

CBSE Class 12 Physics Question Paper Solution 2016

SET 55/1/1/N

MARKING SCHEME

Q. No.	Expected Answer / Value Points	Marks	Total Marks				
Set1,Q1 Set2,Q2 Set3,Q4	SECTION A Zero / No work done / None	1	1				
Set1,Q2 Set2,Q5 Set3,Q3	Drift velocity per unit field ($\mu_m = v_d/E$) $\mu_n \propto \tau$ (directly proportional to relaxation time)	$\frac{1}{2}$ $\frac{1}{2}$	1				
Set1,Q3 Set2,Q4 Set3,Q2	Charged particle moves inclined to the magnetic field (angle between \vec{v} and \vec{B} is neither $\pi/2$ nor 0) (component of \vec{v} , parallel to \vec{B} , is not zero.)	1	1				
Set1,Q4 Set2,Q1 Set3,Q5	(some) light gets deviated / scattered / absorbed Scattering of light	$\frac{1}{2}$ $\frac{1}{2}$	1				
Set1,Q5 Set2,Q3 Set3,Q1	$v_{side\ bands} = v_c \pm v_m$ = 2005 kHz ; 1995 kHz (Give full 1 mark if the student straightaway writes the answer as 2005 kHz and 1995 kHz)	$\frac{1}{2}$ $\frac{1}{2}$	1				
Set1,Q6 Set2,Q8 Set3,Q7	SECTION B <table border="1"><tr><td>Formulae:</td><td>1</td></tr><tr><td>Substitution and calculation:</td><td>1</td></tr></table> $R = \rho \frac{l}{A}; I = neAv_d$ $\therefore \rho = \frac{V}{neIv_d}$ Alternatively, $\left(j = \sigma E = \frac{E}{\rho} \text{ or } \frac{E}{j} = \rho \right)$ $\left(\therefore \rho = \frac{V}{Inev_d} \right)$ (Award this 1 mark even if the student writes the formula for ρ directly as such) $\therefore \rho = \frac{5}{0.1 \times 8 \times 10^{28} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-4}} \Omega - m$ $= 1.56 \times 10^{-5} \Omega - m$ $\simeq 1.6 \times 10^{-5} \Omega - m$	Formulae:	1	Substitution and calculation:	1	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2
Formulae:	1						
Substitution and calculation:	1						

Set1,Q7 Set2,Q10 Set3,Q8	<table> <tr> <td>Formulae</td> <td>$\frac{1}{2} + \frac{1}{2}$</td> </tr> <tr> <td>Conclusions in the two cases</td> <td>$\frac{1}{2} + \frac{1}{2}$</td> </tr> </table> <p>(i) $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$ $\therefore (mq)$ is more for α – particle, we have $\lambda_{proton} > \lambda_{\alpha - particle}$ (Also, accept if the student writes $\frac{\lambda_{proton}}{\lambda_{\alpha}} = 2\sqrt{2}$ (or $\sqrt{8}$)</p> <p>(ii) K.E. = q V $\therefore q$ is less for proton, we have $(K.E)_{proton} < (K.E)_{\alpha - particle}$ (Also accept if the student writes $\frac{(K.E.)_{\alpha}}{(K.E.)_{\rho}} = 2$)</p>	Formulae	$\frac{1}{2} + \frac{1}{2}$	Conclusions in the two cases	$\frac{1}{2} + \frac{1}{2}$	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2
Formulae	$\frac{1}{2} + \frac{1}{2}$						
Conclusions in the two cases	$\frac{1}{2} + \frac{1}{2}$						
Set1,Q8 Set2,Q9 Set3,Q6	<table> <tr> <td>Indicating the transition</td> <td>1</td> </tr> <tr> <td>Calculation of frequency</td> <td>1</td> </tr> </table> <p>When the electron jumps from the orbit with $n=3$ to $n=2$ (Longest wavelength of the Balmer series / First line of the Balmer series)</p> $h\nu = E_3 - E_2 = \frac{E_1}{9} - \frac{E_1}{4}$ $= \frac{-5}{36} E_1 = \frac{-5}{36} \times (-13.6 \text{ eV})$ $= \frac{5}{36} \times 13.6 \times 1.6 \times 10^{-19} \text{ J}$ $\therefore \nu = \frac{5 \times 13.6 \times 1.6 \times 10^{-19}}{36 \times 6.63 \times 10^{-34}} \text{ Hz}$ $\approx 4.57 \times 10^{14} \text{ Hz.}$ <p>(If the student just writes $\nu = \frac{-5}{36} \frac{E_1}{h}$, award $\frac{1}{2}$ mark)</p> <p>(Alternatively,</p> $\frac{1}{\lambda} = R \left(\frac{1}{2^2} - \frac{1}{3^2} \right) = \frac{5}{36} R$ $\therefore \nu = \frac{c}{\lambda}$ $= c \times \frac{5}{36} R$ $= 3 \times 10^8 \times \frac{5}{36} \times 1.097 \times 10^7 \text{ Hz}$ $\approx 4.57 \times 10^{14} \text{ Hz})$	Indicating the transition	1	Calculation of frequency	1	1 $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2
Indicating the transition	1						
Calculation of frequency	1						

$$(i) \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$$

$\therefore (mq)$ is more for α - particle, we have

$$\lambda_{proton} > \lambda_{\alpha - particle}$$

(Also, accept if the student writes $\frac{\lambda_{proton}}{\lambda_{\alpha}} = 2\sqrt{2}$ (or $\sqrt{8}$))

$$(ii) K.E. = qV$$

$\therefore q$ is less for proton, we have

$$(K.E)_{proton} < (K.E)_{\alpha - particle}$$

(Also accept if the student writes $\frac{(K.E.)_{\alpha}}{(K.E.)_p} = 2$)

Indicating the transition	1
Calculation of frequency	1

When the electron jumps from the orbit with $n=3$ to $n=2$

(Longest wavelength of the Balmer series / First line of the Balmer series)

$$\begin{aligned} h\nu &= E_3 - E_2 = \frac{E_1}{9} - \frac{E_1}{4} \\ &= \frac{-5}{36} E_1 = \frac{-5}{36} \times (-13.6 \text{ eV}) \\ &= \frac{5}{36} \times 13.6 \times 1.6 \times 10^{-19} \text{ J} \end{aligned}$$

$$\begin{aligned} \therefore \nu &= \frac{5 \times 13.6 \times 1.6 \times 10^{-19}}{36 \times 6.63 \times 10^{-34}} \text{ Hz} \\ &\simeq 4.57 \times 10^{14} \text{ Hz.} \end{aligned}$$

(If the student just writes $\nu = \frac{-5}{36} \frac{E_1}{h}$, award $\frac{1}{2}$ mark)

(Alternatively,

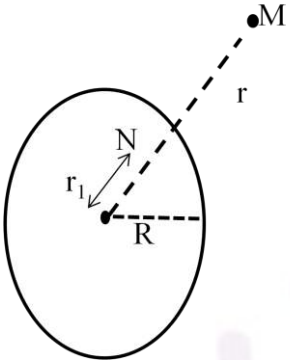
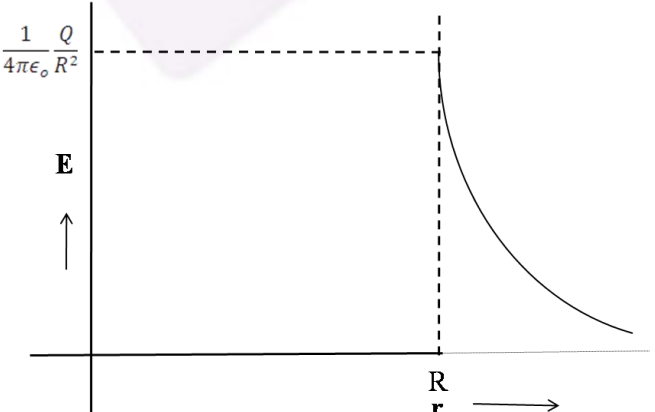
$$\frac{1}{\lambda} = R \left(\frac{1}{2^2} - \frac{1}{3^2} \right) = \frac{5}{36} R$$

$$\therefore \nu = \frac{c}{\lambda}$$

$$= c \times \frac{5}{36} R$$

$$\begin{aligned} &= 3 \times 10^8 \times \frac{5}{36} \times 1.097 \times 10^7 \text{ Hz} \\ &\simeq 4.57 \times 10^{14} \text{ Hz} \end{aligned}$$

	OR								
	<table><tr><td>Formula</td><td>1</td></tr><tr><td>Calculation of λ</td><td>1</td></tr></table>	Formula	1	Calculation of λ	1				
Formula	1								
Calculation of λ	1								
	$\frac{1}{\lambda} = R \left(\frac{1}{1^2} - \frac{1}{\infty^2} \right)$ $\therefore \lambda = \frac{1}{R}$ $= \frac{1}{1.097 \times 10^7} \text{ m}$ $\simeq 9.116 \times 10^{-8} \text{ m}$ $\simeq 912 \text{ \AA}^0 \text{ (91.2 nm)}$	$\frac{1}{2}$ $\frac{1}{2}$							
Set1,Q9 Set2,Q6 Set3,Q10	<table><tr><td>Two Reasons 1+ 1</td></tr></table> <p>If base band signal were to be transmitted directly</p> <ol style="list-style-type: none">1. The height of the antennae needed will be impractically large.2. The effective power radiated would be too low.3. There would be a high probability of different signals getting mixed up with one another. <p>(Any two)</p>	Two Reasons 1+ 1	1	2					
Two Reasons 1+ 1									
Set1,Q10 Set2,Q7 Set3,Q9	<table><tr><td>Identifying that θ is the angle of minimum deviation</td><td>$\frac{1}{2}$</td></tr><tr><td>Formula</td><td>$\frac{1}{2}$</td></tr><tr><td>Calculation of θ</td><td>1</td></tr></table> <p>Since AQ = AR, we have QR BC $\therefore \theta$ is the angle of minimum deviation.</p> <p>(Alternatively: Since AQ=AR, we get $\angle r_1 = \angle r_2$ $\therefore \theta$ is the angle of minimum deviation.)</p> $\mu = \frac{\sin \left(\frac{A + \delta m}{2} \right)}{\sin(A/2)}$ $\therefore \sqrt{3} = \frac{\sin \left(\frac{60 + \delta m}{2} \right)}{\sin 30^0}$ $\therefore \frac{\sqrt{3}}{2} = \sin \left(\frac{60 + \delta m}{2} \right)$ $\therefore \frac{60 + \delta m}{2} = 60$ <p>or $\delta m = 60^0$</p>	Identifying that θ is the angle of minimum deviation	$\frac{1}{2}$	Formula	$\frac{1}{2}$	Calculation of θ	1	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$	2
Identifying that θ is the angle of minimum deviation	$\frac{1}{2}$								
Formula	$\frac{1}{2}$								
Calculation of θ	1								

SECTION C			
Set1,Q11 Set2,Q17 Set3,Q22	<div> <div>Statement of Gauss's Law</div> <div>Calculation of field</div> <div>(i) Outside the shell</div> <div>(ii) Inside the shell</div> <div>Graph</div> </div> <div> <div>$\frac{1}{2}$</div> <div>1</div> <div>1</div> <div>$\frac{1}{2}$</div> </div>		
<p>We have by Gauss's law $\oint \vec{E} \cdot d\vec{S} = \frac{Q_{enclosed}}{\epsilon_0}$</p> <p>Let Q be the total charge on the shell</p> <p>(i) For the point M outside the shell, we have</p>  <div> <div>$E \cdot 4\pi r^2 = \frac{Q}{\epsilon_0}$</div> <div>$\therefore E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$</div> </div> <p>(ii) For the point N inside the shell, as charge enclosed inside the shell is zero.</p> <div> <div>$E \cdot 4\pi r_1^2 = 0$</div> <div>$\therefore E = 0$</div> </div> <p>The graph is as shown</p> 		<div>$\frac{1}{2}$</div> <div>$\frac{1}{2}$</div> <div>$\frac{1}{2}$</div> <div>$\frac{1}{2}$</div> <div>$\frac{1}{2}$</div> <div>$\frac{1}{2}$</div>	3

Formulae	1
Calculation of r	2

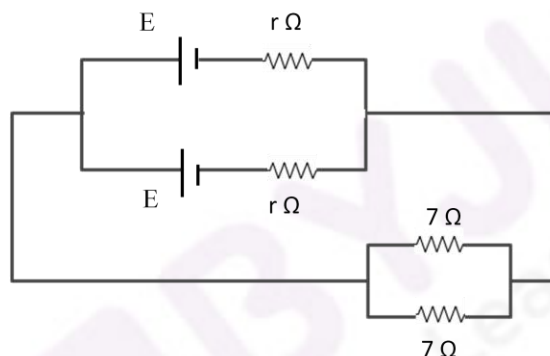
$$r = \left(\frac{E}{V} - 1 \right) R$$
$$\frac{r}{2} = \left(\frac{E}{V} - 1 \right) \frac{R}{2}$$

$$\therefore r = \left(\frac{1.5}{1.4} - 1 \right) \times 7\Omega$$

$$= \frac{0.1}{1.4} \times 7 \, \Omega$$

$$= 0.5\Omega$$

(Alternatively,



$$I = \frac{V}{(R/2)}$$

And $E = V - I(r/2)$

This gives $I = \frac{1.4}{7/2} \text{A} = 0.4 \text{A}$

$$\therefore \frac{r}{2} = \frac{1.5-1.4}{0.4} = 0.25$$

$$\therefore r = 0.5\Omega)$$

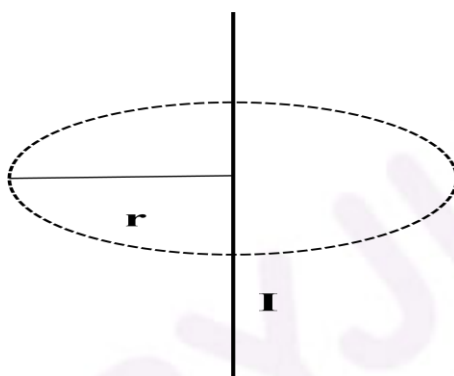
(Note: If the student just draws the circuit diagram of the setup but does not do any calculations, award 1 mark only.)

According to Ampers's circuital law, "The line integral of the magnetic field, around a closed loop, equals μ_o times the total current passing through the surface enclosed by that loop."

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$
$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$

$$\text{or } B2\pi r = \mu_0 I$$

$$\text{or } B = \frac{\mu_0 I}{2\pi r}$$



OR

The cyclotron uses both electric and magnetic fields, in combination, to increase the energy of the charged particles.

(i) A magnetic field to make the charged particles move in a circular path.

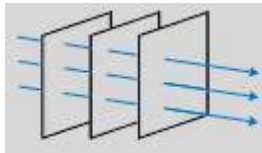
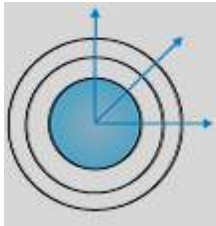
(ii) An alternating electric field which accelerates the charged particles as they repeatedly cross it in a way that makes them gain energy continuously.)

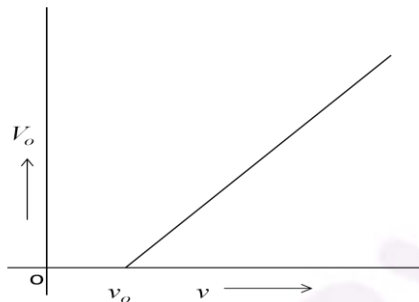
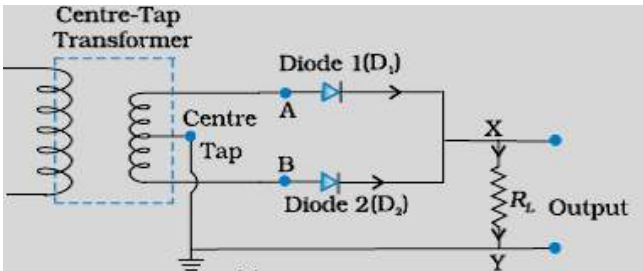
We have

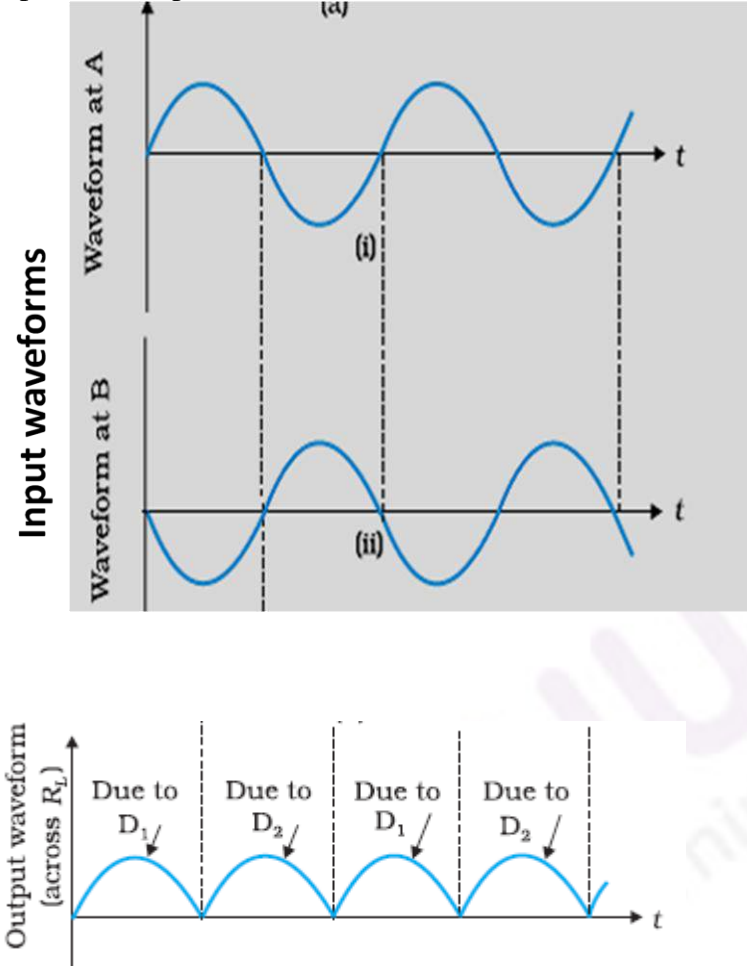
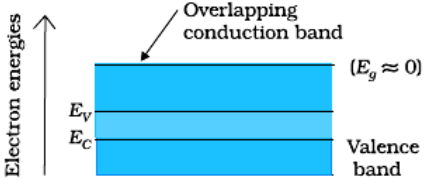
$$\frac{mv^2}{r} = qvB$$

	$\therefore r = \frac{mv}{qB}$ $\text{Also } T = \frac{2\pi r}{v}$ $\therefore T = \frac{2\pi m}{qB}$ <p>$\therefore T$ is independent of v, the speed of the charged particles.</p> <p>This property ensures that if the frequency of the applied alternating electric field matches the cyclotron frequency, the particle would keep on getting accelerated every time it crosses the gap between the dees.</p> <p>(Alternatively : Because of the property, the applied alternating electric field can be made to accelerate the charged particles continuously. This property ensures that the resonance condition can be satisfied and the particle gets accelerated continuously. This property ensures that we can have $\vartheta = \vartheta_c$, the resonance condition.)</p>	1/2 1/2 1/2	3
Set1,Q14 Set2,Q14 Set3,Q19	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> Showing that the average power, over a complete cycle is zero 2 Effect on brightness of bulb 1 </div> <p>(i) Let the applied voltage be</p> $V = V_0 \sin \omega t$ <p>The current through an ideal capacitor, would then be</p> $I = I_0 \sin \left(\omega t + \frac{\pi}{2} \right) = I_0 \cos \omega t$ $\therefore P_{inst} = VI$ $\therefore P_{AV} = \frac{1}{T} \int_0^T VI dt$ $\therefore P_{AV} = \frac{V_0 I_0}{2} \langle \sin 2\omega t \rangle$ $= 0$ <p>(Alternatively , For an ideal capacitor, the current leads voltage in phase by $\pi/2$. $\therefore P = \frac{E_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}} \cos \phi = \frac{E_0 I_0}{2} \cos \frac{\pi}{2}$ $= 0)$</p> <p>(ii) The brightness of the bulb would also reduce gradually.</p> <p>(Alternatively: $X_c = \frac{1}{\omega C}$ $\therefore X_c \text{ increases as } C \text{ decreases. Hence, with decreasing } C, \text{ the brightness of the bulb would decrease.})$</p>	1/2 1/2 1/2 1/2 1	3

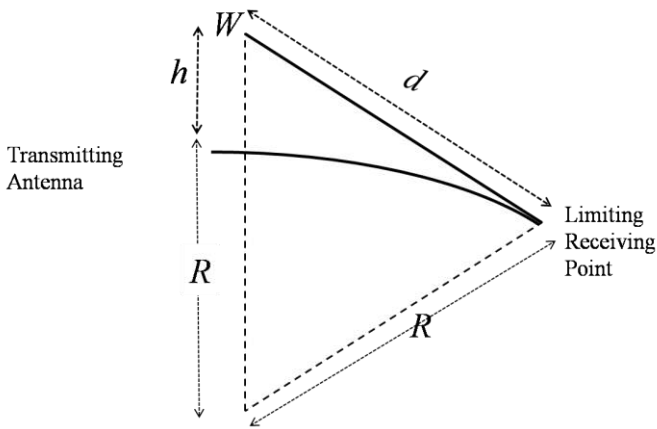
Set1,Q15 Set2,Q22 Set3,Q18	<div style="border: 1px solid black; padding: 5px;"> <p>Production of e.m. waves $\frac{1}{2}$</p> <p>Source of energy $\frac{1}{2}$</p> <p>Expressions for electric and magnetic fields $\frac{1}{2} + \frac{1}{2}$</p> <p>Any two properties $\frac{1}{2} + \frac{1}{2}$</p> </div> <p>$\epsilon$.M. waves are produced by accelerated /oscillating charges.</p> <p>Source of energy is the source that accelerates the charges</p> <p>Expression for the electric and magnetic fields (for an e.m. wave propagating along the z – axis) can be</p> <p>$E_x = E_0 \sin(kz - wt)$</p> <p>$B_y = B_0 \sin(kz - wt)$</p> <p>Properties (any two)</p> <ul style="list-style-type: none"> (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. 	$\frac{1}{2}$	
Set1,Q16 Set2,Q15 Set3,Q17	<div style="border: 1px solid black; padding: 5px;"> <p>(i) Derivation of Snell's law 2</p> <p>(ii) Sketches to differentiate between plane wavefront and spherical wavefront 1</p> </div> <div style="text-align: center;"> <p>(i)</p> </div> <p>We have $BC = v_1 t$ and $AE = v_2 t$</p> <p>Also $\sin i = \frac{BC}{AC}$ and $\sin r = \frac{AE}{AC}$</p>	$\frac{1}{2}$	
		$\frac{1}{2}$	3

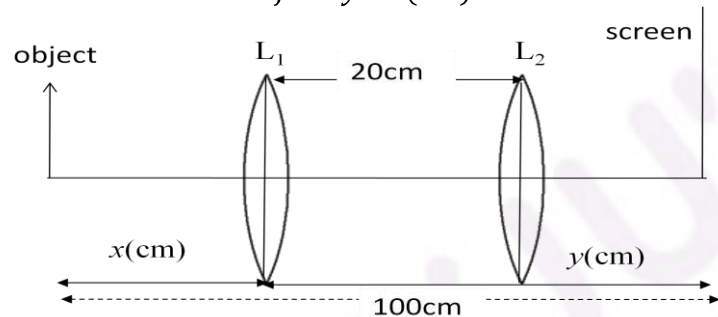
	$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{\vartheta_1}{\vartheta_2} = \frac{n_2}{n_1}$ <p>= a constant This is Snell's law.</p> <p>(ii) Plane wavefront</p>  <p>Spherical wavefront</p> 	1/2											
		1/2											
		1/2	3										
Set1,Q17 Set2,Q11 Set3,Q16	<table><tr><td>Two properties of Photon</td><td>1/2 + 1/2</td></tr><tr><td>Writing Einstein's equation</td><td>1/2</td></tr><tr><td>Definition of stopping potential (V_0)</td><td>1/2</td></tr><tr><td>Definition of Threshold frequency (ν_0)</td><td>1/2</td></tr><tr><td>Plot between V_0 and ν</td><td>1/2</td></tr></table> <p>Properties of Photon</p> <p>(i) For a radiation of frequency ν, each photon has an energy, $E = h\nu$, associated with it</p> <p>(ii) The energy of a photon is independent of the intensity of incident radiation.</p> <p>(iii) During the collision of a photon, with an electron, the total energy of the photon gets absorbed by the electron. (Any two)</p> <p>Einstein's photoelectric equation is</p> $K_{max} = h\nu - \phi_0$ <p>or $eV_0 = h\nu - \phi_0$</p> <p>(a) Stopping potential, V_0, equals that value of the negative potential for which</p> $ eV_0 = K_{max}$	Two properties of Photon	1/2 + 1/2	Writing Einstein's equation	1/2	Definition of stopping potential (V_0)	1/2	Definition of Threshold frequency (ν_0)	1/2	Plot between V_0 and ν	1/2	1/2 + 1/2	
Two properties of Photon	1/2 + 1/2												
Writing Einstein's equation	1/2												
Definition of stopping potential (V_0)	1/2												
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Plot between V_0 and ν	1/2												
		1/2											
		1/2											

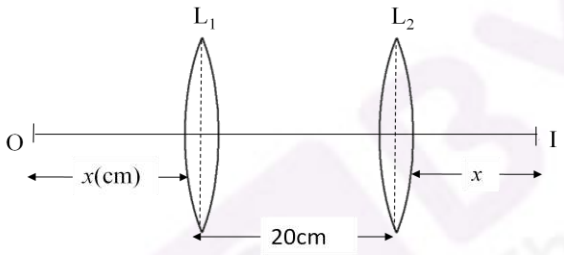
	<p>(Alternatively: The stopping potential (V_0) equals that (least) value of the (negative) plate potential that just stops the most energetic emitted photoelectrons from reaching the plate.)</p> <p>(b) Threshold frequency (ν_0) equals that value of the frequency of incident radiation for which $K_{max} = 0$.</p> <p>(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.)</p> <p>The plot, between V_0 and ν, has the form shown:</p> 	1	
Set1,Q18 Set2,Q20 Set3,Q15	<p>(i) Naming the two processes $\frac{1}{2} + \frac{1}{2}$</p> <p>(ii) Circuit diagram 1</p> <p>Input and output waveforms $\frac{1}{2}$</p> <p>Unidirectional nature of output voltage/current $\frac{1}{2}$</p> <p>(i) Diffusion and Drift [Also accept if the student writes</p> <p>a) Appearance of a BARRIER POTENTIAL across the junction.</p> <p>b) Formation of a DEPLETION REGION on either side of the junction.]</p> <p>(ii) Circuit diagram</p> 	$\frac{1}{2} + \frac{1}{2}$	3
		1	

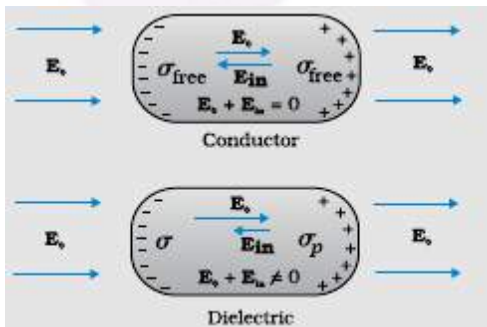
	<p>Input and Output waveforms.</p>  <p>[Note: Award this 1/2 mark even if the student draws the output waveform only.]</p> <p>Because of (i) the use of the centre tap transformer and (ii) the manner in which the load is connected, the voltage across/current through, the load has the same direction during both halves of the input wave.</p>	1/2	3
Set1,Q19 Set2,Q12 Set3,Q14	<div style="border: 1px solid black; padding: 10px; margin-bottom: 10px;"> <p>(i) Distinguishing on the basis of energy band diagram 1/2+1/2</p> <p>(ii) Identifying the gate 1</p> <p>Truth Table 1/2</p> <p>Logic symbol 1/2</p> </div> <p>(i)</p> 	1/2	

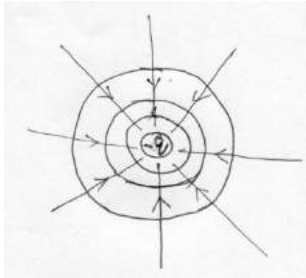
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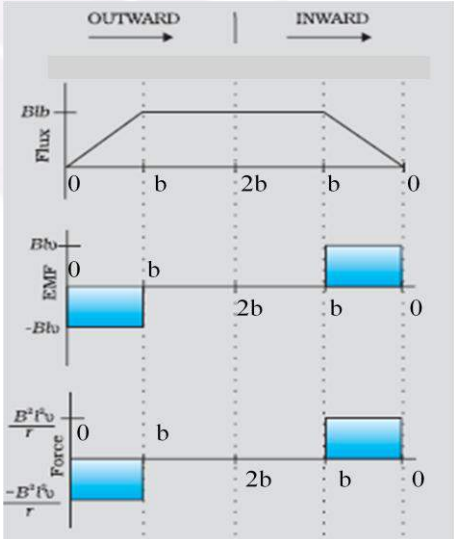
	<p><u>Derivation</u></p>  <p>From the figure, we have</p> $(R + h)^2 = R^2 + d^2$ <p>Or</p> $2Rh \cong d^2 \text{ (as } h^2 \ll 2Rh)$ $\therefore d = \sqrt{2Rh}$ <p>For a transmitting antenna of height h_T, and a receiving antenna of height h_R, the maximum line of sight distance becomes</p> $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$ <p>[NOTE: Give 1 mark if the student writes the expression for d_M]</p>	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>3</p>	
<p>Set1,Q21 Set2,Q13 Set3,Q12</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>(i) Derivation of the mathematical expression $2\frac{1}{2}$</p> <p>(ii) Relation between mean life and decay constant $\frac{1}{2}$</p> </div> <p>(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</p> $\frac{-dN}{dt} \propto N$ <p>or $\frac{-dN}{dt} = \lambda N$ ($\lambda = \text{decay constant}$)</p> $\therefore \frac{dN}{N} = -\lambda dt$ <p>or $\ln N = -\lambda t + \text{constant}$</p> <p>$\therefore$ At $t=0$, we have</p> $\ln N_0 = \text{constant}$	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p>	

	$\ln N = -\lambda t + \ln N_0$ $\text{or } \ln \left(\frac{N}{N_0} \right) = -\lambda t$ $\therefore N = N_0 e^{-\lambda t}$ <p>(ii) Mean life = $\frac{1}{\text{decay constant}}$</p> <p>(Alternatively, $\tau = \frac{1}{\lambda}$)</p>	1/2	
		1/2	3
Set1,Q22 Set2,Q16 Set3,Q11	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>(i) Calculating the focal length of the lens 2</p> <p>(ii) Calculating the focal length of the combination 1</p> </div> <p>(i) For first position of the lens , we have</p> $\frac{1}{f} = \frac{1}{y} - \frac{1}{(-x)}$  <p>For second position of the lens , we have</p> $\frac{1}{f} = \frac{1}{y-20} - \frac{1}{-(x+20)}$ $\frac{1}{y} + \frac{1}{x} = \frac{1}{(y-20)} + \frac{1}{(x+20)}$ $\frac{x+y}{xy} = \frac{(x+20) + (y-20)}{(y-20)(x+20)}$ $\therefore xy = (y-20)(x+20)$ $= xy - 20x + 20y - 400$ $\therefore x - y = -20$ <p>Also , $x + y = 100$ $\therefore x = 40 \text{ cm}$ and $y = 60 \text{ cm}$</p> $\therefore \frac{1}{f} = \frac{1}{60} - \frac{1}{-40} = \frac{2+3}{120} = \frac{5}{120}$ $\therefore f = 24 \text{ cm}$	1/2	
		1/2	
		1/2	
		1/2	

	<p>Alternatively , We have</p> $f = \frac{D^2 - d^2}{4D}$ $= \frac{100^2 - 20^2}{4 \times 100}$ $= \frac{120 \times 80}{400}$ $= 24 \text{ cm}$ <p>Alternatively,</p> <p>For the two positions of the lens , the values of the magnitudes of u and v , get interchanged.</p> <p>Hence , $u + v = 100$ $u - v = 20$, This gives $u = 60$ $v = 40$ $\therefore f = 24 \text{ cm}$</p> <p>Alternatively ,</p>  <p>$2x + 20 = 100$ $\therefore x = 40 \text{ cm}$</p> <p>For lens at position L_1 ; $u = -x = -40 \text{ cm}$ $v = 20 + 40 = 60 \text{ cm}$</p> <p>This gives $f = 24 \text{ cm}$</p> <p>(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 $F = \text{infinite}$</p> <p>Alternatively , $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$</p>	<p>1</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p>	
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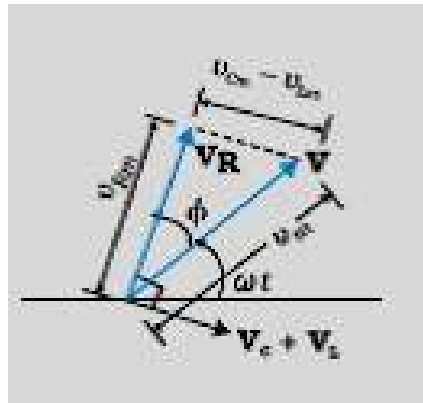
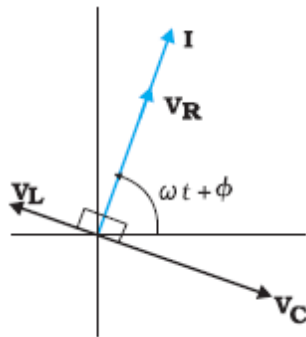
	$= \frac{1}{f} + \left(\frac{-1}{f} \right) = 0$												
	F = infinite	1/2											
Set1,Q23 Set2,Q23 Set3,Q23	<table><tr><td>(a) Values displayed</td><td>1/2 + 1/2 + 1/2</td></tr><tr><td>(b) Possible reason</td><td>1/2</td></tr><tr><td>(c) Formula for force</td><td>1/2</td></tr><tr><td>Max. value</td><td>1</td></tr><tr><td>Min. value</td><td>1/2</td></tr></table> <p>a) Value displayed by Seema : Helpful , considerate Family : Concerned , Affectionate Doctor : Humane nature (any one in all three cases)</p> <p>b) Expensive machinery/technique</p> <p>c) $F = qvB\sin\theta$ $F_{max} = qvB = 1.6 \times 10^{-19} \times 10^4 \times 0.1$ $= 1.6 \times 10^{-16}\text{N}$</p> <p>$F_{min}=\text{zero}$ (for $\theta = 0^0$)</p>	(a) Values displayed	1/2 + 1/2 + 1/2	(b) Possible reason	1/2	(c) Formula for force	1/2	Max. value	1	Min. value	1/2	1/2 1/2 1/2 1/2 1 1/2	4
(a) Values displayed	1/2 + 1/2 + 1/2												
(b) Possible reason	1/2												
(c) Formula for force	1/2												
Max. value	1												
Min. value	1/2												
Set1,Q24 Set2,Q25 Set3,Q26	<p style="text-align: center;">SECTION E</p> <table><tr><td>a) Difference between the behaviours of the two</td><td>(1/2 + 1/2)</td></tr><tr><td>Modification of electric field.</td><td>1</td></tr><tr><td>b) (i) Charge stored + justification</td><td>1/2 + 1/2</td></tr><tr><td>(ii) field strength + justification</td><td>1/2 + 1/2</td></tr><tr><td>(iii) energy stored + justification</td><td>1/2 + 1/2</td></tr></table> <p>a)</p>  <p>No electric field inside a conductor . (Give full credit to diagram. Give 1/2 mark if explanation only is given without</p>	a) Difference between the behaviours of the two	(1/2 + 1/2)	Modification of electric field.	1	b) (i) Charge stored + justification	1/2 + 1/2	(ii) field strength + justification	1/2 + 1/2	(iii) energy stored + justification	1/2 + 1/2	1/2 + 1/2	
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(ii) field strength + justification	1/2 + 1/2												
(iii) energy stored + justification	1/2 + 1/2												

	<p>diagram)</p> <p>Induced electric field ,due to polarisation of dielectric, is in opposite direction to the applied field.</p> $E_{net} = E_0 - E_p$ <p>(b)</p> <p>(i) Charge remains same, as after disconnecting capacitor no transfer of charge take place.</p> <p>(ii) Electric field, $E = \frac{\sigma}{\epsilon_0} = \frac{q}{\epsilon_0 A}$ remain same, as there is no change in charge.</p> <p>(iii) Energy stored $= \frac{q^2}{2C} = \frac{q^2}{2\left(\frac{\epsilon_0 A}{d}\right)} = \frac{q^2 d}{2\epsilon_0 A}$</p> <p>a. Energy will be doubled as separation between the plates(d) is doubled.</p> <p style="text-align: center;">OR</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p>a) Why is electric field normal to the equipotential surface. 1 ½</p> <p>Sketch of the equipotential surface and electric field lines. ½ + ½</p> <p>b) Obtaining the expression for the work done. 2 ½</p> </div> <p>(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.</p> <p>(Alternatively,</p> <p>Work done to move a charge dq, on a surface, can be expressed as</p> $dW = dq(\vec{E} \cdot \vec{dr})$ <p>But $dW=0$ on an equipotential surface</p> <p>$\therefore \vec{E} \perp \vec{dr}$</p> <p>Equipotential surfaces for a charge -q</p> <div style="text-align: center; margin: 10px 0;">  </div> <p>(b) Work done to dissociate the system = -Potential energy of the system</p>	<p>1</p> <p>½ + ½</p> <p>½ + ½</p> <p>½</p> <p>½</p> <p>5</p> <p>1 ½</p> <p>½</p> <p>½</p> <p>½</p> <p>½ + ½</p> <p>½</p>	
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	$= \frac{-1}{4\pi\epsilon_0} \left[\frac{(-4q)(q)}{a} + \frac{(2q)(q)}{a} + \frac{(-4q)(2q)}{a} \right]$ $= -\frac{1}{4\pi\epsilon_0 a} [-4q^2 + 2q^2 - 8q^2]$ $= + \left[\frac{10q^2}{4\pi\epsilon_0 a} \right]$	1 $\frac{1}{2}$ $\frac{1}{2}$	5														
Set1,Q25 Set2,Q26 Set3,Q24	<table><tr><td>(a) Identification of phenomenon</td><td>$\frac{1}{2}$</td></tr><tr><td>Stating the factors</td><td>$\frac{1}{2} + \frac{1}{2}$</td></tr><tr><td>Law</td><td>$\frac{1}{2}$</td></tr><tr><td>(b) Sketch of change in</td><td></td></tr><tr><td> i. Flux</td><td>1</td></tr><tr><td> ii. Emf</td><td>1</td></tr><tr><td> iii. Force</td><td>1</td></tr></table> <p>(a) The phenomenon involved is electromagnetic induction (EMI) $\frac{1}{2}$ For the deflection: Amount depends upon the speed of movement of the magnet. $\frac{1}{2}$ Direction depends on the sense (towards, or away) of the movement of the magnet. $\frac{1}{2}$ 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. $\frac{1}{2}$ (Note: Also accept if a student writes: whenever magnetic flux linked with a conductor changes, an induced emf is setup in the conductor.) (Alternatively, $\epsilon = -\frac{d\phi_B}{dt}$)</p> <p>(b)</p> 	(a) Identification of phenomenon	$\frac{1}{2}$	Stating the factors	$\frac{1}{2} + \frac{1}{2}$	Law	$\frac{1}{2}$	(b) Sketch of change in		i. Flux	1	ii. Emf	1	iii. Force	1	1 1 1	5
(a) Identification of phenomenon	$\frac{1}{2}$																
Stating the factors	$\frac{1}{2} + \frac{1}{2}$																
Law	$\frac{1}{2}$																
(b) Sketch of change in																	
i. Flux	1																
ii. Emf	1																
iii. Force	1																

OR

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

Phasor diagram

Using the phasor diagram, we get

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

$$\text{Or } v_m^2 = i_m^2 [R^2 + (X_C - X_L)^2]$$

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

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

\therefore the expression, for current, is

$$i = i_m \sin(\omega t + \phi)$$

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

Power dissipated:

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

$$p = v i$$

$$= (v_m \sin \omega t)(i_m \sin(\omega t + \phi))$$

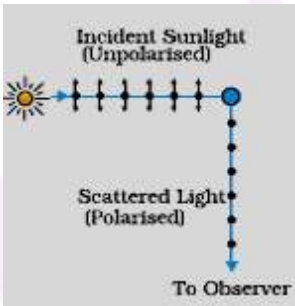
$$= \frac{v_m i_m}{2} [\cos \phi - \cos(2\omega t + \phi)]$$

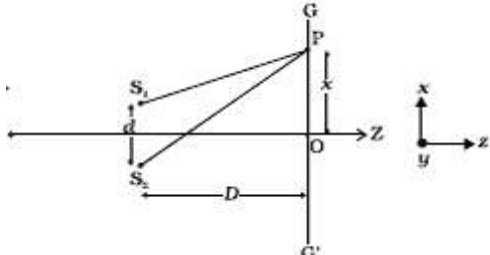
The average power, over a cycle, is, therefore

$$P = \langle p \rangle = \frac{v_m i_m}{2} (\cos \phi)$$

$$= VI \cos \phi$$

At resonance, we have

	$X_c = X_L$ $\tan \phi = 0 \Rightarrow \phi = 0^\circ$ $\therefore \cos \phi = 1$, its maximum value. Hence $P(=VI \cos \phi)$ has its maximum value at resonance.	$\frac{1}{2}$ $\frac{1}{2}$	5												
Set1,Q26 Set2,Q24 Set3,Q25	<table><tr><td>a) Reason for variation</td><td>$\frac{1}{2}$</td></tr><tr><td>Polarisation due to scattering</td><td>2</td></tr><tr><td>b) Statement for Malus' law</td><td>$\frac{1}{2}$</td></tr><tr><td>Calculation of intensities for</td><td></td></tr><tr><td>(i) $\theta = 30^\circ$</td><td>1</td></tr><tr><td>(ii) $\theta = 60^\circ$</td><td>1</td></tr></table> <p>(a) As per Malus' law, Transmitted intensity $I=I_o \cos^2 \theta$ \therefore The transmitted intensity will show a variation as per $\cos^2 \theta$.</p> <p>[Note: If the student writes that “<u>unpolarised light will not show any variation in intensity, when viewed through a polaroid, which is rotated</u>” award this $\frac{1}{2}$ mark]</p> <div></div> <p>The electric field, of the incident wave, makes the electrons of the air molecules, acquire both components of motion. (\updownarrow as well as \bullet).</p> <p>Charges accelerating parallel to \updownarrow, do not radiate energy towards the observer. Hence the radiation, scattered towards the observer gets linearly polarised.</p> <p>(Note: Award these 2 marks even if the student just draws a well labelled diagram, without giving any explanation.)</p>	a) Reason for variation	$\frac{1}{2}$	Polarisation due to scattering	2	b) Statement for Malus' law	$\frac{1}{2}$	Calculation of intensities for		(i) $\theta = 30^\circ$	1	(ii) $\theta = 60^\circ$	1	$\frac{1}{2}$ 1 $\frac{1}{2}$ $\frac{1}{2}$	
a) Reason for variation	$\frac{1}{2}$														
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(i) $\theta = 30^\circ$	1														
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	<p>(b) We have, as per Malus's law:</p> $I = I_0 \cos^2 \theta$ <p>\therefore If the intensity of light, incident on P_1, is I_0, we have</p> $I_1 = \text{Intensity transmitted through } P_1 = \frac{I_0}{2}$ $I_2 = \text{Intensity transmitted through } P_2 = \left(\frac{I_0}{2}\right) \cos^2 60^\circ = \frac{I_0}{8}$ <p>For $\theta = 30^\circ$, we have Angle between pass axis of P_2 and P_3 $= (30^\circ + 30^\circ) = 60^\circ$ or $(30^\circ - 30^\circ) = 0^\circ$</p> <p>$\therefore I_3$ can be either $\frac{I_0}{32}$ or $\frac{I_0}{8}$.</p> <p>For $\theta = 60^\circ$, we have Angle between pass axis of P_2 and P_3 $= (30^\circ + 60^\circ) = 90^\circ$ or $(30^\circ - 60^\circ) = -30^\circ$ $\therefore I_3$ can be either 0 or $\frac{3I_0}{32}$.</p> <p>[Note: Award the last $(1 + \frac{1}{2})$ marks to the student even if he/she calculates I_3 for only the first (or second) values of the angle between the pass axis of P_2 and P_3.]</p> <p style="text-align: center;">OR</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <p>a) Expression for Path difference 2 $\frac{1}{2}$ Conditions for constructive and destructive interference $\frac{1}{2} + \frac{1}{2}$</p> <p>b) Finding intensities at points where path difference is</p> <p>(i) $\lambda/6$ $\frac{1}{2}$</p> <p>(ii) $\lambda/4$ $\frac{1}{2}$</p> <p>(iii) $\lambda/3$ $\frac{1}{2}$</p> </div> <p>(a)</p> 	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>1</p> <p>$\frac{1}{2}$</p> <p>5</p> <p>$\frac{1}{2}$</p>	
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	<p>Path difference $= S_2P - S_1P$</p> <p>Now $(S_2P)^2 - (S_1P)^2 = \left[D^2 + \left(x + \frac{d}{2} \right)^2 \right] - \left[D^2 + \left(x - \frac{d}{2} \right)^2 \right]$</p> <p style="text-align: center;">$= 2xd$</p> <p>where $S_1S_2 = d$ and $OP = x$</p> <p>$\therefore S_2P - S_1P = \frac{2xd}{(S_2P + S_1P)}$</p> <p>For $x \ll D$ and $d \ll D$, we can write</p> <p>$S_2P + S_1P \approx 2D$</p> <p>Hence, Path difference $= S_2P - S_1P = \frac{2xd}{2D} = \frac{xd}{D}$</p> <p>For constructive interference, we must have</p> <p>$\frac{xd}{D} = n\lambda$</p> <p>$\therefore x = x_n = \frac{n\lambda D}{d} \quad (n=0, \pm 1, \pm 2, \dots)$</p> <p>For destructive interference, we must have</p> <p>$\frac{xd}{D} = \left(n + \frac{1}{2} \right) \lambda$</p> <p>$\therefore x = x'_n = \frac{(n + \frac{1}{2})\lambda D}{d} \quad (n=0, \pm 1, \pm 2, \dots)$</p> <p>(b) The general expression, for the intensity, at a point is</p> <p>$I = I_0 \cos^2 \frac{\phi}{2}$</p> <p>(i) For path difference $= \lambda/6$, $\phi = 60^\circ$</p> <p style="margin-left: 40px;">$I = 3I_0/4$</p> <p>(ii) For path difference $= \lambda/4$, $\phi = 90^\circ$</p> <p style="margin-left: 40px;">$I = I_0/2$</p> <p>(iii) For path difference $= \lambda/3$, $\phi = 120^\circ$</p> <p style="margin-left: 40px;">$I = I_0/4$</p>	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p>	<p>5</p>
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