ULTIMATE KCET

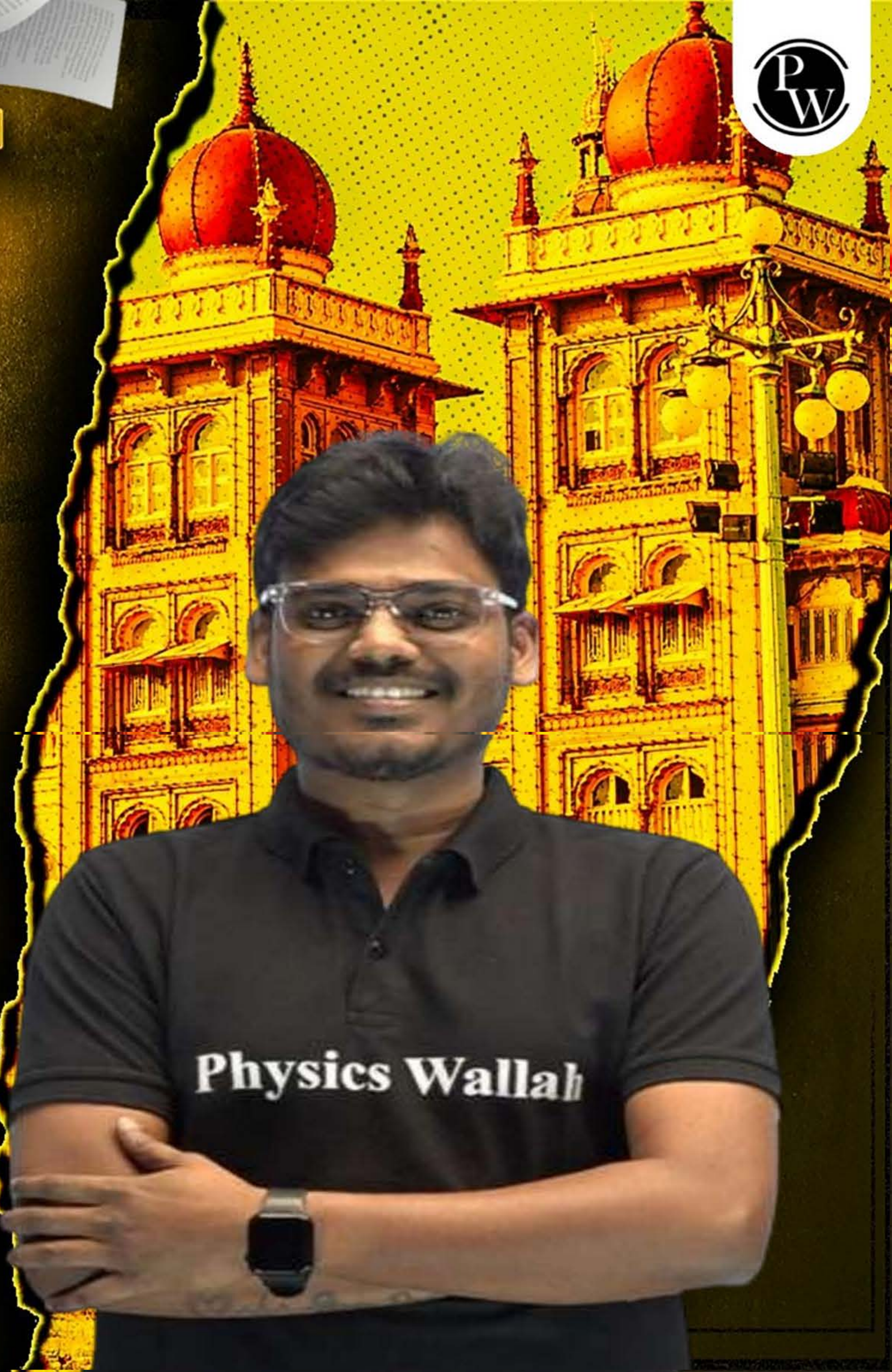
CRASH COURSE 2026

PHYSICS

Lecture : 01

DUAL NATURE OF RADIATION AND MATTER

By – AK SIR



Recap of previous lecture

1. REFRACTION AT CURVED SURFACE AND LENSES
2. REFRACTION BY LENS
3. POWER OF LENS AND COMBINATION OF LENS
4. WAVE OPTICS

Topics *to be covered*

1. QUESTIONS ON INTENSITY AND AMPLITUDE OF WAVES
2. YOUNG'S DOUBLE SLIT EXPERIMENT
3. LIGHT DIFFRACTION AND POLARISATION
4. DUAL NATURE OF RADIATION AND MATTER

Question

Among the given two statements:

$\boxed{\text{Statement-I}}$: Wavefront is the surface of constant phase.

$\boxed{\text{Statement-II}}$: When a plane wavefront is passed through a thin prism, it emerges out as a spherical wavefront.

A. Both the statements are correct

B. Both the statements are wrong

C. $\boxed{\text{I is correct but II is wrong}}$

D. I is wrong but II is correct

Question

Two waves having the intensities in the ratio of 16 : 9 produce interference. Find the ratio of maximum to minimum intensity?

$$\frac{I_1}{I_2} = \frac{16}{9}$$

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$$

$$= \frac{(\sqrt{16} + \sqrt{9})^2}{(\sqrt{16} - \sqrt{9})^2} = \frac{(4+3)^2}{(4-3)^2} = \frac{7^2}{1^2} = \boxed{\frac{49}{1}}$$

Question

The ratio of maximum to minimum intensity when two waves interfere is equal to 16 : 9, find the ratio of Amplitudes of superimposing waves.

$$\frac{I_{max}}{I_{min}} = \frac{16}{9}$$

$$I \propto (amp)^2$$

$$\left(\frac{A_{max}}{A_{min}}\right)^2 = \frac{16}{9}$$

$$\boxed{\frac{A_{max}}{A_{min}} = \sqrt{\frac{16}{9}} = \frac{4}{3}}$$

$$\frac{A_1 + A_2}{A_1 - A_2} = \frac{4}{3}$$

$$3(A_1 + A_2) = 4(A_1 - A_2)$$

$$3A_1 + 3A_2 = 4A_1 - 4A_2$$

$$4A_2 + 3A_2 = 4A_1 - 3A_1$$

$$7A_2 = 1A_1$$

$$\boxed{\frac{A_1}{A_2} = \frac{7}{1}}$$

Question

If ratio of amplitude of two sources are 2:1. Find

(i) $\frac{I_1}{I_2}$ (ii) $\frac{I_{max}}{I_{min}}$ (iii) $\frac{A_{max}}{A_{min}}$

$A_1 : A_2$

(i) $I \propto (\text{amp})^2$

$$\frac{I_1}{I_2} = \frac{A_1^2}{A_2^2}$$

$$= \frac{2^2}{1^2}$$

$$= \frac{4}{1}$$

$$\boxed{\frac{I_1}{I_2} = \frac{4}{1}}$$

M₂

(ii) $\frac{I_{max}}{I_{min}} = \frac{A_{max}^2}{A_{min}^2}$

M-1

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$$

$$= \frac{(\sqrt{4} + \sqrt{1})^2}{(\sqrt{4} - \sqrt{1})^2} = \frac{(2+1)^2}{(2-1)^2}$$

$$\boxed{\frac{I_{max}}{I_{min}} = \frac{9}{1}}$$

M2

$$\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2}$$

$$= \frac{(2+1)^2}{(2-1)^2} = \frac{3^2}{1^2}$$

$$\boxed{\frac{I_{max}}{I_{min}} = \frac{9}{1}}$$

(iii) $\frac{A_{max}}{A_{min}} = \frac{A_1 + A_2}{A_1 - A_2}$

$$= \frac{2+1}{2-1}$$

$$\boxed{\frac{A_{max}}{A_{min}} = \frac{3}{1}}$$

Question

Find resultant amplitude of two superimposing waves given by

$y_1 = 6\sin(\omega t)$, $y_2 = 8\cos(\omega t)$

$y_1 = A_1 \sin\omega t$

$y_1 = 6\sin\omega t$

$y_2 = 8\sin(\omega t + \frac{\pi}{2})$

$y_2 = A_2 \sin(\omega t + \phi)$

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

$$R = \sqrt{6^2 + 8^2 + 2\times\underbrace{6\times 8\times\cos\frac{\pi}{2}}_{0}}$$

$$R = \sqrt{36+64} = \sqrt{100}$$

$$\boxed{R = 10 \text{ units}}$$

Question

Find resultant intensity of two superimposing waves of $\boxed{\text{same intensity } \mathbf{Io}}$ and phase difference $\boxed{\Delta\varphi}$

$$R^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$

$$I \propto A^2$$

$$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

$$I_0^{\frac{1}{2}} I_0^{\frac{1}{2}} = I_0^{\frac{1}{2}+\frac{1}{2}} = I_0$$

$$I_1 = I_2 = I_0$$

$$I = I_0 + I_0 + 2\sqrt{I_0}\sqrt{I_0}\cos\Delta\phi$$

$$\frac{1+\cos\Delta\phi}{2} = \cos^2\left(\frac{\Delta\phi}{2}\right)$$

$$I = 2I_0 + 2I_0\cos\Delta\phi$$

$$I = 2I_0(1+\cos\Delta\phi) \times \frac{2}{2}$$

$$I = 4I_0\left[\frac{1+\cos\Delta\phi}{2}\right]$$

*

$$\boxed{I = 4I_0\cos^2\left(\frac{\Delta\phi}{2}\right)}$$

Question

A_1 A_2

Two monochromatic light wave of amplitudes 3A and 2A interfering at a point have a phase difference of $\boxed{60°}$. The intensity at that point will be proportional to $I \propto R$

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$

$$R = \sqrt{(3A)^2 + (2A)^2 + 2(3A)(2A) \times \underbrace{\cos 60°}_{\frac{1}{2}}}$$

$$R = \sqrt{9A^2 + 4A^2 + 6A^2}$$

$$\boxed{R = \sqrt{19A^2}} \qquad \boxed{I \propto R^2 = 19A^2}$$

(A) $5\ A^2$

(B) $13\ A^2$

(C) $7\ A^2$

(D) $\boxed{19\ A^2}$

Young's Double slit Experiment

$\theta = \frac{\beta}{D}$

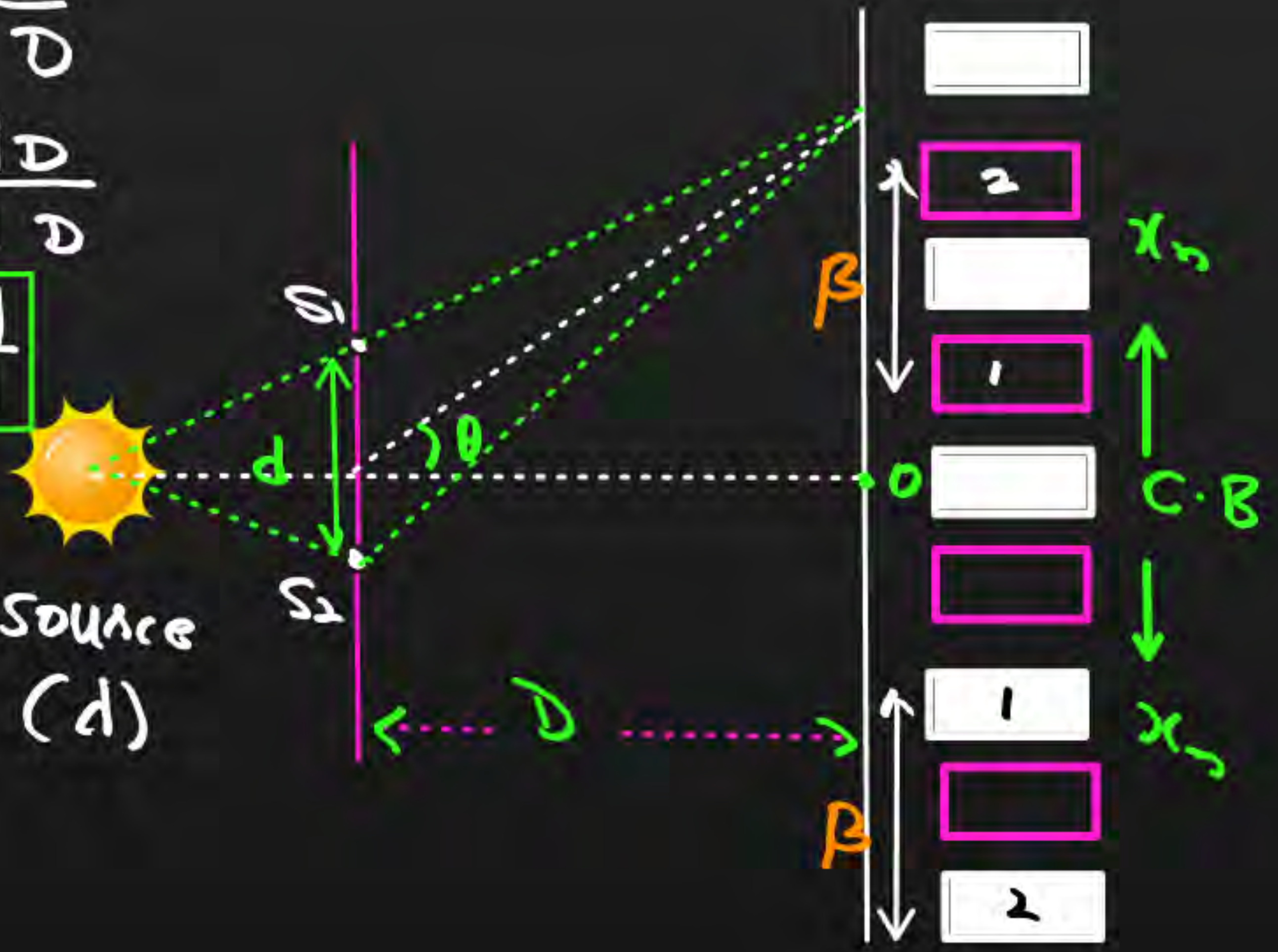
$\theta = \frac{\lambda D}{d D}$

Position of n^{th} bright fringe

$$\boxed{x_n = \frac{n\lambda D}{d}}$$

$n = 0, 1, 2, 3 \ldots\ldots$

$$\boxed{\theta = \frac{\lambda}{d}}$$



Position of n^{th} dark fringe

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

$n = 1, 2, 3, 4 \ldots\ldots$

Young's Double slit Experiment

Distance between two successive dark fringes or two successive bright fringes is known as fringe width.

$$\boxed{\beta = \frac{\lambda D}{d}}$$

$\theta = \frac{\beta}{D}$

$\theta = \frac{\lambda}{d}$

All fringe width have equal space between them

Bright : $x_n = \frac{n\lambda D}{d}$

$x_1 = \frac{\lambda D}{d}$

$x_2 = \frac{2\lambda D}{d}$

$\beta = x_2 - x_1 = \frac{2\lambda D}{d} - \frac{\lambda D}{d}$

$$\boxed{\beta = \frac{\lambda D}{d}}$$

Dark fringe $x_n = (2n-1)\frac{\lambda D}{2d}$

$x_1 = \frac{\lambda D}{2d}$

$x_2 = 3\frac{\lambda D}{2d}$

$\beta = x_2 - x_1 = \frac{3\lambda D}{2d} - \frac{\lambda D}{2d} = \frac{2\lambda D}{2d}$

$$\boxed{\beta = \frac{\lambda D}{d}}$$

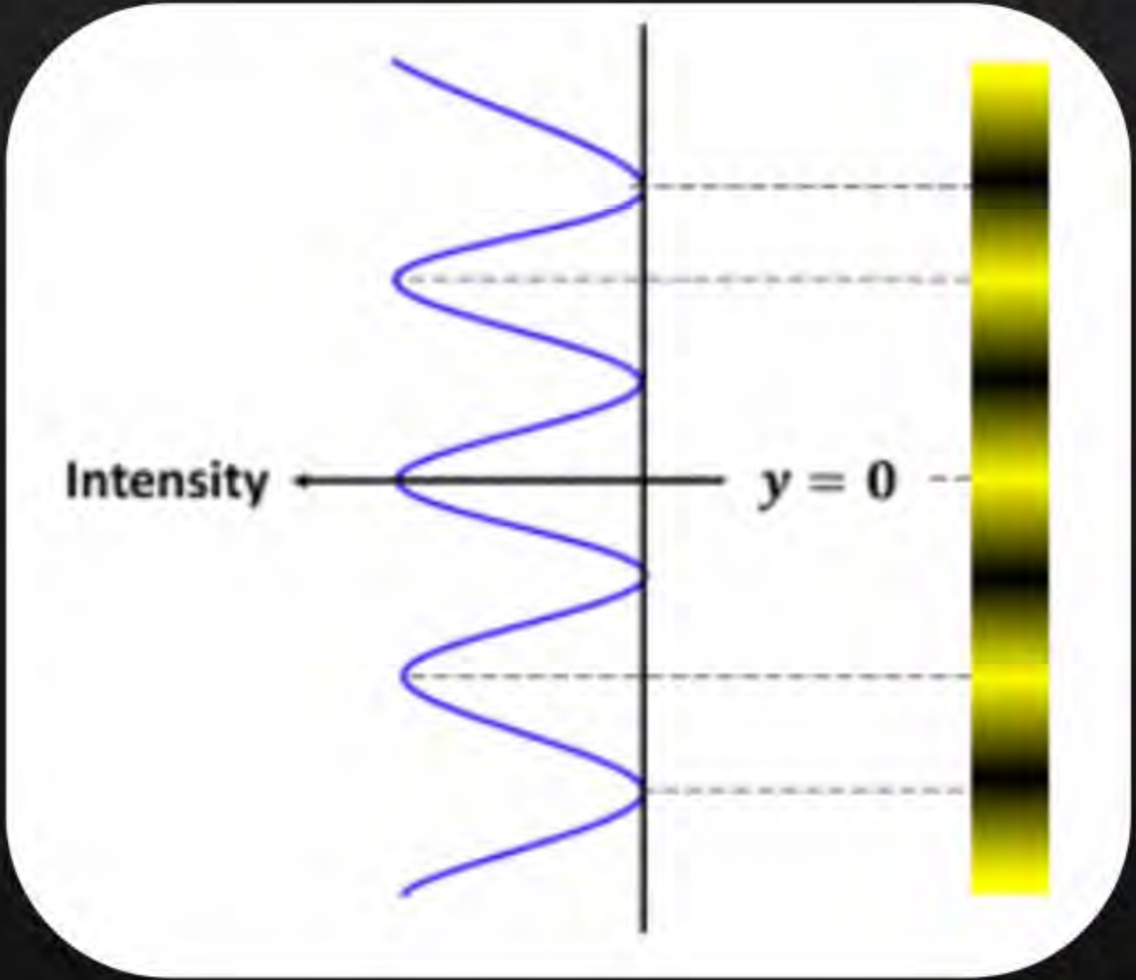
It is the angle subtended by linear fringe width at the centre of the plane of slit.

Note : Angular fringe width does not depend on the distance between plane of slit and screen

Variation of intensity with phase difference

If slits are of equal width then intensity is also equal.

$$\boxed{I = 4I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)}$$



Question

In YDSE two narrow slits are 1 mm apart are illuminated by a source of light of wavelength 500 nm. How far apart adjacent bright bands in the interference pattern observed on a screen 2 m away and also find distance of $\boxed{\text{third bright fringe}}$ from center of screen?

d λ D $n = 3$ x_3

(i) Fringe width

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

$$\beta = \frac{500 \times 10^{-9} \times 2}{1 \times 10^{-3}}$$

$$\beta = 1000 \times 10^{-9} \times 10^{+3}$$

$$\beta = 10^{6-9} = 10^{-3}$$

$$\boxed{\beta = 1\,mm}$$

(ii) $x_n = \frac{n \lambda D}{d}$

$$x_3 = 3\frac{\lambda D}{d} = 3 \times \beta = 3 \times 1\,mm.$$

$$\boxed{x_3 = 3\,mm}$$

Question

In the above question find the distance of third dark fringe from central maxima and also find distance between 4th dark and 6th bright fringe on same side of central maxima?

↳ Dark Fringe

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

$$x_3 = (2\times3-1)\frac{1}{2}\left(\frac{\lambda D}{d}\right)$$

↳ $\beta = 1\,mm$

$$x_3 = \frac{5}{2}\times 1\,mm$$

$$\boxed{x_3 = 2.5\,mm}$$

$$x_4 = (2\times4-1)\frac{\lambda D}{2d}$$

$$x_4 = \frac{7}{2}\beta$$

$$x_4 = \frac{7}{2}\times 1\,mm$$

$$\boxed{x_4 = 3.5\,mm}$$

Bright Fringe

$$x_n = n\frac{\lambda D}{d} = n\beta$$

$$x_6 = 6\times 1\,mm$$

$$\boxed{x_6 = 6\,mm}$$

$$\text{Distance} = x_6 - x_4 = 6 - 3.5$$

$$= \boxed{2.5\,mm}$$

Question

f

In a Young's double slit experiment, light has a frequency of 6×10^{14} Hz. The distance between the centre of adjacent bright fringes is 1 mm. If the screen is 2 m away then find the distance between the slits?

β $\quad$ D

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

$$\beta = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{\beta} = \frac{c}{f} \times \frac{D}{\beta}$$

$$c = f\lambda$$

$$\lambda = \frac{c}{f}$$

$$d = \frac{\cancel{3}\times10^{8}\times 2}{\cancel{6}_{2}\times10^{14}\times1\times10^{-3}}$$

$$d = 10^{8}\times10^{-11}$$

$$d = 10^{-3}\,m \Rightarrow \boxed{d = 1\,mm}$$

Question

In Young's double slit experiment, an electron beam is used to produce interference fringes of width β_1 Now the electron beam is replaced by a beam of protons with the same experimental set-up and same speed. The fringe width obtained is β_2. The correct relation between β_1 and β_2 is.

(A) $\beta_1 = \beta_2$

(B) No fringes are formed

(C) $\beta_1 < \beta_2$

(D) $\boxed{\beta_1 > \beta_2}$

$\lambda = \frac{h}{p} = \frac{h}{mv}$, $\lambda \propto \frac{1}{m}$

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

$\boxed{\beta \propto \lambda}$

$m_p > m_e$

$\lambda_p < \lambda_e$

$\beta_p < \beta_e$

$$\boxed{\begin{array}{c}\beta_2 < \beta_1 \\ \beta_1 > \beta_2\end{array}}$$

Question

$\boxed{\Delta x = d\sin\theta = d\tan\theta}$

$\Delta x = \frac{dx}{D}$

In the Young's double slit experiment a monochromatic source of wavelength λ is used. The intensity of light passing through each slit is I_0. The intensity of light reaching the screen S_c at a point P, a distance x from O is given by (Take, $d \ll D$)

(A) $I_0 \cos^2\left(\frac{\pi D}{\lambda d}x\right)$ ✗

(B) $\boxed{4I_0 \cos^2\left(\frac{\pi d}{\lambda D}x\right)}$

(C) $I_0 \sin^2\left(\frac{\pi d}{2\lambda D}x\right)$ ✗

(D) $4I_0 \cos\left(\frac{\pi d}{2\lambda D}x\right)$ ✗

$I = 4I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$

$\boxed{I = 4I_0 \cos^2\left(\frac{\pi d x}{\lambda D}\right)}$ *

$\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x$

$\Delta\phi = \frac{2\pi}{\lambda} \times \frac{dx}{D}$

$\frac{\Delta\phi}{2} = \frac{\cancel{2}\pi}{\lambda} \times \frac{dx}{D} \frac{1}{\cancel{2}}$

$= \frac{\pi d x}{\lambda D}$

Question

In the Young's double slit experiment, the intensity of light passing through each of the two double slits is 2×10^{-2} Wm^{-2}. The screen-slit distance is very large in comparison with slit-slit distance. The fringe width is ß. The distance between the central maximum and a point P on the screen is $x = ß/3$. Then, the total light intensity at the point is

(A) 8×10^{-2} Wm^{-2}

(B) 4×10^{-2} Wm^{-2}

(C) $\boxed{2 \times 10^{-2}\ Wm^{-2}}$

(D) 16×10^{-2} Wm^{-2}

$$x = \frac{\beta}{3} = \frac{\lambda D}{3d}$$

$$I = 4I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$$

$$I = 4I_0 \cos^2\left(\frac{\pi d x}{\lambda D}\right)$$

$$I = 4I_0 \cos^2\left(\frac{\pi \cancel{d}}{\cancel{\lambda D}} \times \frac{\cancel{\lambda D}}{3\cancel{d}}\right)$$

$$I = 4I_0 \cos^2\left(\frac{\pi}{3}\right)$$

$$I = 4I_0\left(\frac{1}{2}\right)^2 = 4I_0 \times \frac{1}{4} \Rightarrow I = I_0 = 2 \times 10^{-2}\ W/m^2$$

Question

The fringe width for red colour as compared to that for violet colour is approximately

(A) $\boxed{\text{2 times}}$

(B) 4 times

(C) 8 times

(D) 3 times

$\beta = \frac{\lambda D}{d}$ $\quad \beta \propto \lambda$

$\lambda_R = 8000\,Å$

$\lambda_V = 4000\,Å$

$\frac{\beta_R}{\beta_V} = \frac{\lambda_R}{\lambda_V}$

$\frac{\beta_R}{\beta_V} = \frac{8000}{4000} = \frac{8}{4} = 2$

$\boxed{\beta_R = 2\beta_V}$

Question

In Young's double slit experiment, slits are separated 2 mm and the screen is placed at a distance of 1.2 m from the slits. Light consisting of two wavelengths 6500 Å and 5200 Å are used to obtain interference fringes. Then, the separation between the fourth bright fringes of two different patterns produced by the two wavelengths is

(A) $\boxed{0.312 \text{ mm}}$

(B) 0.123 mm

(C) 0.213 mm

(D) 0.412 mm

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

$$\Delta x = (x_4)_{\lambda_1} - (x_4)_{\lambda_2}$$

$$\Delta x = \frac{4\lambda_1 D}{d} - \frac{4\lambda_2 D}{d}$$

$$\Delta x = \frac{4D}{d}(\lambda_1 - \lambda_2)$$

$$\Delta x = \frac{4 \times 1.2}{2 \times 10^{-3}}(6500 - 5200) \times 10^{-10}$$

$$\Delta x = 2.4(1300) \times 10^{-10+3}$$

$$\Delta x = 3120 \times 10^{-10+3} = 3120 \times 10^{-7}$$

$$= 3120 \times 10^{-4} \times 10^{-3}$$

$$= 0.3120 \times 10^{-3}$$

$$\boxed{\Delta x = 0.3120 \text{ mm}}$$

Question

In Young's double slit experiment, the source is which light one slit is covered with $\boxed{\text{red}}$ filter and the other with $\boxed{\text{blue}}$ filter. There shall be

(A) alternate red and blue fringes

(B) alternate dark and pink fringes

(C) alternate dark and yellow fringes

(D) $\boxed{\text{no interference}}$

Question

A fringe width of a certain interference pattern is ß = 0.002 cm. What is the distance of 5th dark fringe from centre?

(A) $\boxed{1 \times 10^{-2}\text{ cm}}$

(B) 1.1×10^{-2} cm

(C) 11×10^{-2} cm

(D) 3.28×10^{6} cm

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

$$x_n = \frac{(2n-1)}{2}\beta$$

$$x_5 = \frac{(2\times5-1)}{2}\times0.002$$

$$x_5 = \frac{9}{2}\times0.002$$

$$x_5 = 9\times0.001$$

$$x_5 = 0.009 \simeq 0.01\text{ cm}$$

$$= \underline{\underline{1\times10^{-2}}}\text{ cm}$$

Diffraction

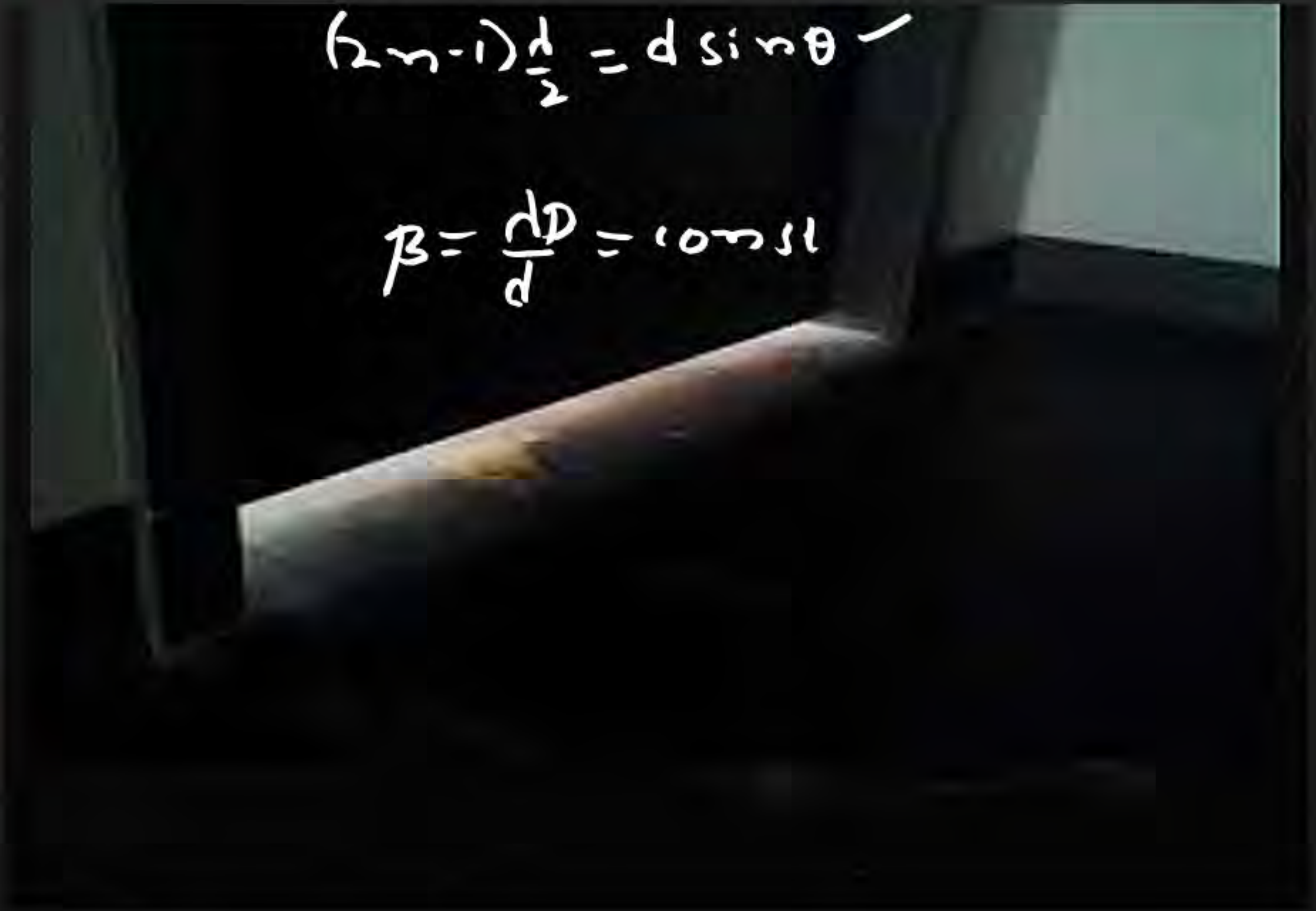
⇒ All types of waves

$\Delta x = d\sin\theta$ ✓

$n\lambda = d\sin\theta$ ✓

$(2n-1)\frac{\lambda}{2} = d\sin\theta$ ✓

$\beta = \frac{\lambda D}{d} = \text{const}$



The phenomenon of bending of light around the edges or corners of an obstacle and hence the encroachment of shadow region by light is called diffraction.

Size of the obstacle $\simeq \lambda$

Interference pattern observed through single slit is diffraction pattern

Question

To observed diffraction, the size of the obstacle

(A) should be much larger than the wavelength

(B) has no relation to wavelength

(C) $\boxed{\text{should be of the order of wavelength}}$

(D) should be $\frac{\lambda}{2}$ where λ is the wavelength

Question

Consider the following two statements regarding diffraction of light.

Statement – I: We do not easily encounter diffraction effects of light in everyday observation.

Statement – II: The wavelength of light is much smaller than the dimensions of most of the obstacles. Choose the correct option from the following:

(A) Both the statements are correct and statement–II is the correct explanation for statement–I.

(B) Both the statements are correct and statement–II is not the correct explanation of statement–I.

(C) Statement–I is correct and statement–II is wrong

(D) Both the statements are wrong.

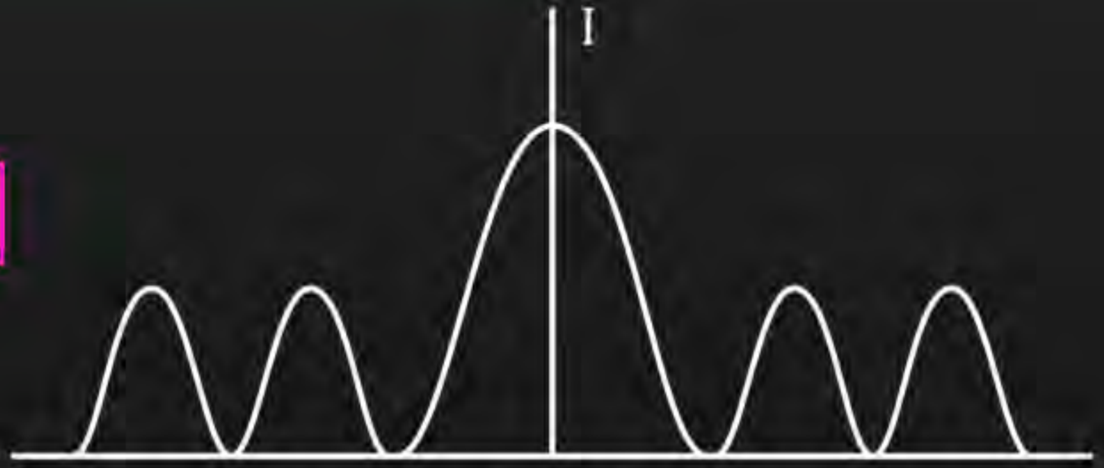
Single slit diffraction

Location of maxima : $x_{max} = \frac{(2n-1)\ \lambda D}{2d}$

$\Delta x = d\ sin\theta = \frac{(2n-1)\lambda}{2}$

Location of minima : $x_{min} = \frac{n\lambda D}{d}$

$\Delta x = d\ sin\theta = n\lambda$



Width of central fringe : $\beta_{central} = \frac{2\lambda D}{d}$

Note : Width of central maxima = 2 [Width of secondary maxima]

Question

In case of diffraction at a single slit, the diffraction pattern on the screen is correct for which of the following statements?

A. Central bright band having alternate dark and bright bands of decreasing intensity on either side.

B. Central dark band having uniform brightness on either side.

C. Central bright band having dark bands on either side.

D. Central dark band having alternate dark and bright bands of decreasing intensity on either side.

Question

Which of the following statements are $\boxed{\text{correct}}$ with reference to $\boxed{\text{single slit diffraction}}$ pattern?

(I) Fringes are of unequal width. ✓

(II) Fringes are of equal width. ✗

(III) Light energy is conserved. ✓

(IV) Intensities of all bright fringes are equal. ✗

A. $\boxed{\text{Both (I) and (III)}}$

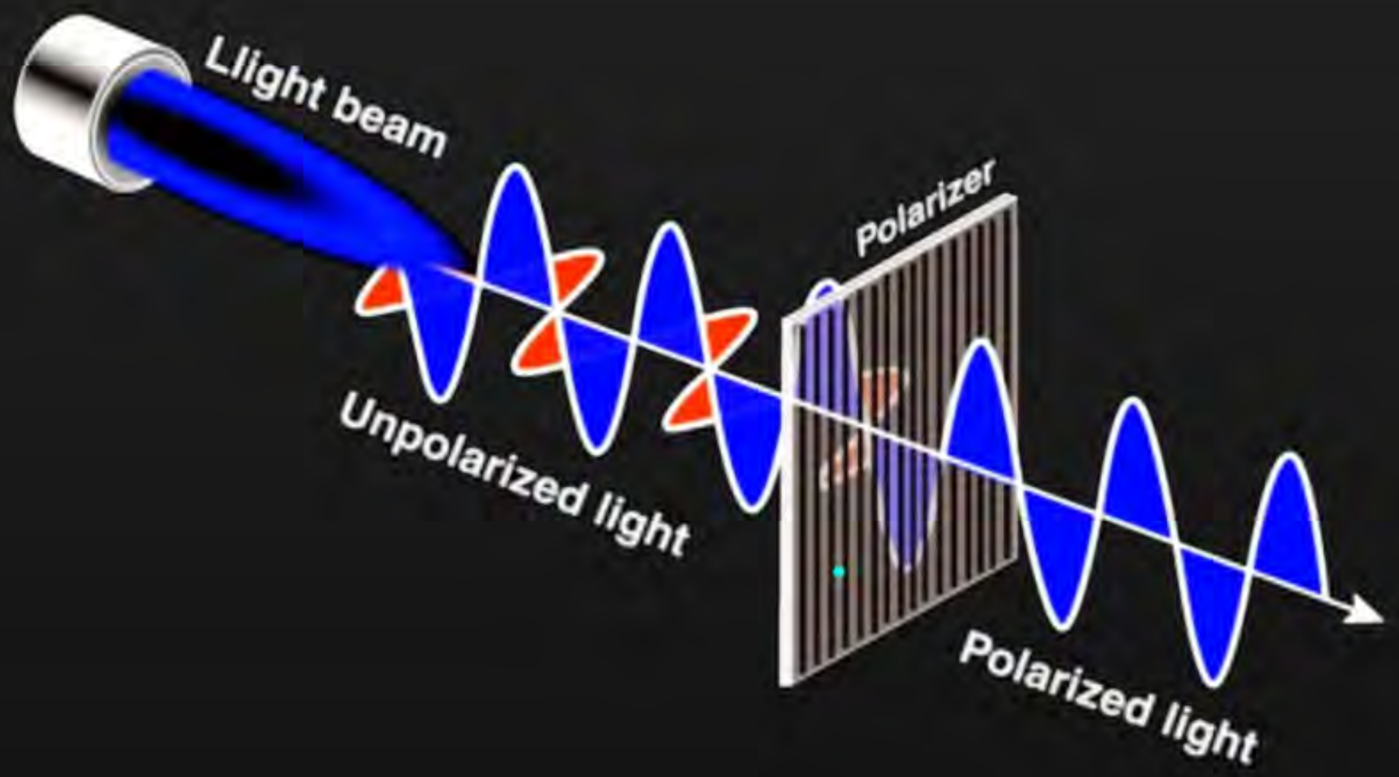
B. Both (I) and (IV)

C. Both (II) and (IV)

D. Both (II) and (III)

Polarisation of Light

Polarization of light is the process of transforming unpolarized light into polarized light

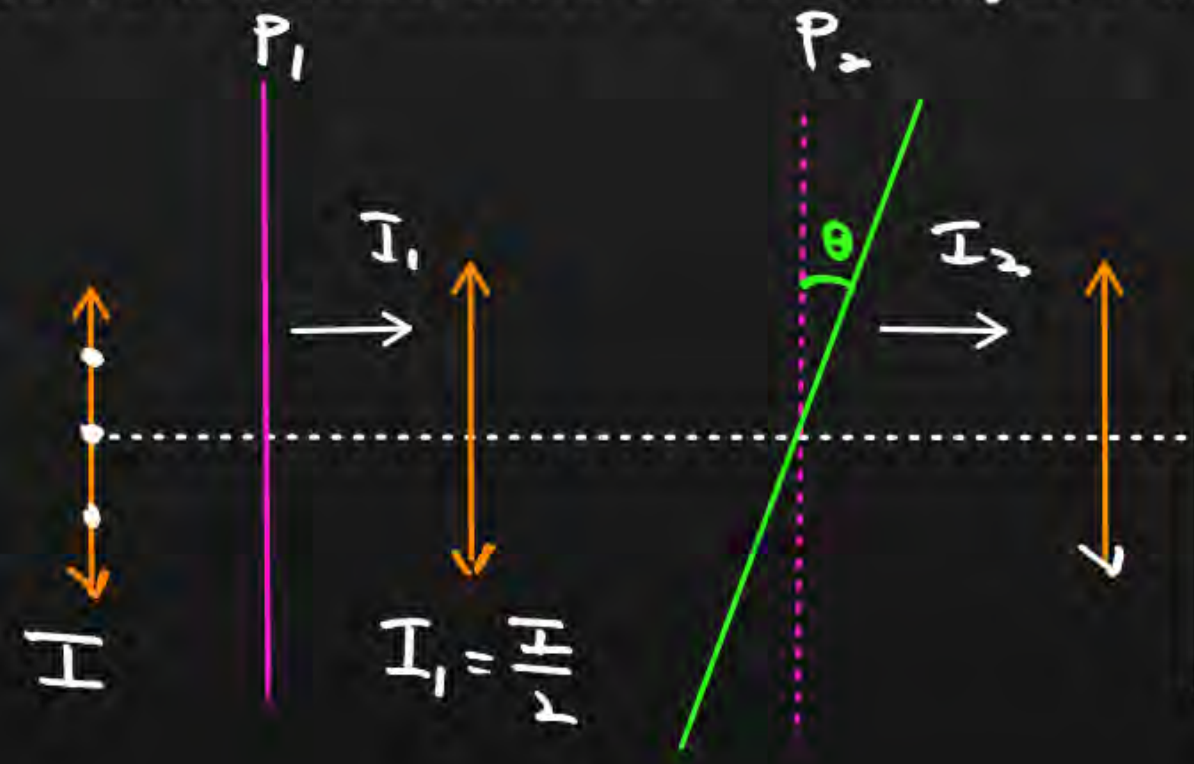


UPL

PPL

Malu's law

When a completely plane-polarized light beam from a polarizer is incident on an analyzer, the intensity of light emerging from the analyzer varies as the cosine of the angle of between the planes of transmission of the analyzer and of the polarizer

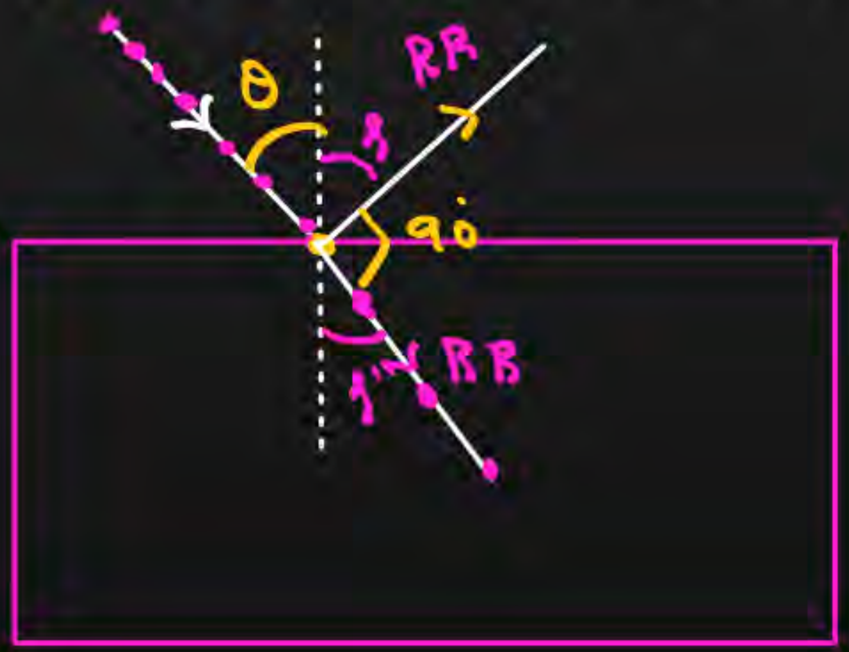


$$\boxed{\begin{aligned} I_2 &= I_1 \cos^2\theta \\ I_2 &= \frac{I}{2}\cos^2\theta \end{aligned}}$$

BREWSTER'S LAW

Brewster's law : Brewster's Law describes how unpolarized light becomes completely polarized when reflected off a transparent surface at a specific angle.

The reflected light is fully polarized perpendicular to the plane of incidence, and the reflected and refracted rays are 90 degrees apart.



$\tan\theta = \mu$

Question

Identify the correct statement.

(A) Light waves exhibit diffraction but not sound waves.

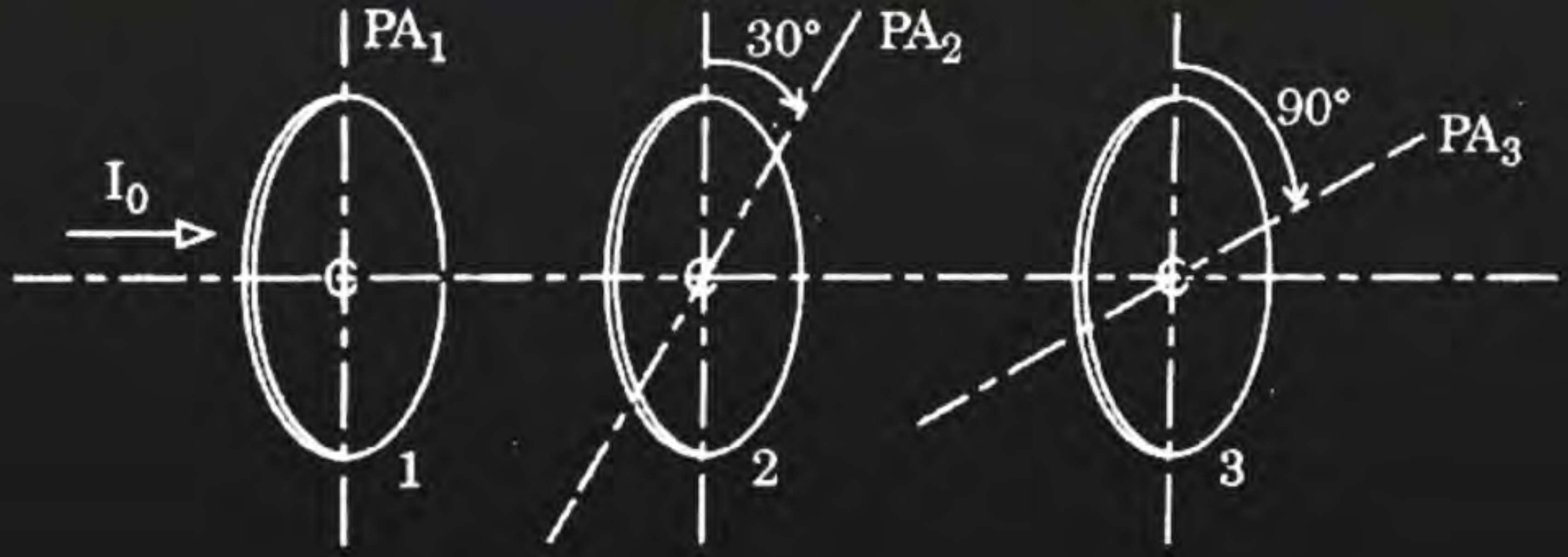
(B) Sound waves exhibit diffraction but not light waves.

(C) Light waves exhibit diffraction but not polarization.

(D) $\boxed{\text{Light waves exhibit both diffraction and polarization.}}$

Question

Three polaroid sheets are co-axially placed as indicated in the diagram. Pass axes of the polaroids 2 and 3 make $30°$ and $90°$ with pass axis of polaroid sheet 1. If I_0 is the intensity of the incident un-polarised light entering sheet 1, the intensity of the emergent light through sheet 3 is

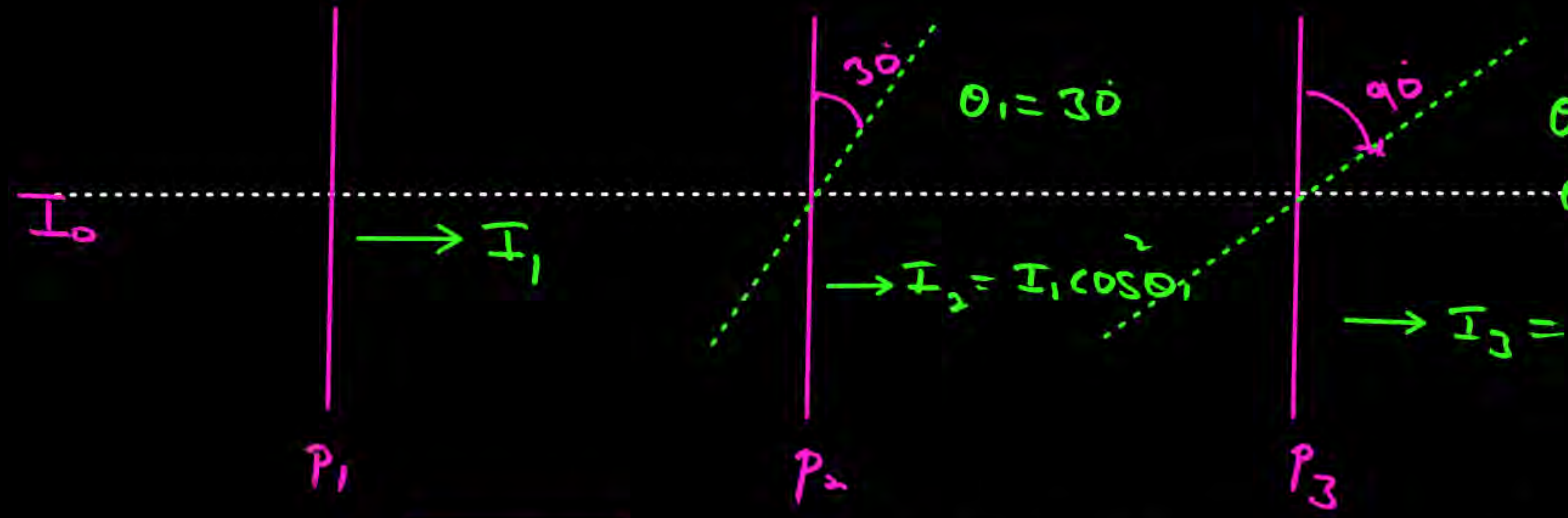


(A) zero

(B) $\boxed{3I_0/32}$

(C) $3I_0/8$

(D) $3I_0/16$



$\theta_1 = 30^\circ$

$\theta_2 = 90^\circ - 30^\circ$

$\theta_2 = 60^\circ$

$\rightarrow I_2 = I_1 \cos^2\theta_1$

$\rightarrow I_3 = I_2 \cos^2\theta_2$

$$\boxed{I_1 = \frac{I_0}{2}}$$

$$I_2 = \frac{I_0}{2}\cos^2 30^\circ$$

$$I_2 = \frac{I_0}{2}\left(\frac{\sqrt{3}}{2}\right)^2$$

$$I_2 = \frac{I_0}{2} \times \frac{3}{4}$$

$$\boxed{I_2 = \frac{3I_0}{8}}$$

$$I_3 = \frac{3I_0}{8}\cos^2 60^\circ$$

$$I_3 = \frac{3I_0}{8}\left(\frac{1}{2}\right)^2$$

$$\boxed{I_3 = \frac{3I_0}{32}}$$

Question

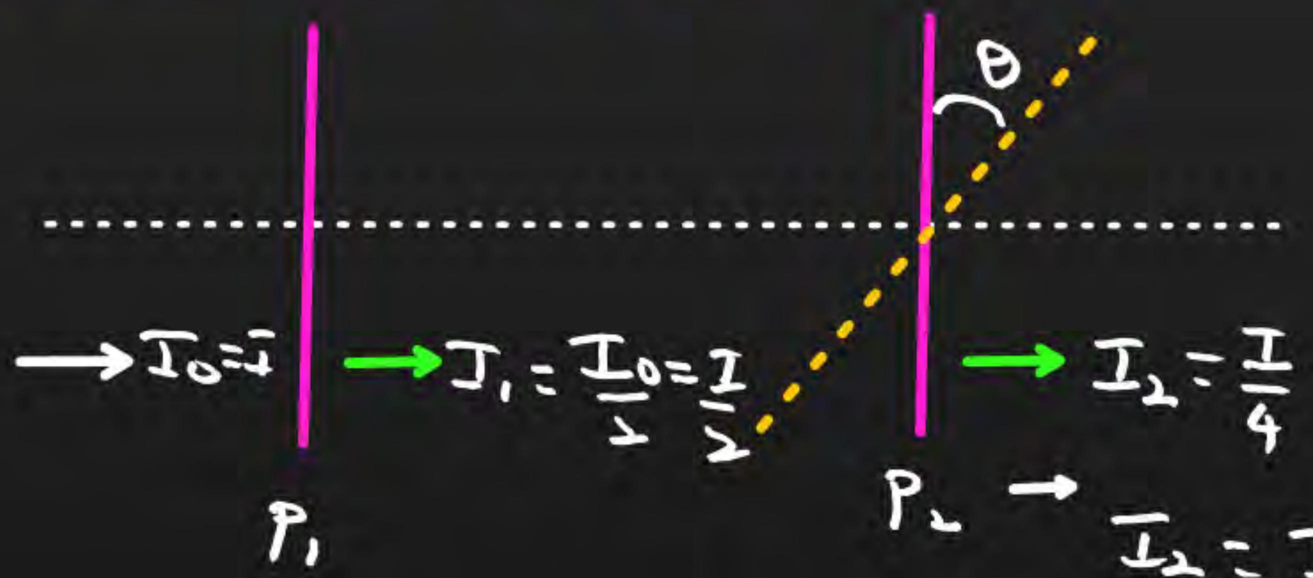
An unpolarised light of intensity I is passed through two polaroids kept one after the other with their planes parallel to each other. The intensity of light emerging from second polaroid is $I/4$. The angle between the pass axes of the polaroids is

(A) $\boxed{45^\circ}$

(B) 0°

(C) 60°

(D) 30°



$$I_2 = I_1 \cos^2\theta$$

$$\frac{I}{4} = \frac{I}{2}\cos^2\theta$$

$$\frac{1}{2} = \cos^2\theta$$

$$\cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45^\circ$$

Question

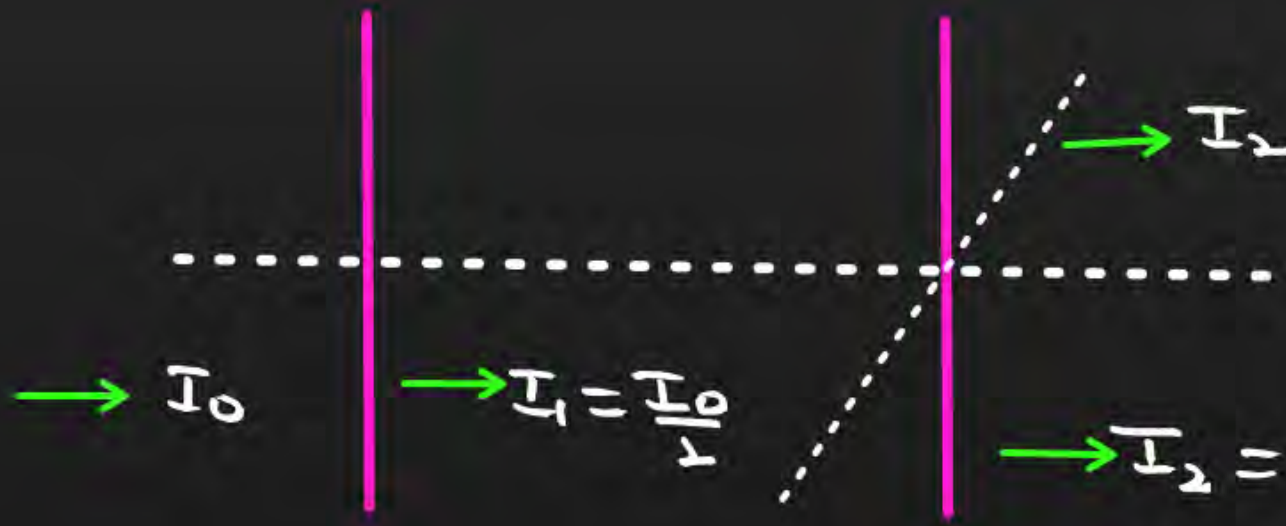
In a system of two crossed polarisers, it is found that the intensity of light from the second polariser is half from that of first polariser. The angle between their pass axes is

(A) 60°

(B) 30

(C) 0°

(D) $\boxed{45°}$



$I_2 = \frac{I_1}{2} = \frac{I_0}{2\times 2} = \frac{I_0}{4}$

$I_2 = I_1 \cos^2\theta$

$\frac{I_0}{4} = \frac{I_0}{2}\cos^2\theta$

$\frac{1}{2} = \cos^2\theta$

$\cos\theta = \frac{1}{\sqrt{2}}$

$\theta = 45°$

Question

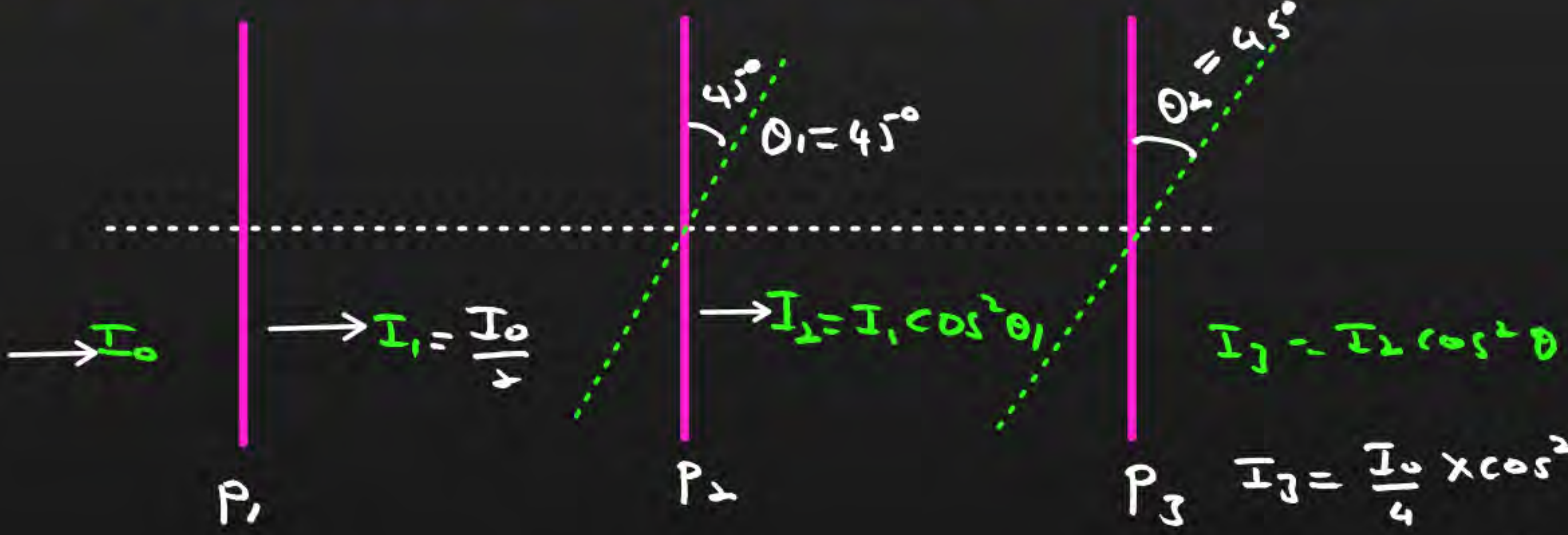
Three polaroid sheets P_1, P_2 and P_3, are kept parallel to each other such that the angle between pass axes of P_1 and P_2 is 45° and that between P_2 and P_3 is 45°. If unpolarised beam of light of intensity 128 Wm^{-2} (I_0) is incident on P_1. What is the intensity of light coming out of P_3?

(A) 128 Wm^{-2}

(B) zero

(C) $\boxed{16\ Wm^{-2}}$

(D) 64 Wm^{-2}



$I_3 = \frac{I_0}{4} \times \cos^2 45°$

$= \frac{I_0}{4} \times \frac{1}{2}$

$I_1 = \frac{I_0}{2}$

$I_2 = \frac{I_0}{2} \cos^2 45°$

$I_2 = \frac{I_0}{2} \times \frac{1}{2} = \frac{I_0}{4}$

$I_3 = \frac{I_0}{8} = \frac{128}{8} = 16$

Question

$\mu = \frac{\sin i}{\sin r}$

A transparent medium shows relation between i and r as shown. If the speed of light in vacuum is c, the Brewster angle for the medium is

$\tan\theta = \mu = \sqrt{3}$

(A) $30°$

$\mu = \tan\theta$

(B) $45°$

$\sqrt{3} = \tan\theta$

(C) $\boxed{60°}$

$\boxed{\theta = 60°}$

(D) $90°$

$\frac{\sin r}{\sin i} = \frac{1}{\mu} = \frac{1}{\tan 30°} = \frac{1}{\frac{1}{\sqrt{3}}}$

Question

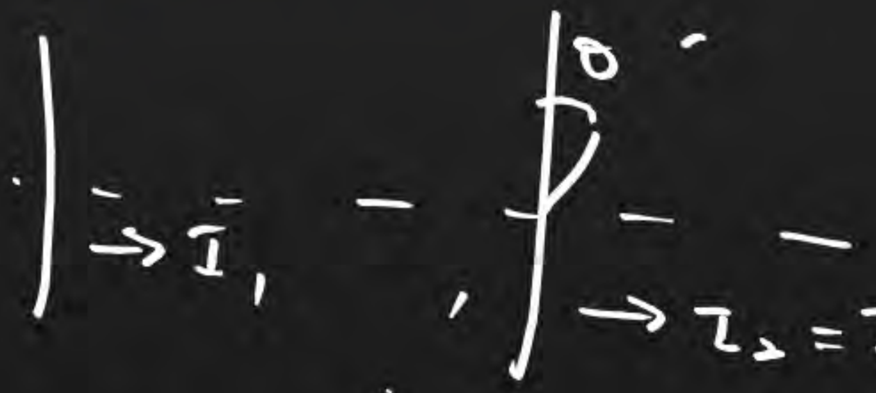
A $\boxed{\text{polarized light of intensity } I_0,}$ is passed through another polarizer whose pass axis makes an angle of 60° with the pass axis of the former. What is the intensity of emergent polarized light from second polarizer?

A $I = I_0$

B $I = I_0/6$

C $I = I_0/5$

D $\boxed{I_0/4}$



$I_2 = I_1 \cos^2\theta$

$I_1 = I_0$

$I_2 = I_0 \times \cos^2 60°$

$= I_0 \times \left(\frac{1}{2}\right)^2$

$\boxed{= \frac{I_0}{4}}$

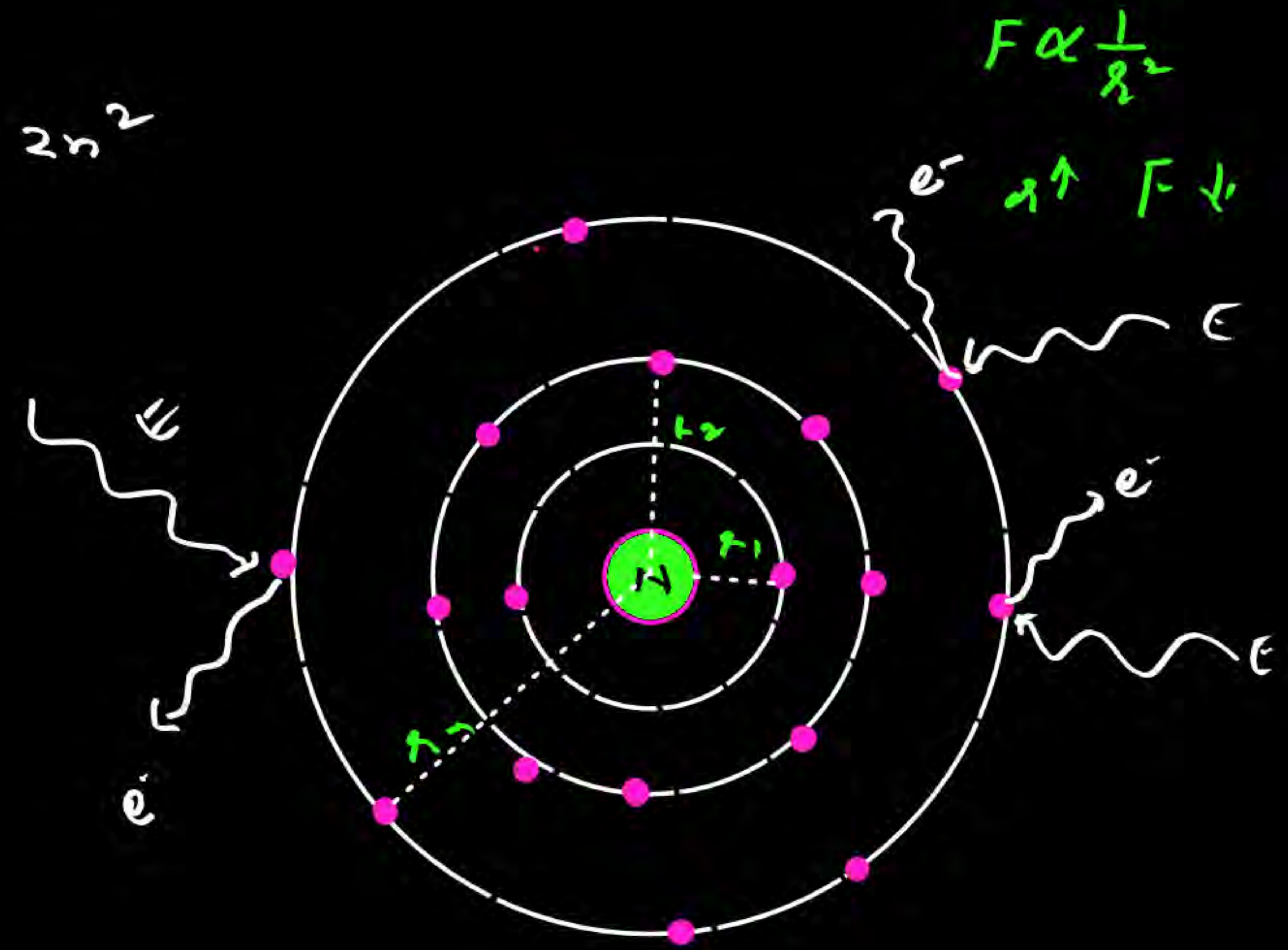
DUAL NATURE OF RADIATION AND MATTER

KCET analysis of chapter - Marks weightage

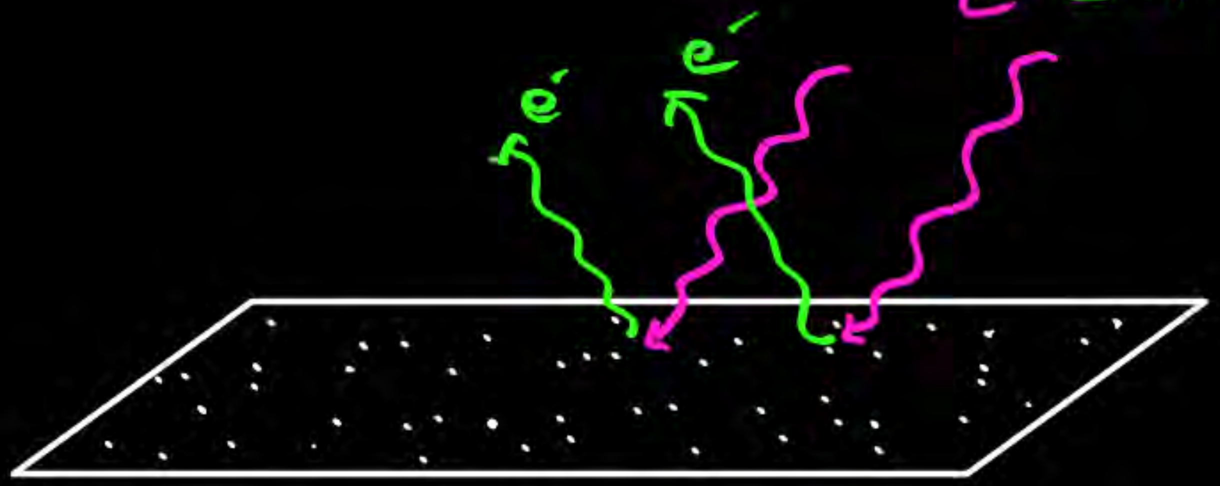
Year	Topic
2025 (2Q)	De-Broglie Wavelength and Variation of Photo current with frequency
2024(2Q)	Kinetic Energy of photoelectrons and Photoelectric Work Function
2023(3Q)	Variation of stopping potential with frequency, Emission of photons and Momentum of emitted photons
2022(3Q)	Wavelength of incident light, de-Broglie wavelength and Saturation photocurrent
2021(3Q)	Velocity of emitted photoelectrons, Momentum of photoelectrons and Variation of Kinetic energy with frequency

KCET analysis of chapter - Marks weightage

Year	Topic
2020(1Q)	Variation of photocurrent with anode potential
2019(2Q)	De-Broglie wavelength and Photoelectric saturation current
2018 (3Q)	Wavelength of light, Kinetic energy of emitted photoelectrons and de-Broglie wavelength
2017(2Q)	Variation of Photocurrent and potential, de-Broglie wavelength
2016(2Q)	Variation of photocurrent with collector potential and de-Broglie wavelength
2015	De-Broglie wavelength and Maximum speed of emitted electrons

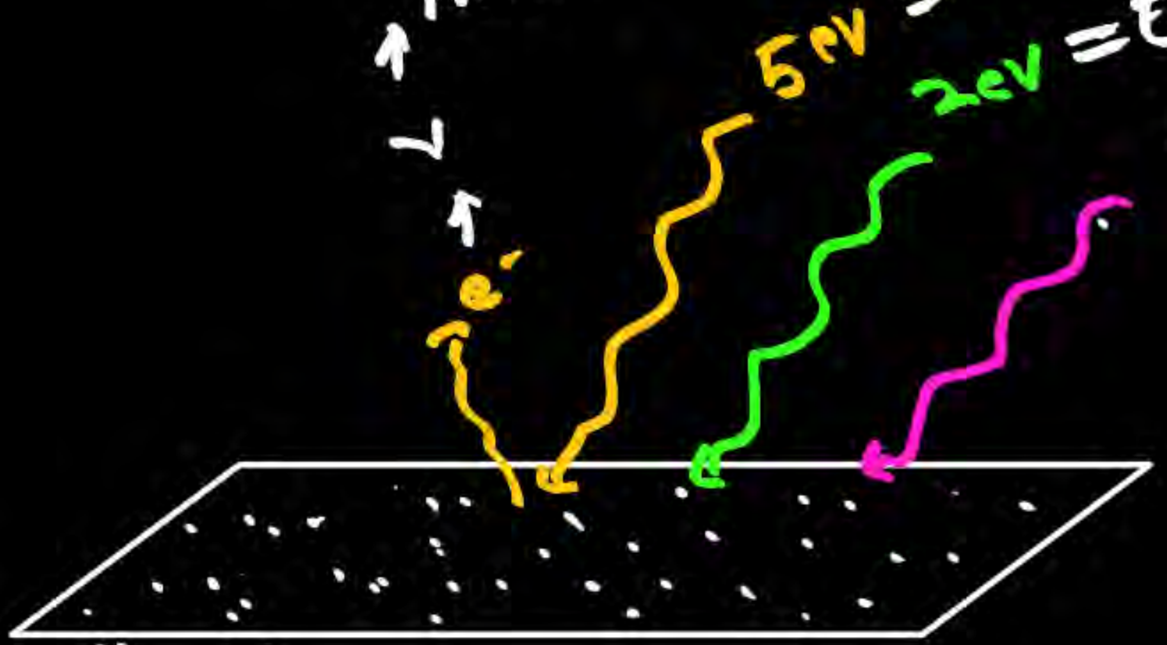


2n^2
F ∝ 1/r^2
r ↑ F ↓
e-
E
E
e-
E
e-
N
r1
r2
rn



$$E = h\nu = \frac{hc}{\lambda}$$

$E = h\nu$



(i) $E > W \Rightarrow$ PEE ✓

$E \leq W =$ PEE ×

$E = W + K.E_{max}$

$W = 4.5ev$

$W = h\nu_0$

ν_0 - Threshold Freq

$E = 5ev$

$W = 4.5ev$

$K.E = 0.5ev$

$1 \rightarrow v = 0$

$2 \rightarrow v = 1 m/s$

$3 \rightarrow v = 2 m/s$

$4 \rightarrow v = 10 m/s$

$0 \leq K.E \leq K.E_{max}$

Electron Emission

I. Emission of electron from a metal surface, when energy is incident upon the surface.

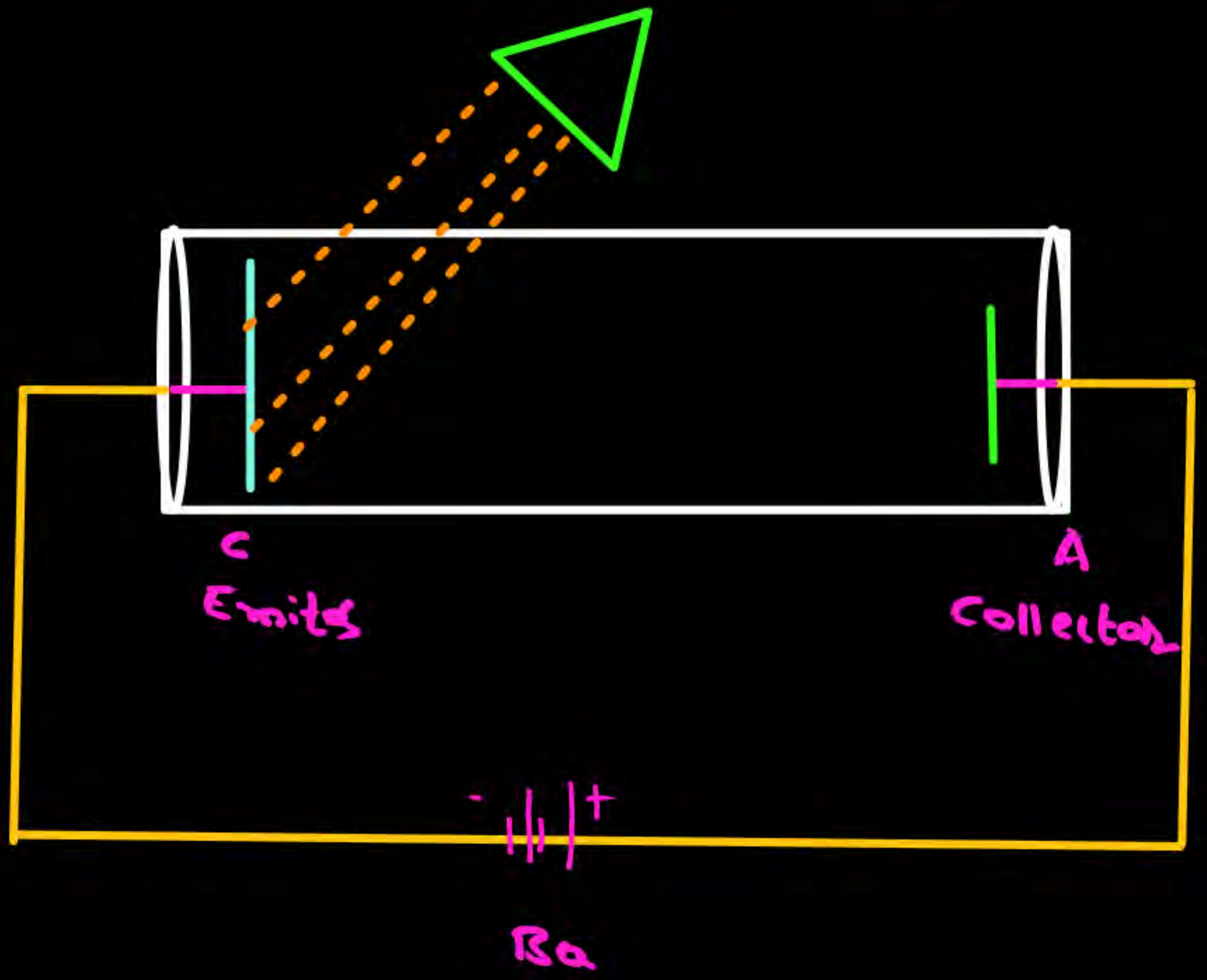
II. Minimum energy required to bring out the electron from metal surface is called work function ($\varnothing_0$).

III. It depends on nature of material and nature of surface.

Types of Electron Emission

1. Thermionic emission
2. Field emission
3. Photoelectric emission

Photoelectric Effect (PEE)



$K.E \propto f$

$K.E \propto V_0$

$\boxed{K.E = eV_0}$

↳ stopping

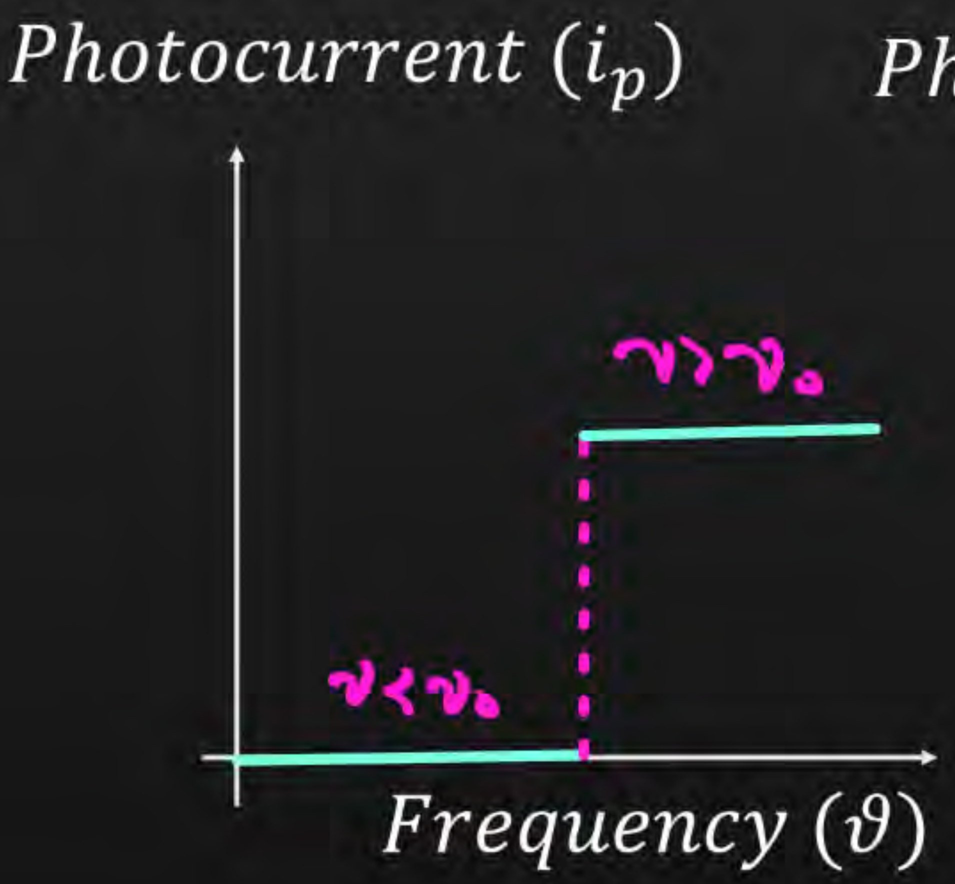
The experiment to study photoelectric effect

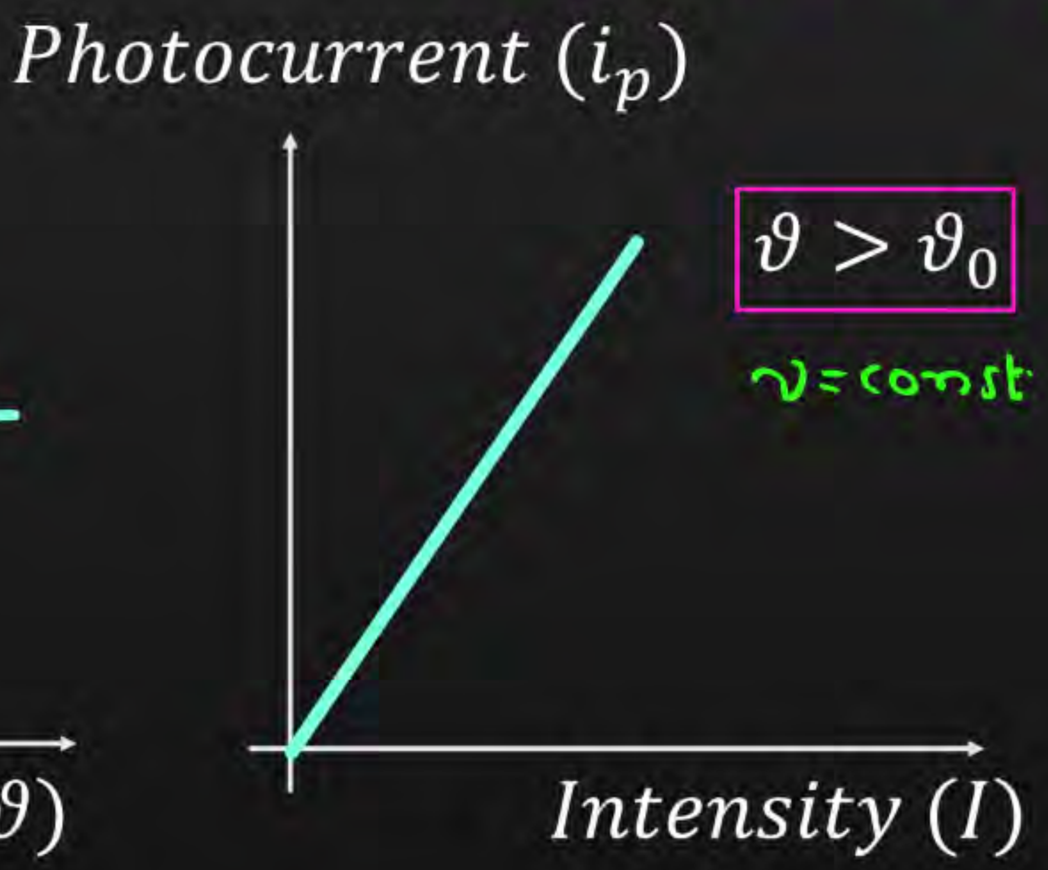
$\vartheta = constant$

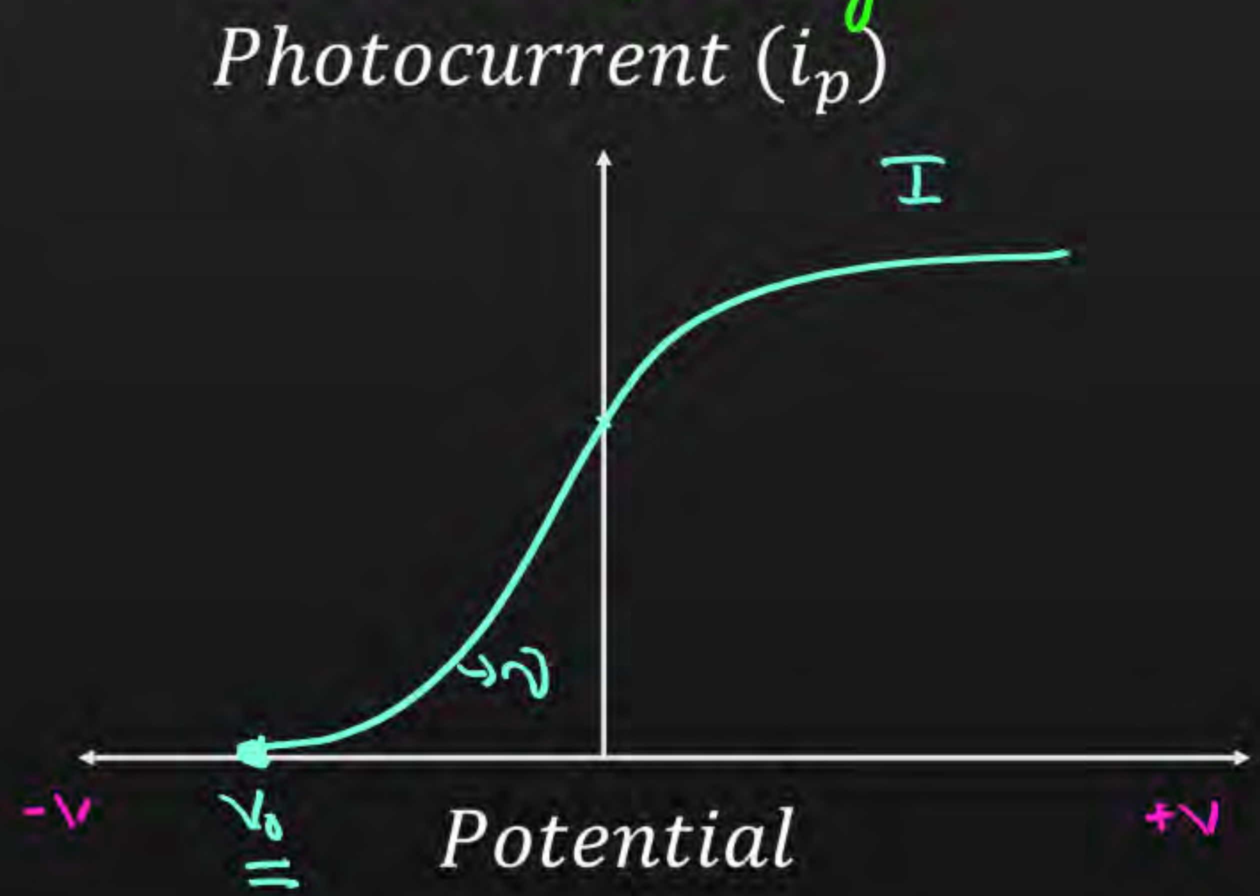
$I = Constant$

I ∝ No. of emission of electrons ∝ i_p

K.E ∝ frequency







The experiment to study photoelectric effect

$\vartheta = constant$

$I = variable$

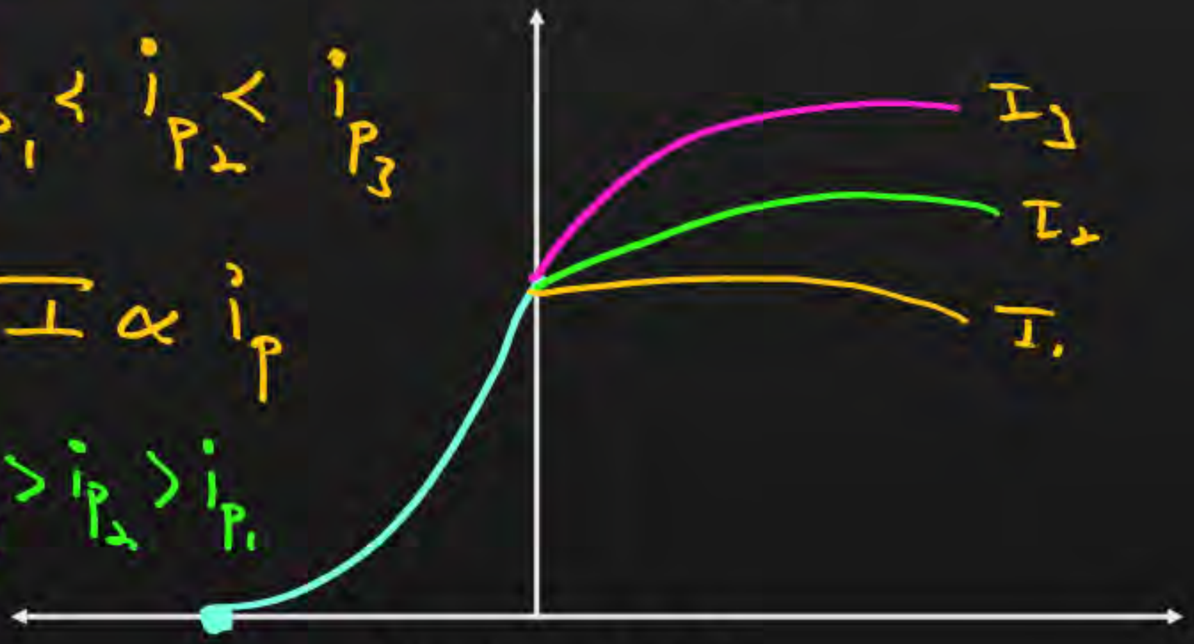
$K.E \propto f \propto V_0$

Photocurrent (i_p)

$i_{p_1} < i_{p_2} < i_{p_3}$

$I \propto i_p$

$i_{p_3} > i_{p_2} > i_{p_1}$



Potential

$\vartheta = variable$

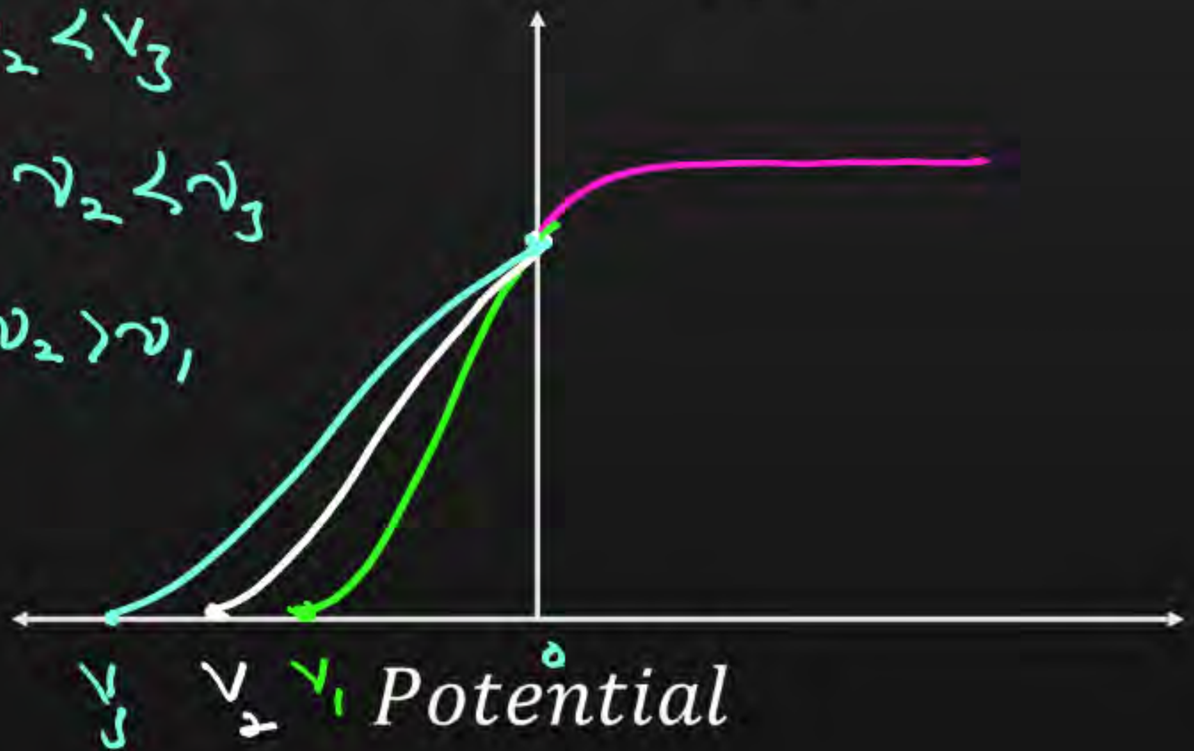
$I = constant$

Photocurrent (i_p)

$V_1 < V_2 < V_3$

$\nu_1 < \nu_2 < \nu_3$

$\nu_3 > \nu_2 > \nu_1$



Potential

— . - 4 3 2 1

Laws of Photoelectric Emission

Instantanous process
↳ PEE

Lenard and Millikan gave the following laws on the basis of experiments on photoelectric effect:

(i) The rate of emission of photoelectrons from the surface of a metal varies directly as the intensity of the incident light falling on the surface. $i_p \propto I$

(ii) The maximum kinetic energy of the emitted photoelectrons is independent of the intensity of the incident light. $K.E \propto \nu$

(iii) The maximum kinetic energy of the photoelectrons increases linearly with increase in the frequency of the incident light. $\nu < \nu_0$ PEE ✗

(iv) If the frequency of the incident light is below a certain lowest value, then no photoelectron is emitted from the metal. This lowest frequency (threshold frequency) is different for different metals. $\nu > \nu_0$ PEE ✓

(v) As soon as the light is incident on the surface of the metal, the photoelectrons are emitted instantly, that is, there is no time-lag between incidence of light and emission of electrons.

Einstein's Photoelectric Equation

Energy of incident photon = photoelectric work function + maximum kinetic energy of photoelectron

$E = W + K.E_{max}$

$0 \le K \le K.E_{max}$

Frequency $h\vartheta = h\vartheta_0 + K.E_{max}$

$K.E = \frac{1}{2} mv^2$

Wavelength, $\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + K.E_{max}$

$c = f\lambda$

$K = eV_0$

$f = \vartheta = \frac{c}{\lambda}$

Observations:

1. If $\vartheta = \vartheta_0$, then K.E is positive, Photo emission is just possible.
2. If $\vartheta > \vartheta_0$, then K.E is positive, Photo emission is possible.
3. If $\vartheta < \vartheta_0$, then K.E is negative , but K.E is never negative, photo emission not takes place

$E = h\nu$ ✓

$$E = \frac{hc}{\lambda} = \frac{6.67\times10^{-34}\times3\times10^{8}}{\lambda}$$

$$\boxed{E = \frac{2\times10^{-25}}{\lambda}\ \mathrm{J}}$$

* $\boxed{E = \frac{1241}{\lambda(nm)}\ \mathrm{eV}}$

Einstein's Photoelectric Equation

$1\,eV = 1.6\times10^{-19}\,J$

$1\,J = \frac{1}{1.6\times10^{-19}}\,eV$

At a time, only one photon can interact with one electron. Energy of photon used by the electron is

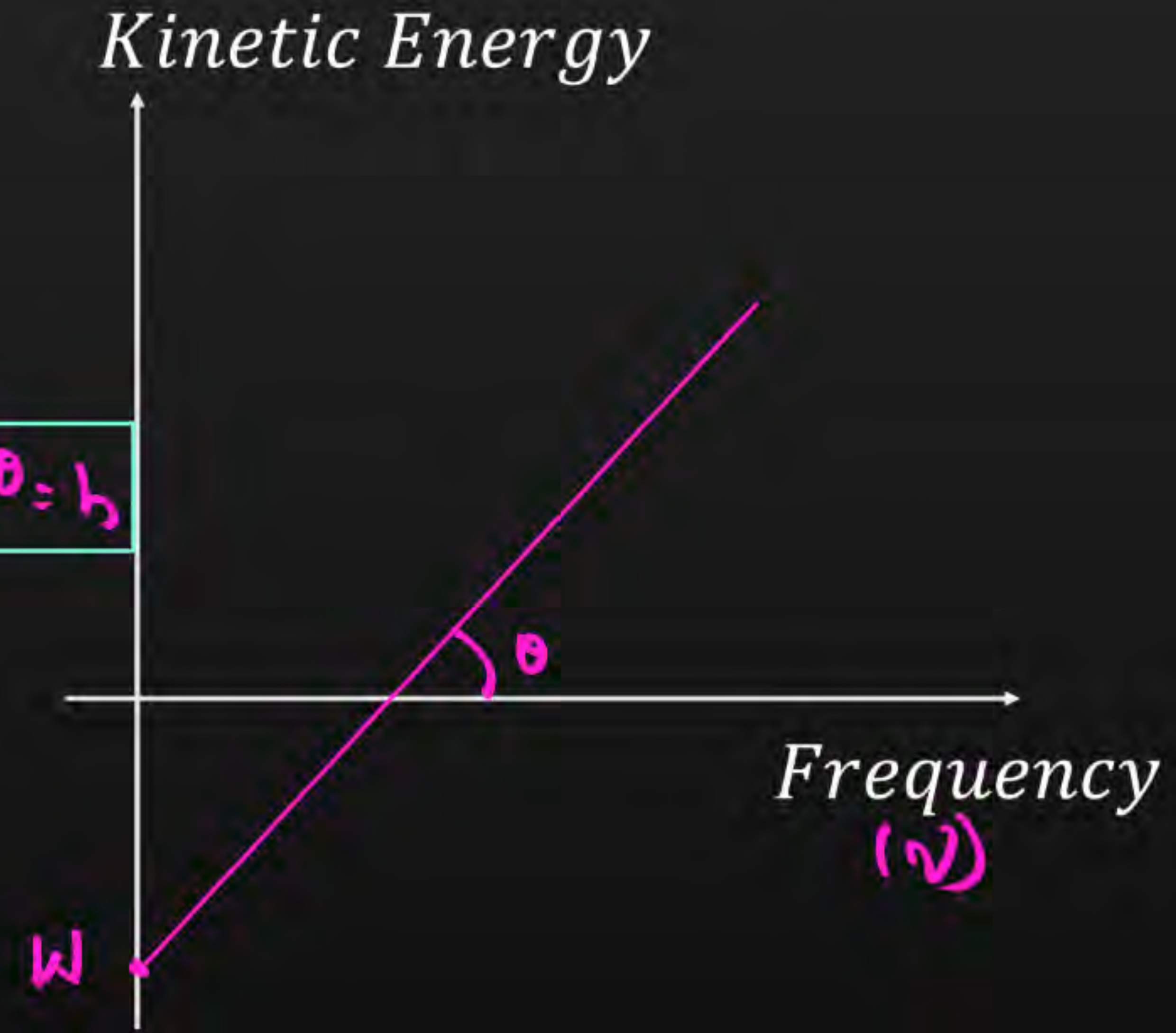
$$E = W + K.E$$

$$K.E = E - W$$

$$K.E = h\nu - W$$

$$y = mx + c$$

$\boxed{\text{Slope} = m = \tan\theta = h}$



Einstein's Photoelectric Equation

At a time, only one photon can interact with one electron. Energy of photon used by the electron is

$$E = W + K.E_{max}$$

$$K.E_{max} = E - W$$

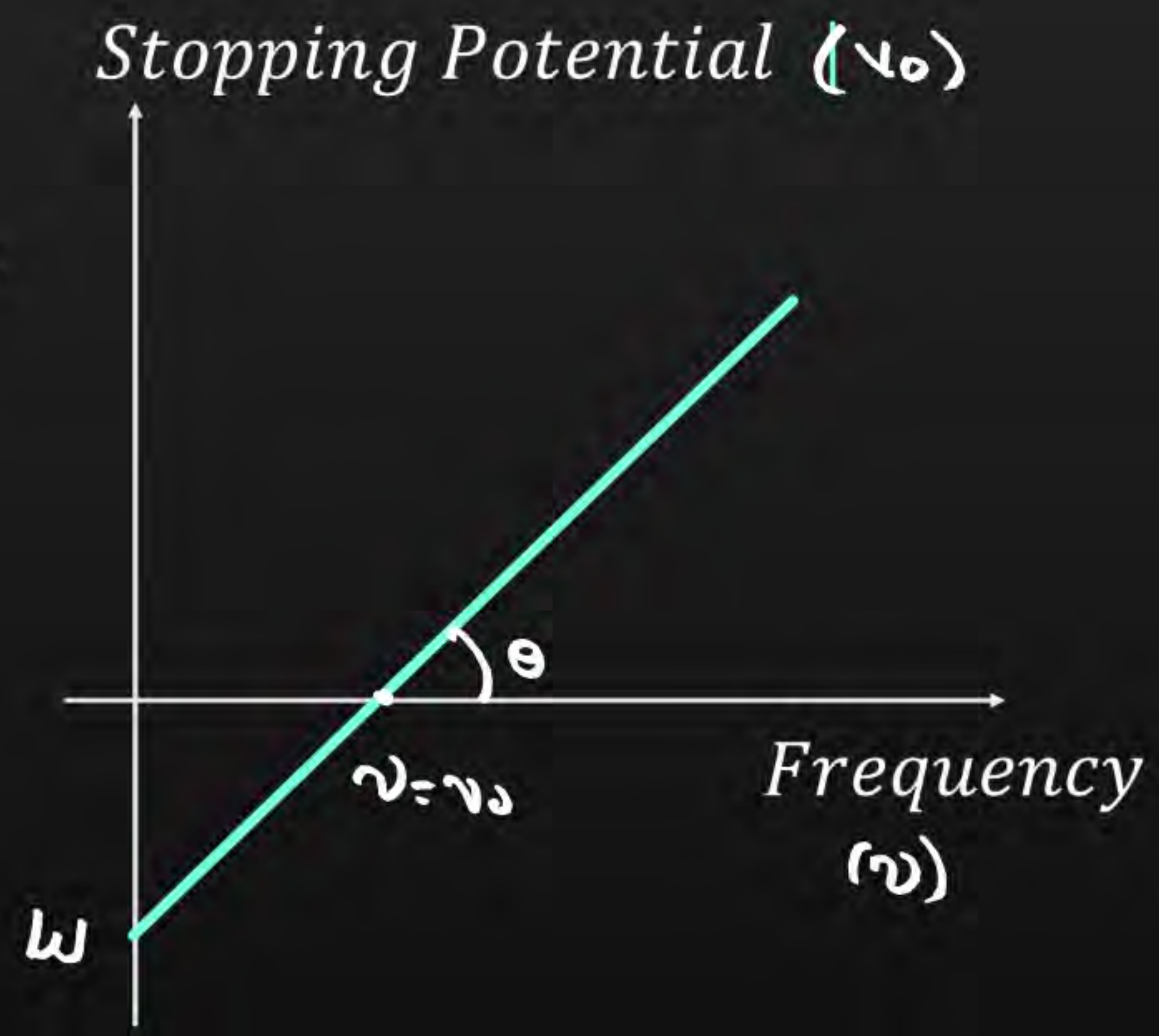
$$eV_0 = h\nu - W$$

$$\boxed{V_0 = \frac{h}{e}.\nu - W \qquad y = mx + c}$$

slope = m = tan θ

$$\boxed{= \frac{h}{e}}$$

$W = h\nu_0$



Thank

You