25 Set3,Q26	**SECTION E** a) Difference between the behaviours of the two (½ + ½) Modification of electric field. 1 b) (i) Charge stored + justification ½ + ½ (ii) field strength + justification ½ + ½ (iii) energy stored + justification ½ + ½ a)  No electric field inside a conductor . (Give full credit to diagram. Give ½ mark if explanation only is given without	½ + ½	

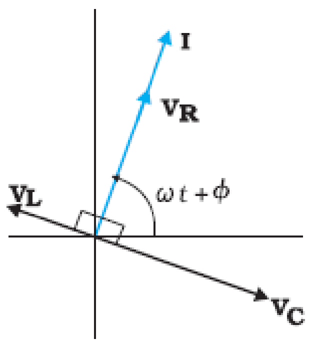
	diagram)		
	Induced electric field ,due to polarisation of dielectric, is in opposite direction to the applied field.	1	
	$$E_{net} = E_0 - E_\rho$$		
	(b)		
	(i) Charge remains same, as after disconnecting capacitor no transfer of charge take place.	½ + ½	
	(ii) Electric field, $E = \frac{\sigma}{\epsilon_0} = \frac{q}{\epsilon_0 A}$ remain same, as there is no change in charge.	½ + ½	
	(iii)Energy stored $= \frac{q^2}{2C} = \frac{q^2}{2\left(\frac{\epsilon_0 A}{d}\right)} = \frac{q^2 d}{2\epsilon_0 A}$	½	
	a. Energy will be doubled as separation between the plates(d) is doubled.	½	5
	OR		
	a) Why is electric field normal to the equipotential surface. 1 ½ Sketch of the equipotential surface and electric field lines. ½ + ½ b) Obtaining the expression for the work done. 2 ½		
	(a) If the field is not normal to an equipotential surface, it would have a non zero component along the surface. This would imply that work would have to be done to move a charge on the surface which is contradictory to the definition of equipotential surface.	1 ½	
	(Alternatively, Work done to move a charge dq, on a surface, can be expressed as $$dW = dq(\vec{E}.\vec{dr})$$	½	
	But *dW=0* on an equipotential surface	½	
	$\therefore \vec{E} \perp \vec{dr}$)	½	
	Equipotential surfaces for a charge –q 	½ +½	
	(b) Work done to dissociate the system = -Potential energy of the system	½	

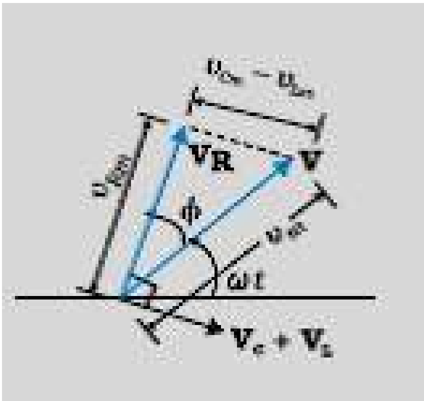
	$=\frac{-1}{4\pi\epsilon_0}\left[\frac{(-4q)(q)}{a}+\frac{(2q)(q)}{a}+\frac{(-4q)(2q)}{a}\right]$ $=-\frac{1}{4\pi\epsilon_0 a}[-4q^2+2q^2-8q^2]$ $=+\left[\frac{10q^2}{4\pi\epsilon_0 a}\right]$	1 ½ ½	5
Set1,Q25 Set2,Q26 Set3,Q24	(a) Identification of phenomenon ½ Stating the factors ½ + ½ Law ½ (b) Sketch of change in i. Flux 1 ii. Emf 1 iii. Force 1 (a) The phenomenon involved is electromagnetic induction (EMI) For the deflection: Amount depends upon the speed of movement of the magnet. Direction depends on the sense (towards, or away) of the movement of the magnet. The law describing the phenomenon is : The magnitude of the induced emf, in a circuit, is equal to the time rate of change of the magnetic flux through the circuit. (Note: Also accept if a student writes: whenever magnetic flux linked with a conductor changes, an induced emf is setup in the conductor.) (Alternatively, $\epsilon = -\frac{d\phi_B}{dt}$) (b) 	½ ½ ½ ½ 1 1 1	5

OR

Phasor diagram	½
Derivation of expression for current	1 ½
Power dissipated	2
Reason for maximum power dissipation at resonance	1

Phasor diagram





½

Using the phasor diagram, we get

$v_m^2 = v_{Rm}^2 + \ (v_{Cm} - \ v_{Lm})^2$ ½

Or $v_m^2 = i_m^2[R^2 + (X_c - X_L)^2]$ ½

$\therefore\ i_m = \frac{v_m}{\sqrt{R^2+(X_c-X_L)^2}}$

Also, $\tan\phi = \frac{v_C - v_L}{v_R} = \frac{X_C - X_L}{R}$

$\therefore$ the expression, for current, is

$$i = i_m \sin(wt + \emptyset)$$ ½

(Note: Award these two marks even if the student draws the phasor diagram / does the derivation of $i = i_m \sin(wt - \emptyset)$ for $X_C < X_L$)

Power dissipated:

The instantaneous power, p, supplied by the source, is

p= ϑi

$= (\vartheta_m \sin wt)(i_m \sin(wt + \phi))$ ½

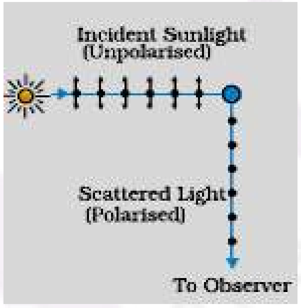
$= \frac{\vartheta_m i_m}{2}[\cos\phi - \cos(2wt + \phi)]$ ½

The average power, over a cycle, is, therefore

P=<p>=$\frac{V_m i_m}{2}(\cos\phi)$ ½

= VIcos ϕ ½

At resonance, we have

	$X_c = X_L$ $\tan\phi = 0 \Longrightarrow \phi = 0^0$ $\therefore \cos\phi = 1$, its maximum value. Hence P(=VI $\cos\phi$) has its maximum value at resonance.	½ ½	 5
Set1,Q26 Set2,Q24 Set3,Q25	a) Reason for variation — ½ Polarisation due to scattering — 2 b) Statement for Malus' law — ½ Calculation of intensities for (i) $\theta = 30^o$ — 1 (ii) $\theta = 60^o$ — 1 (a) As per Malus' law, Transmitted intensity $I = I_o \cos^2\theta$ $\therefore$ The transmitted intensity will show a variation as per $\cos^2\theta$. [Note: If the student writes that "unpolarised light will not show any variation in intensity, when viewed through a polaroid, which is rotated" award this ½ mark]  The electric field, of the incident wave, makes the electrons of the air molecules, acquire both components of motion. (↕ as well as •). Charges accelerating parallel to ↕ , do not radiate energy towards the observer. Hence the radiation, scattered towards the observer gets linearly polarised. (Note: Award these 2 marks even if the student just draws a well labelled diagram, without giving any explanation.)	 ½ 1 ½ ½	

	Path difference $= S_2P - S_1P$ Now $(S_2P)^2 - (S_1P)^2 = \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x + \frac{d}{2}\right)^2\right]$ $= 2\,xd$ where S_1S_2 =d and OP=x $\therefore\ S_2P - S_1P = \frac{2xd}{(S_2P + S_1P)}$ For x<<D and d<<D, we can write $S_2P + S_1P \simeq 2D$ Hence, Path difference= $S_2P - S_1P = \frac{2xd}{2D} = \frac{xd}{D}$ For constructive interference, we must have $\frac{xd}{D} = n\lambda$ $\therefore x = x_n = \frac{n\lambda D}{d}$ (n=0, $\pm 1, \pm 2, ...$) For destructive interference, we must have $\frac{xd}{D} = \left(n + \frac{1}{2}\right)\lambda$ $\therefore x = x'_n = \frac{\left(n+\frac{1}{2}\right)\lambda D}{d}$ (n=0, $\pm 1, \pm 2, ...$) (b) The general expression, for the intensity, at a point is $I = I_0 \cos^2 {\emptyset}/{2}$ (i) For path difference $= {\lambda}/{6}$, $\emptyset = 60^0$ $I = {3I_0}/{4}$ (ii) For path difference $= {\lambda}/{4}$, $\emptyset = 90^0$ $I = {I_0}/{2}$ (iii) For path difference $= {\lambda}/{3}$, $\emptyset = 120^0$ $I = {I_0}/{4}$	½ ½ ½ ½ ½ ½ ½ ½ ½	5