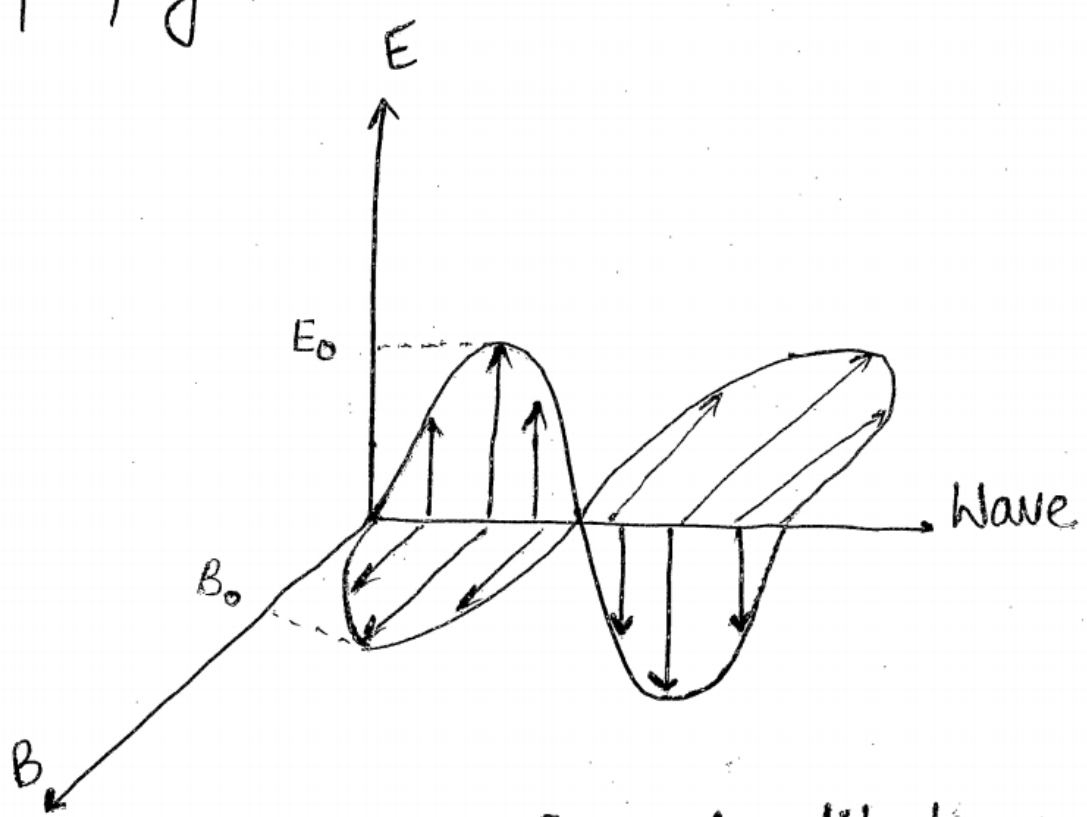
:- Electro-magnetic Waves :-

In electro-magnetic wave electric and magnetic field oscillate ⊥er to each other and also ⊥er to direction of wave propagation.



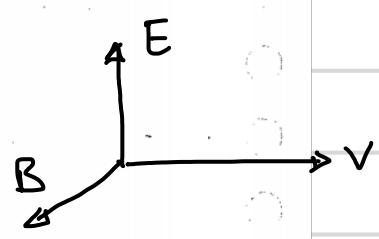
E_0 → Amplitude of electric field.

B_0 → " " magnetic "

** EM Waves are produced by accelerated charged particles

** EM Waves are Transverse non-mechanical waves

:- Points regarding Electro-magnetic waves :-



(i) Dir^n of wave motion is parallel to $\vec{E} \times \vec{B}$

$\rightarrow E = VB$

$\vec{E} = \vec{B} \times \vec{V}$

(ii) E and B are in same phase.

$$E = E_0 \sin(\omega t - kx + \phi)$$

$$B = B_0 \sin(\omega t - kx + \phi)$$

$\rightarrow B = \frac{E}{V}$

$\vec{B} = \frac{\vec{V} \times \vec{E}}{V^2}$

(iii) $B_0 = \frac{E_0}{C}$; $B = \frac{E}{C}$, $E = VB$

(iv) $C = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$

$\mu_r \geq 0$ → dia $0 \leq \mu_r < 1$
→ Para $1 < \mu_r < 2$
→ ferro $1 << \mu_r$

$$V = \frac{1}{\sqrt{\mu \epsilon}} = \frac{1}{\sqrt{\mu_r \mu_0 \epsilon_r \epsilon_0}}$$

$\epsilon_r \geq 1$

$$V = \frac{C}{\sqrt{\mu_r \epsilon_r}} = \frac{C}{n}$$

$\mu_r \epsilon_r \geq 1$

Refractive index = $\sqrt{\mu_r \epsilon_r}$

Speed of light only depend on electric and magnetic properties of medium

(v) Total wave energy is equally divided in E and B

(vi) Electric energy density = $\frac{1}{2} \epsilon_0 E^2$

Magnetic " " = $\frac{B^2}{2\mu_0}$

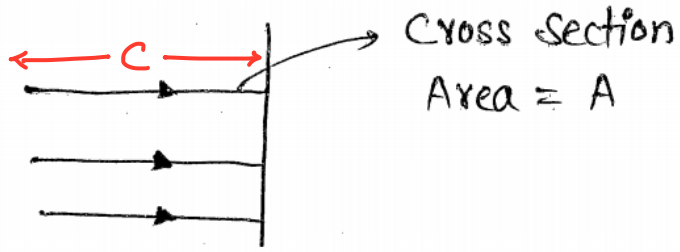
(vii) Average electric energy density $= \frac{1}{2}\epsilon_0 E_{rms}^2 = \frac{1}{4}\epsilon_0 E_0^2$

Average magnetic " " $= \frac{B_{rms}^2}{2\mu_0} = \frac{B_0^2}{4\mu_0}$

Average Total " " $= \frac{1}{4}\epsilon_0 E_0^2 + \frac{B_0^2}{4\mu_0}$

* **Average Total Energy density $= \frac{1}{2}\epsilon_0 E_0^2 = \epsilon_0 E_{rms}^2$**

(viii) Power incident and intensity of light :-

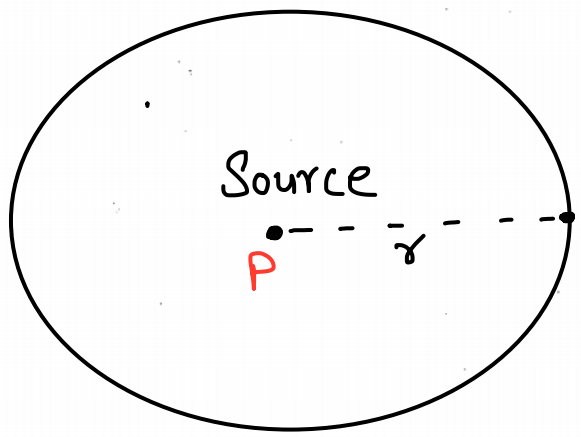


Power = (energy density) $\left(\frac{\text{volume}}{\text{sec.}}\right)$

* $P = \left(\frac{1}{2}\epsilon_0 E_0^2\right)(CA)$

Intensity (I) :-

$$I = \left(\frac{1}{2}\epsilon_0 E_0^2\right)C = \frac{P_{source}}{4\pi r^2}$$



Q. P_0 ——— r ——— Find E_0

Source

$$\frac{1}{2}\epsilon_0 E_0^2 C = \frac{P}{4\pi r^2}$$

Maxwell's Equations of electromagnetism

(i) Gauss's Law for electrostatic $\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

(ii) Gauss's Law for magnetism $\oint \vec{B} \cdot d\vec{A} = 0$

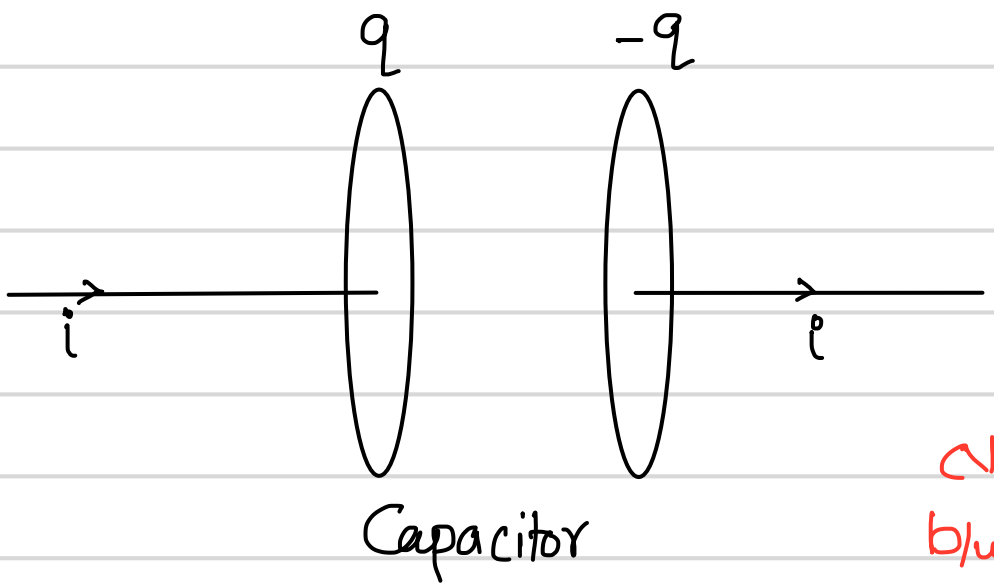
(iii) Faraday's Law $E.m.f = -\frac{d\phi}{dt} \Rightarrow \oint \vec{E} \cdot d\vec{l} = \frac{d\phi}{dt}$

(iv) Ampere-maxwell equation $\oint \vec{B} \cdot d\vec{l} = \mu_0 (i_c + i_d)$

$i_c \rightarrow$ Conduction Current (Current in wire)

$i_d \rightarrow$ displacement Current (Equivalent Current due to time varrying electric field)

$$\boxed{i_d = \epsilon_0 \frac{d\phi_e}{dt}}$$ ($\phi_e \rightarrow$ electric flux)

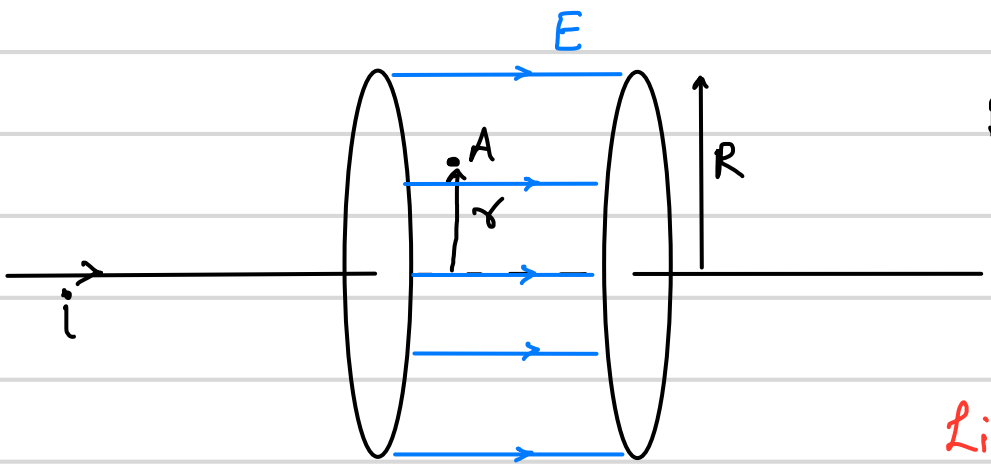


$$\phi_e = EA = \frac{q}{A\epsilon_0} . A$$

$$\Rightarrow i_d = \epsilon_0 \frac{d}{dt} \frac{q}{\epsilon_0} = \frac{dq}{dt} = i_c$$

Now i_d explain magnetic field b/w plates of Capacitor during charging

* $\boxed{i_d = i_c}$ for Capacitor



B at point A $\frac{\mu_0 I r}{2}$ $r < R$

$\frac{\mu_0 i}{2\pi r}$ $r > R$

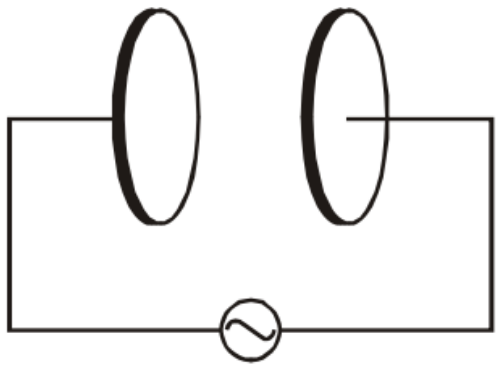
Like Current Carrying Solid Cylinder

52. A parallel plate capacitor (fig.) made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 μF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.

(a) What is the rms value of the conduction current?

(b) Is the conduction current equal to the displacement current?

(c) Determine the amplitude of B at a point 3.0 cm from the axis between the plates.



Sol^n (i) $i_{rms} = \frac{V_{rms}}{Z} = \frac{230}{X_C} = (230)(300 \times 100 \times 10^{-6}) = 6.9A$

(ii) yes $i_d = i_c$

(iii) $B_0 = \frac{\mu_0 I r}{2} = \frac{\mu_0 i_0 r}{2\pi R^2} = \frac{10^{-7}}{2} \times \frac{(6.9\sqrt{2})(3 \times 10^{-2})}{(6 \times 10^{-2})^2}$

$= 1.63 \times 10^{-5} T$

55. Suppose that the electric field part of an electromagnetic wave in vaccum is

$E = \{(3.1\ \text{N/C}) \cos [(1.8\ \text{rad/m})\ y + (5.4 \times 10^8\ \text{rad/s})t]\ \hat{i}$.

(a) What is the direction of propagation?

(b) What is the wavelength λ?

(c) What is the frequency v?

(d) What is the amplitude of the magnetic field part of the wave?

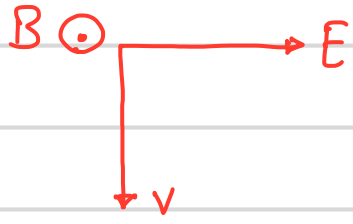
(e) Write an expression for the magnetic field part of the wave.

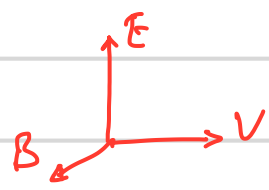
Ans. (a) $-\hat{j}$ (b) 3.5 m (b) 86 MHz (c) 10.3 nT (e) $\{(10.3\ \text{nT}) \cos [(1.8\ \text{rad/m})\ y + (5.4 \times 10^8\ \text{rad/s})t]\} \hat{k}$

(b) $k = 1.8 = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{2 \times 3.14}{1.8} \approx 3.5\text{m}$

(c) $\omega = 2\pi f = 5.4 \times 10^8$ or $f = \frac{c}{\lambda}$

(d) $B_0 = \frac{E_0}{c} = \frac{3.1}{3 \times 10^8} = 10.3\text{nT}$





60. The velocity of electromagnetic waves in a dielectric medium ($\epsilon_r = 4$) is :-

(A) 3×10^8 metre/second (B) 1.5×10^8 metre/second

(C) 6×10^8 metre/second (D) 7.5×10^7 metre/second

Sol^n No information about μ_r So assume $\mu_r = 1$

$$n = \sqrt{\mu_r \epsilon_r} = \sqrt{4 \times 1} = 2$$

$$v = \frac{c}{n} = 1.5 \times 10^8 \text{ m/s}$$

64. A plane electromagnetic wave,

$E_z = 100 \cos (6 \times 10^8 t + 4x)$ V/m

propagates in a medium of dielectric constant:

(A) 1.5 (B) 2.0 (C) 2.4 (D) 4.0

Ans. (D)

Sol^n $v = \frac{\omega}{k} = \frac{6 \times 10^8}{4} = 1.5 \times 10^8$ $\quad n = \frac{c}{v}$

$\Rightarrow n = 2 \quad \Rightarrow \quad \mu_r \epsilon_r = 4$

Now assume $\mu_r = 1 \quad \Rightarrow \quad \epsilon_r = 4$

66. The rms value of the electric field of the light coming from the sun is 720 N/c. The average total energy density of the electromagnetic wave is :

सूर्य से आने वाले प्रकाश के विद्युत क्षेत्र का वर्ग माध्य मूल मान 720 N/c है। विद्युत चुम्बकीय तरंग का औसत कुल ऊर्जा घनत्व होगा:-

(A) 4.58×10^{-6} J/m^3 (B) 6.37×10^{-9} J/m^3 (C) 81.35×10^{-12} J/m^3 (D) 3.3×10^{-3} J/m^3

Ans. **(A)**

Sol. $\epsilon_0 E^2_{RMS}$

Energy density = $\epsilon_0 E^2_{RMS} = 8.85 \times 10^{-12} (720)^2$

$\frac{1}{2}\epsilon_0 E_0^2 = \epsilon_0 E_{rms}^2$

67. A beam of light travelling along x-axis is described by the electric field, $E_y = (600\ Vm^{-1}) \sin \omega (t - x/c)$ then maximum magnetic force on a charge q = 2e, moving along y-axis with a speed of 3.0×10^7 ms^{-1} is (e = 1.6×10^{-19} C) :

(A) 19.2×10^{-17} N (B) 1.92×10^{-17} N (C) 0.192 N (D) None ofthese

x-अक्ष के अनुदिश गतिशील प्रकाश पुंज को विद्युत क्षेत्र $E_y = (600\ Vm^{-1}) \sin \omega (t - x/c)$ द्वारा दर्शाया जाता है। y-अक्ष के अनुदिश 3.0×10^7 ms^{-1} चाल से गतिशील आवेश q = 2e पर अधिकतम चुम्बकीय बल होगा:- (e = 1.6×10^{-19} C):

(A) 19.2×10^{-17} N

(B) 1.92×10^{-17} N

(C) 0.192 N

(D) इनमें से कोई नही

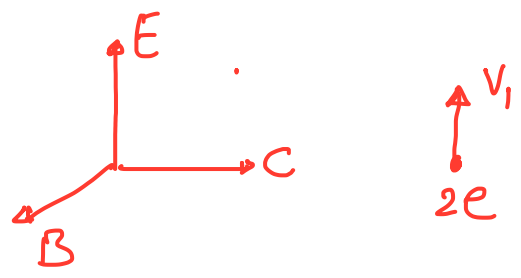
Ans. **(B)**

Sol. $E_0 = B_0 C \Rightarrow B_0 = \frac{600}{3 \times 10^8} = 2\ \mu N/C$

$F = qvB_0$

$= 2(1.6 \times 10^{-19})(3 \times 10^7)(2 \times 10^{-6})$

$= 1.92 \times 10^{-17} N$



62. The amplitude of electric field in a parallel light beam of intensity 4Wm^{-2} is :

तीव्रता 4Wm^{-2} वाले एक समान्तर प्रकाश पुंज में विद्युत क्षेत्र का आयाम होगा:-

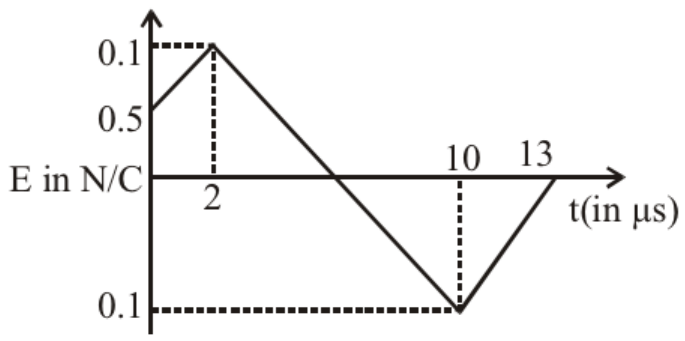
(A) 35.5 NC^{-1} (B) 45.5 NC^{-1} (C) 49.5 NC^{-1} (D) 54.8 NC^{-1}

Ans. **(D)**

Sol. $\left(\frac{1}{2}\epsilon_0 E_0^2\right) C = I \Rightarrow \epsilon_0 = \sqrt{\frac{2I}{\epsilon_0 C}}$

69. The electric field through an area of $2m^2$ varies with time as shown in the graph. The greatest displacement current through the area is at :-

किसी $2m^2$ क्षेत्रफल से निर्गत विद्युत क्षेत्र समय के साथ चित्रानुसार परिवर्तित होता है। क्षेत्रफल से निर्गत अधिकतम विस्थापन धारा कब होगी ?



(A) t = 1 sec. (B) t = 4 sec. (C) t = 8 sec. (D) t = 12 sec.

Ans. (D)

Sol. $i_d = \epsilon_0 \frac{d\phi_E}{dt} = A\epsilon_0 \frac{dE}{dt} = 2\epsilon_0$ (Slope in E-t graph)

$\therefore$ more the rate of change of electric field
more is the displacement current

63. Instantaneous displacement current of 1.0A in the space between the parallel plates of 1μF capacitor can be established by changing potential difference of:

किसी 1μF संधारित्र की समान्तर प्लेटों के मध्य रिक्त स्थान में 1.0 A तात्क्षणिक विस्थापन धारा उत्पन्न करने के लिये विभवान्तर किस दर से परिवर्तित करना होगा ?

(A) 10^{-6} V/s (B) 10^{6} V/s (C) 10^{-8} V/s (D) 10^{8} V/s

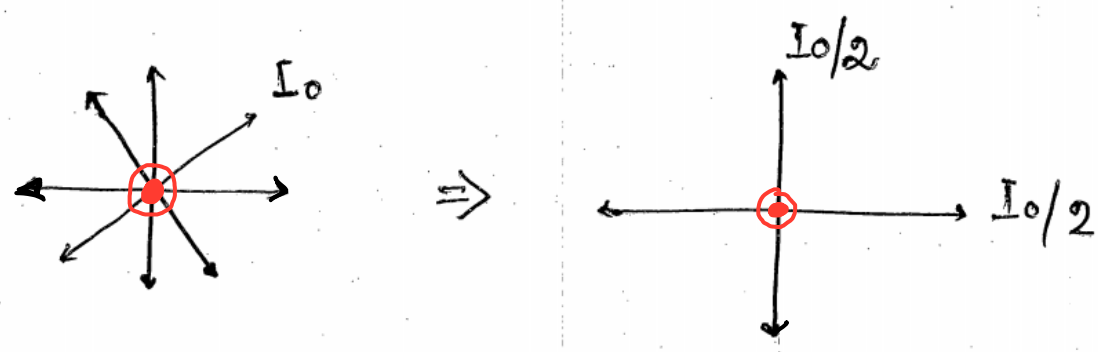
Ans. (B)

Sol. $i_C = i_d = \frac{dq}{dt} = \frac{d(CV)}{dt} = C\frac{dV}{dt}$

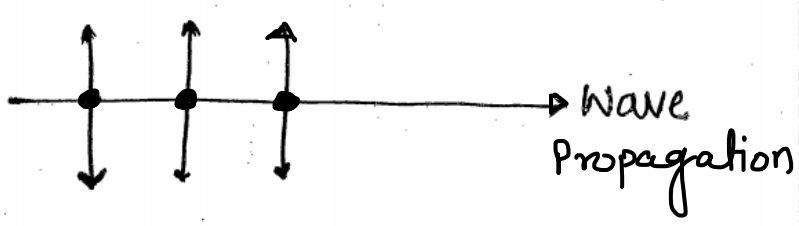
$\frac{dV}{dt} = \frac{i_d}{C}$

—: **Polarisation :—** Process in which un-polarised light get polarised light.

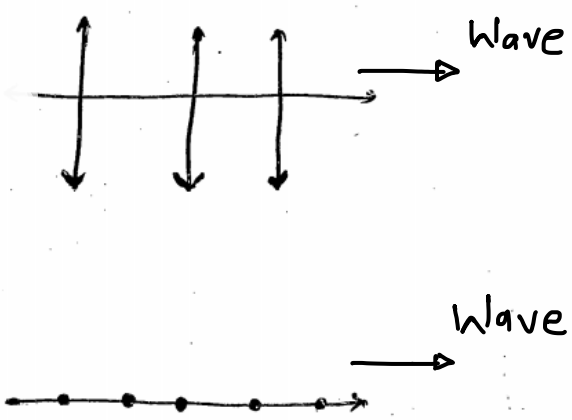
Un Polarised light :- Light in which, direction of oscillation of E is in every dir^n ⊥er to dir^n of wave propagation.



(Dir^n of wave propagation is ⊥er to page)



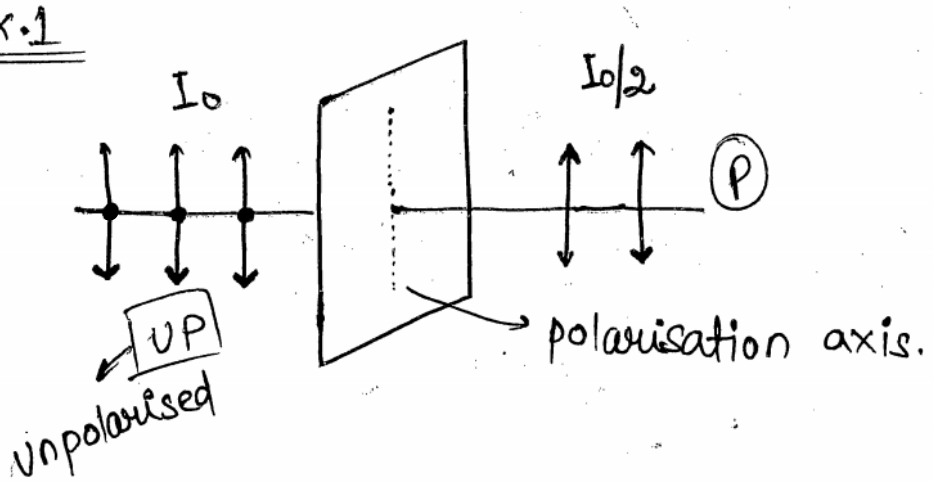
Polarised light :- Light in which oscillation of Electric field are in one dir^n

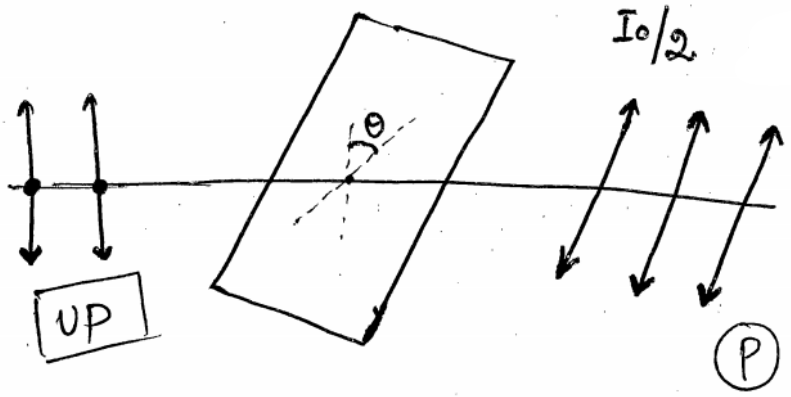


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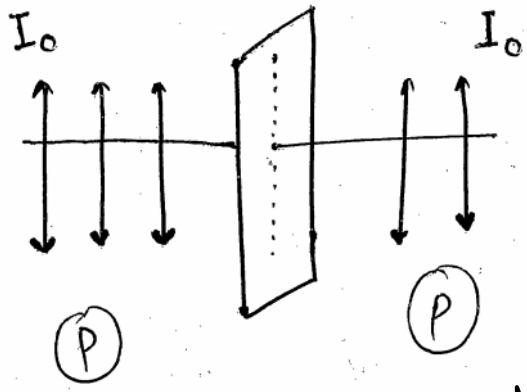
Poloroid :- Material which convert un-polarised light to polarised light. (Examples → nicole Crystal ; Calcite Crystal)

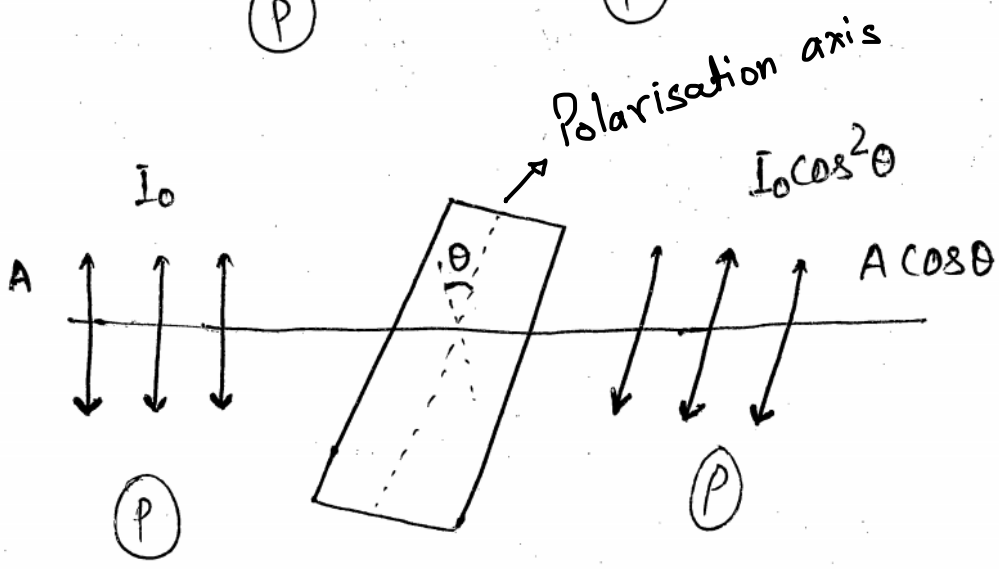
Ex.1

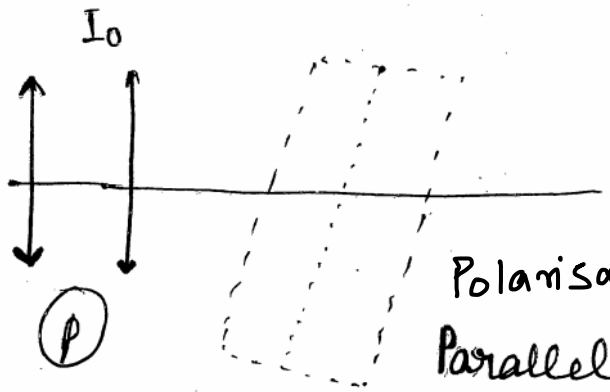




Ex.2



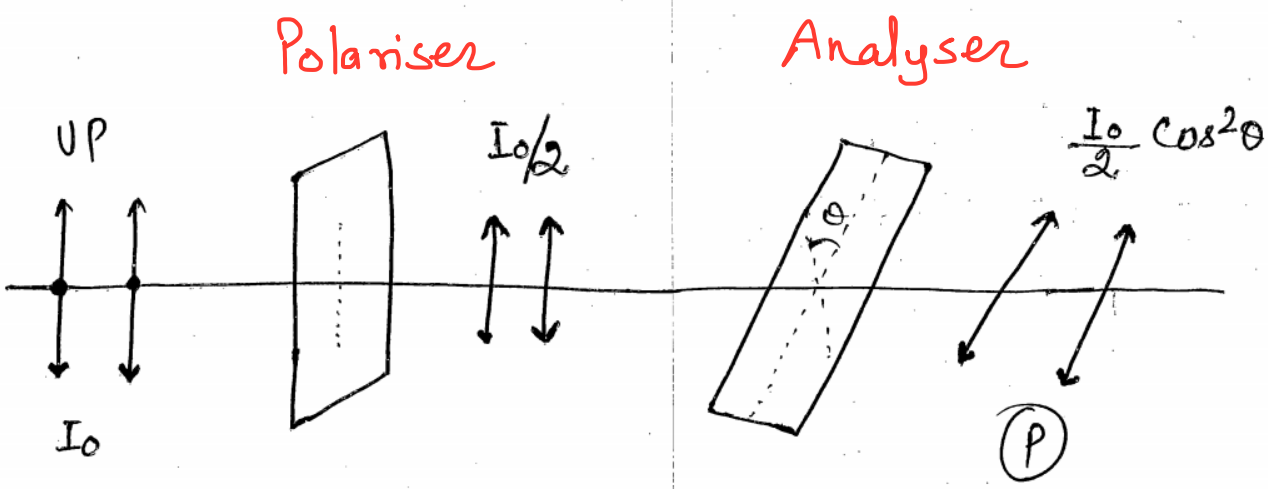




0 (zero)

Polarisation axis Parallel to Z-axis. (Perpendicular to Electric field)

Ex.3.



(known as malus law)

∴ Points :-

1. If we rotate poloroid and intensity of light remain same then incident light is unpolarised

2. If we rotate poloroid & intensity of light varies from max.^{m} to zero then incident light is polarised

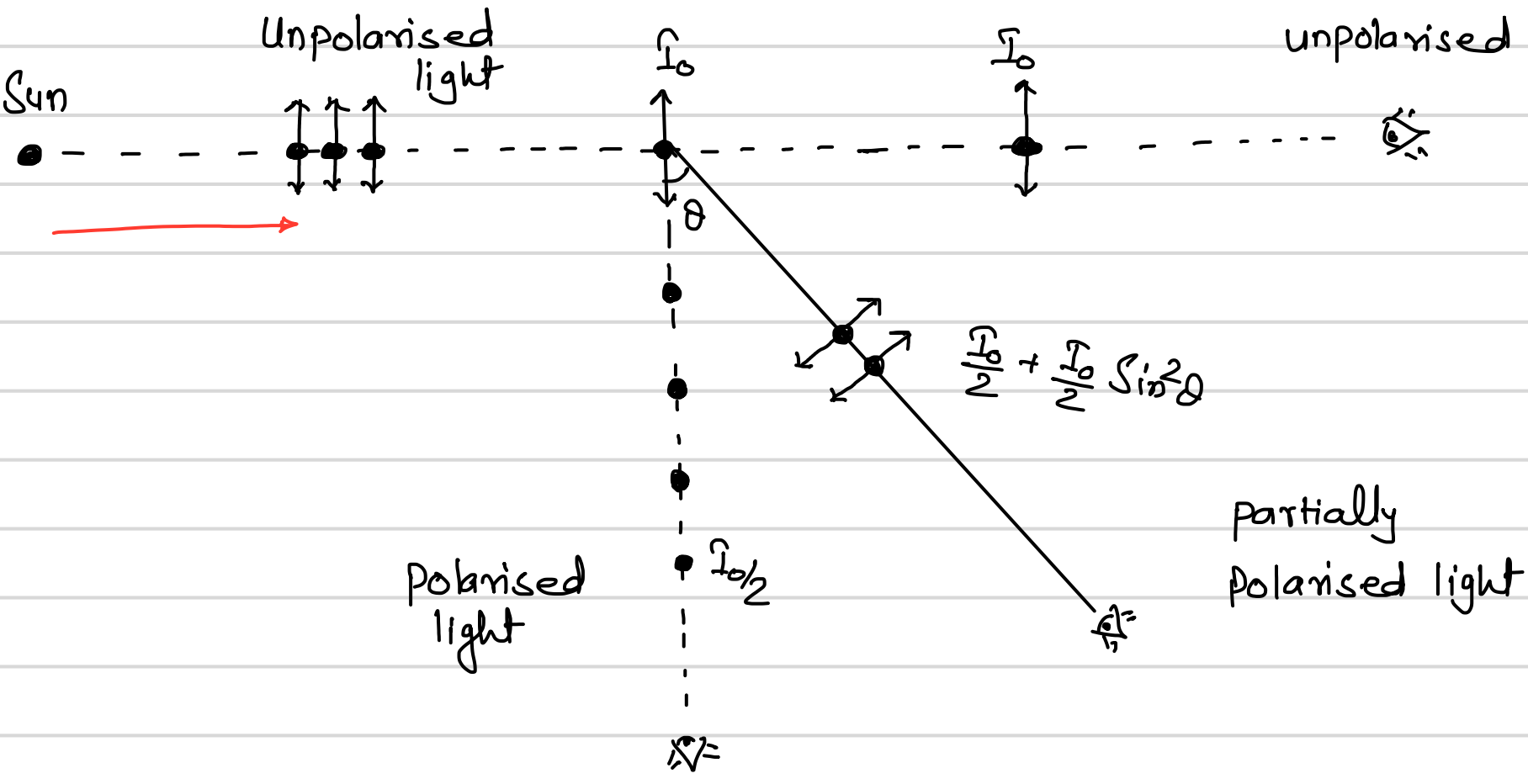
3. If we rotate poloried & intensity of light varies from I_{max} to I_{min} ($I_{min} \neq 0$) then incident light is unpolarised but intensity of light is not uniformly distributed in all direction.
(Partially polarised light)

4. Polarisation axis is parallel to axis of oscillation of electric field

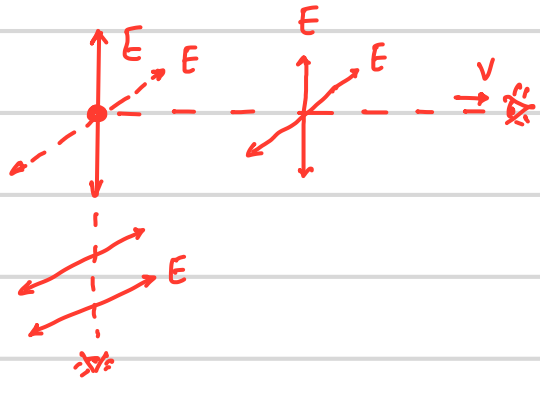
** When light passes through any medium. we can assume any intermediate point as a source and that point oscillate according to incident electric field

if observer is in line of oscillations of electric field than that observer not recieve electromagnetic wave due to those oscillations

Polarisation by Scattering of light :→

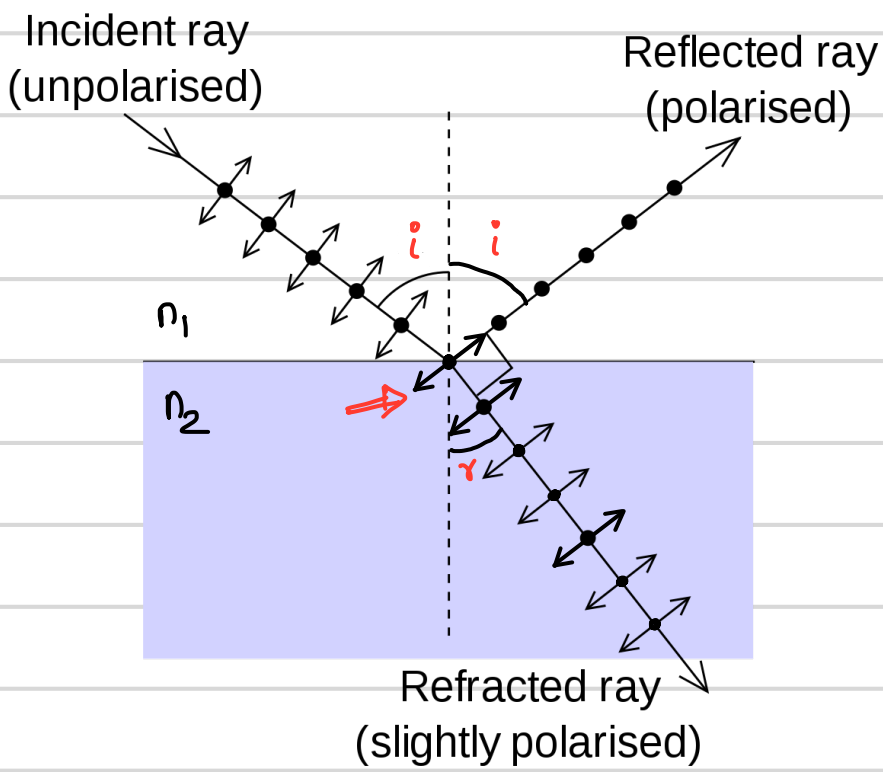


Scattering of light is maximum for blue (in visible)



Polarisation by reflection → When unpolarised light is incident on boundary of two media then light ray is partially reflected and refracted

if reflected ray is ⊥ to refracted ray then reflected ray is polarised



* Particle at boundary oscillate according to refracted ray

* for above Case $i + r + 90^\circ = 180^\circ \Rightarrow r = 90 - i$

Now Snell's law $n_1 \sin i = n_2 \sin r_1 = n_2 \sin(90 - i)$

$\Rightarrow$ * $\boxed{\tan i = \frac{n_2}{n_1}}$

Value of angle of incidence for which reflected ray is polarised is called Brewster Angle

Q.1 Angle b/w Polariser and Analyser is 60° find intensity output if incident light is unpolarised with intensity I_0

Soln

$$I_1 = \frac{I_0}{2} \quad , \quad I_2 = \frac{I_0}{2}\cos^2 60^\circ = \frac{I_0}{8}$$

71. In a stack of three polarizing sheets the first and third are crossed while the middle one has its axis at 45° to the axes of the other two. The fraction of the intensity of an incident unpolarized beam of light that is transmitted by the stack is:

तीन ध्रुवक शीटो की एक व्यवस्था में प्रथम तथा तीसरी शीट एक-दूसरे से क्रोसित अवस्था में है तथा मध्य वाली की अक्ष शेष दोनों की अक्ष से 45° पर है। व्यवस्था द्वारा आपतित अध्रुवित प्रकाश पुंज की तीव्रता का कितना भाग पारगमित होगा ?

(A) 1/2 (B) 1/3 (C) 1/4 (D) 1/8

Ans. (D)

Soln $I_1 = \frac{I_0}{2}$, $I_2 = \frac{I_0}{2}\cos^2 45^\circ = \frac{I_0}{4}$

$$I_3 = I_2 \cos^2 45^\circ = \frac{I_0}{8}$$

Q. two polaroids A and B are arranged such that final intensity of light is Zero. Now one more polaroid C is introduce b/w A and B with angle θ from A find final intensity if an unpolarised light incident on A

Soln final intensity Zero ⇒ A and B are perpendicular

$$I_1 = \frac{I_0}{2} \quad , \quad I_2 = \frac{I_0}{2}\cos^2\theta$$

$$I_3 = \left(\frac{I_0}{2}\cos^2\theta\right)\cos^2(90-\theta) = \frac{I_0}{8}\sin^2 2\theta$$

73. The Sun is directly overhead and you are facing toward the north. Light coming to your eyes from the sky just above the horizon is :-

(A) Partially polarized north-south (B) Partially polarized east,west

(C) Partially polarized up-down (D) Randomly polarized

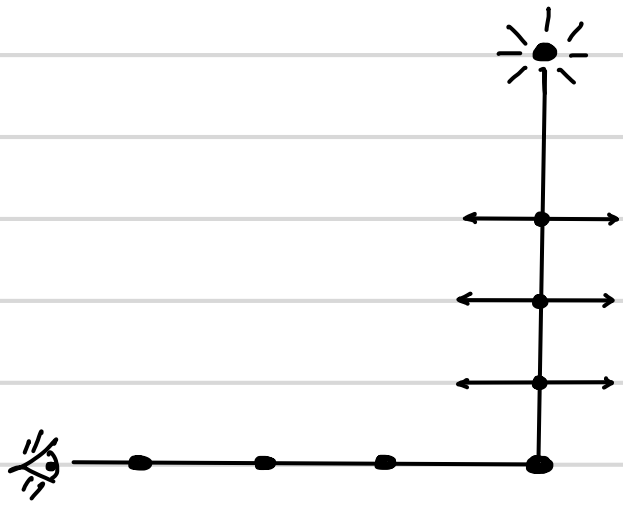
माना सूर्य आपके ठीक ऊपर है तथा आपका मुँह उत्तर की ओर है। आकाश से क्षितिज से ठीक ऊपर से अपकी आँखों में आने वाला प्रकाश है :-

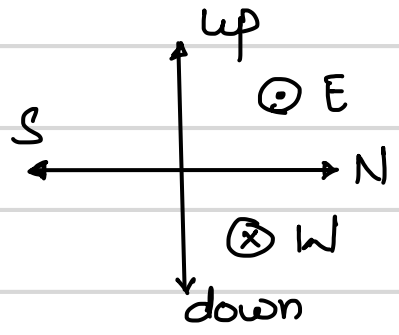
(A) आंशिक ध्रुवित (उत्तर-दक्षिण) (B) आंशिक ध्रुवित (पूर्व-पश्चिम)

(C) आंशिक ध्रुवित (ऊपर-नीचे) (D) यादृच्छिक ध्रुवित

Ans. (B)

Sol. Polarization by scattering.





72. A beam of light strikes a piece of glass at an angle of incidence of 60° and the reflected beam is completely plane polarised. The refractive index of the glass is :-

एक प्रकाश पुंज काँच के टुकड़े पर 60° आपतन कोण पर आपतित होती है तथा परावर्तित पुंज पूर्णतया समतल ध्रुवित होता है। काँच का अपवर्तनांक है:-

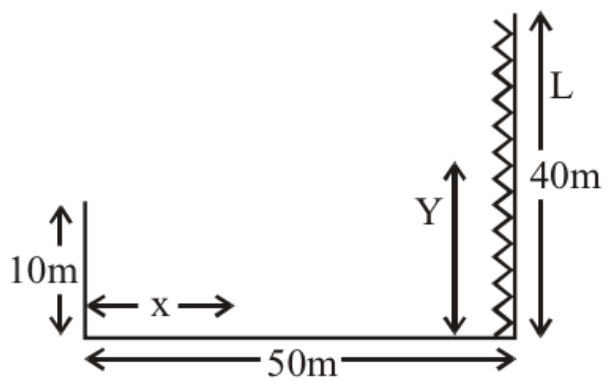
(A) 1.5 (B) $\sqrt{3}$ (C) $\sqrt{2}$ (D)(3/2)

Ans. (B)

Sol. Brewster's law

$$\tan i = \frac{n_2}{n_1} \Rightarrow \tan 60^\circ = \frac{n}{1}$$

79. A person lives in a high-rise building on the bank of a river 50m wide. Across the river is a well lit tower of height 40 m. When the person, who is at a height of 10m, looks through a polarizer at an appropriate angle at light of the tower reflecting from the river surface, he notes that intensity of light coming from distance X from his building is the least and this corresponds to the light coming from light bulbs at height 'Y' on the tower. The values of X and Y are respectively close to (refractive index of water $\simeq$ 4/3)

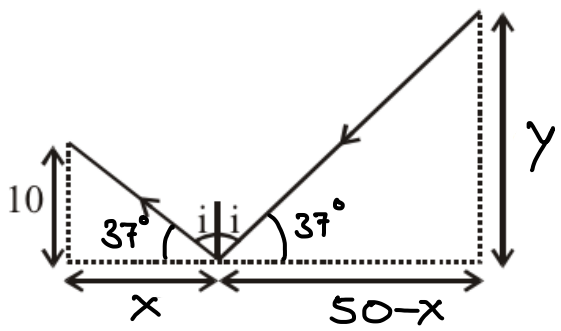


(A) 13 m, 27 m (B) 22 m, 13 m (C) 25 m, 10 m (D) 17 m, 29 m

Ans. (A)

Sol. use brewster's law

$\tan i = \mu \Rightarrow i = 53^\circ$



$\tan 37^\circ = \frac{y}{50-x} = \frac{3}{4}$ and $\tan 37^\circ = \frac{10}{x} = \frac{3}{4}$

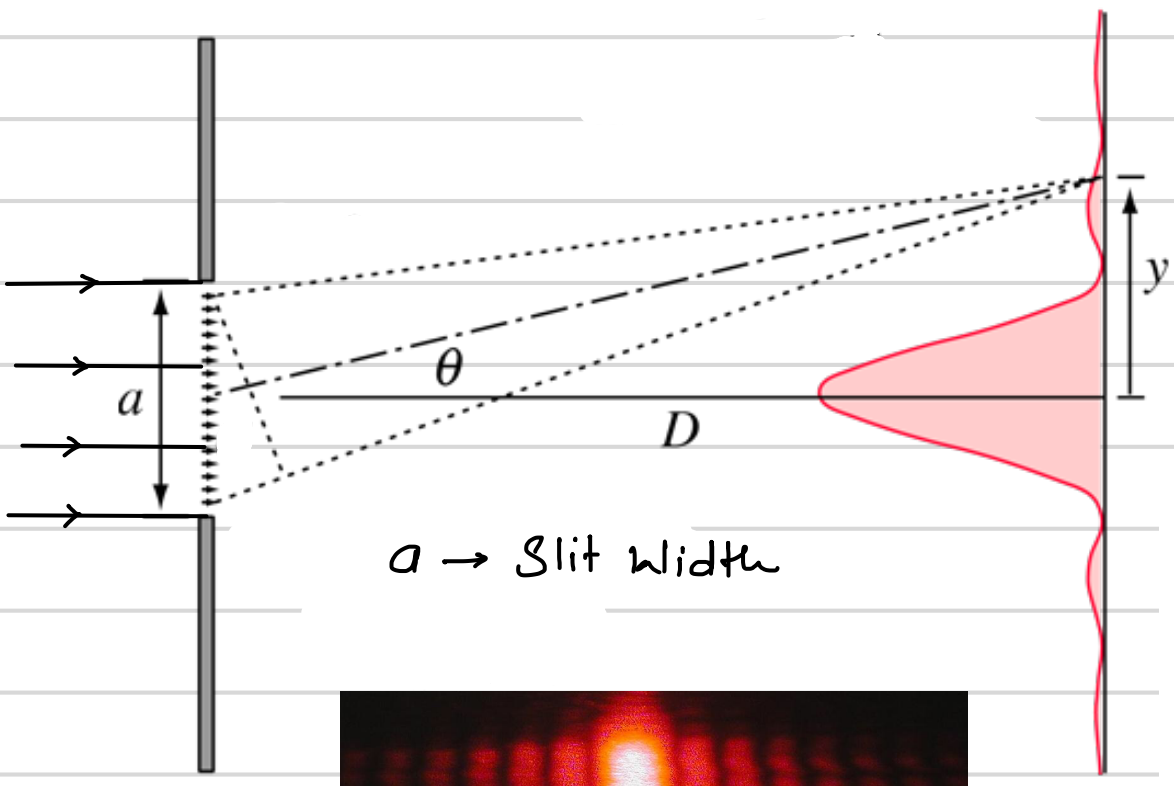
$x = \frac{40}{3}$ m and

$y = \frac{55}{2}$ m

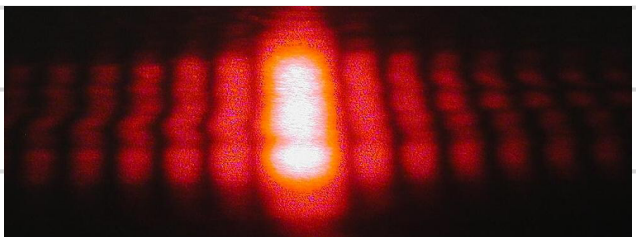
Diffraction

Diffraction refers to various phenomena that occur when a wave encounters an obstacle or opening. It is defined as the bending of waves around the corners of an obstacle or through an aperture into the region of geometrical shadow of the obstacle/aperture. The diffracting object or aperture effectively becomes a secondary source of the propagating wave. Italian scientist Francesco Maria Grimaldi coined the word diffraction and was the first to record accurate observations of the phenomenon in 1660.

Single Slit diffraction (Fresnal diffraction)



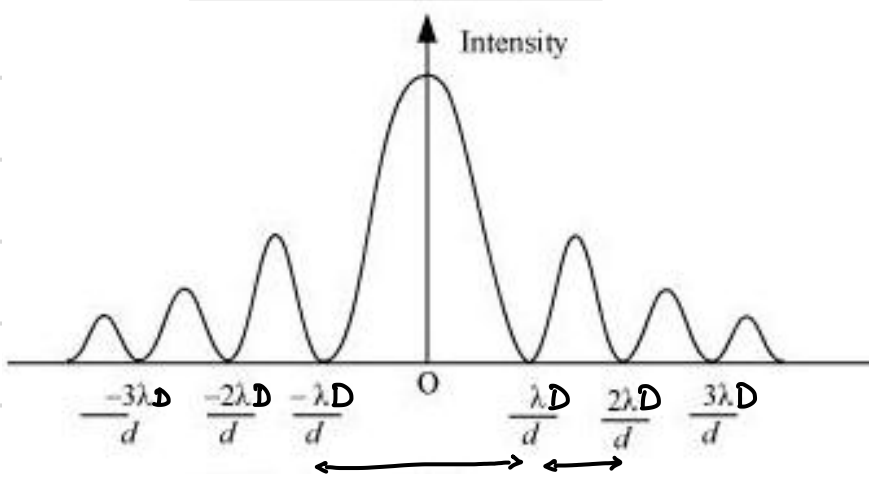
$a \rightarrow$ Slit Width



Position of n^{th} minima

$$a \sin\theta = n\lambda$$

$$y = \frac{n\lambda D}{a}$$



★ Width of Central maxima $= \frac{2\lambda D}{a}$

Width of other maxima's $= \frac{\lambda D}{a}$

★ intensity of CM is maximum and decreases onwards $I = I_0 \left[\frac{\sin\left(\pi \frac{a}{\lambda} \sin\theta\right)}{\frac{\pi a}{\lambda} \sin\theta}\right]^2$

★ dark fringes are not Completly dark (very low intensity)

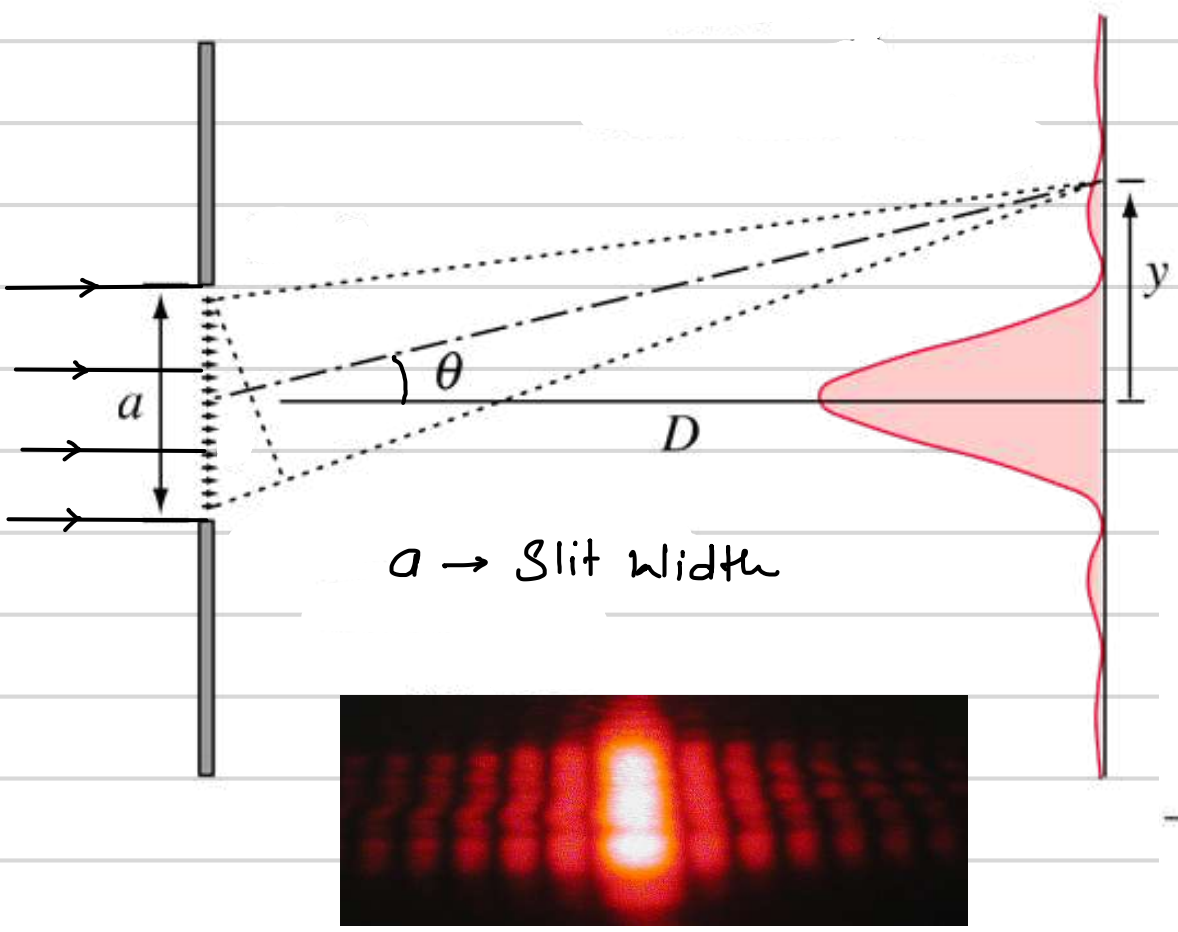
★ As Width Increases, Width of CM decreases and intensity Increases

$\frac{2\lambda D}{a}$

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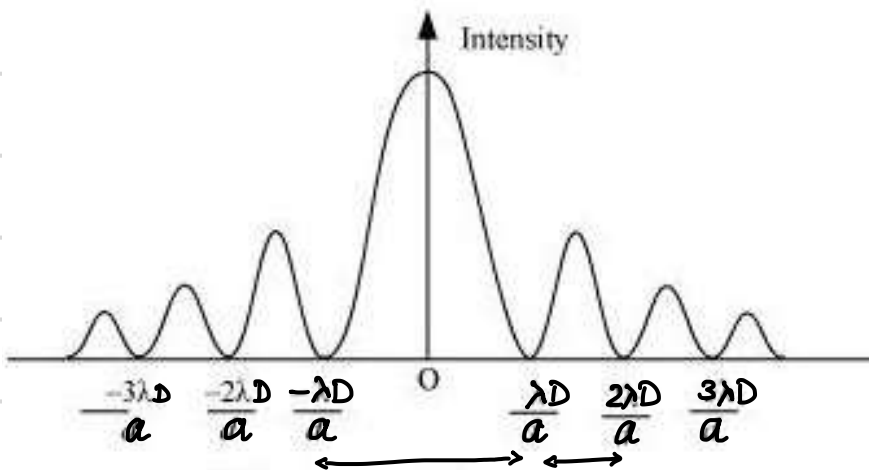


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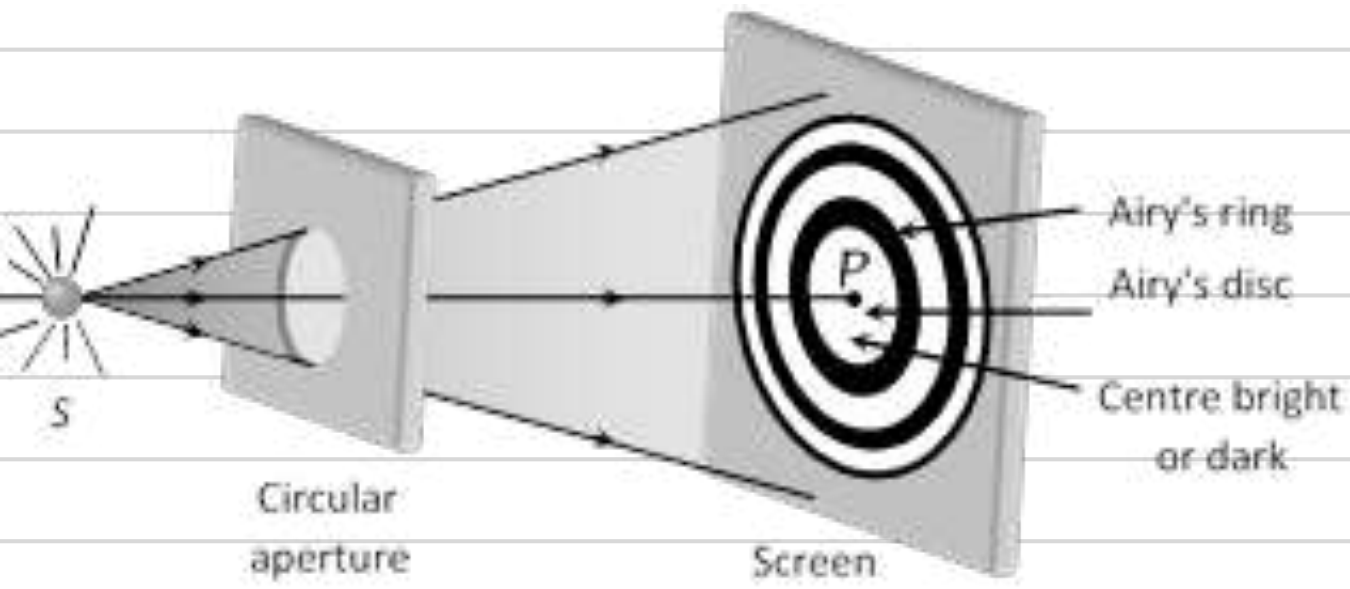
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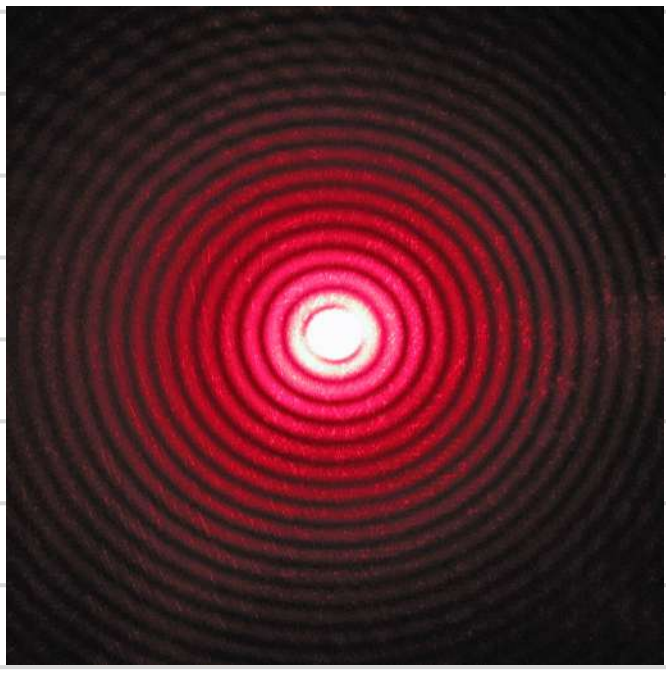
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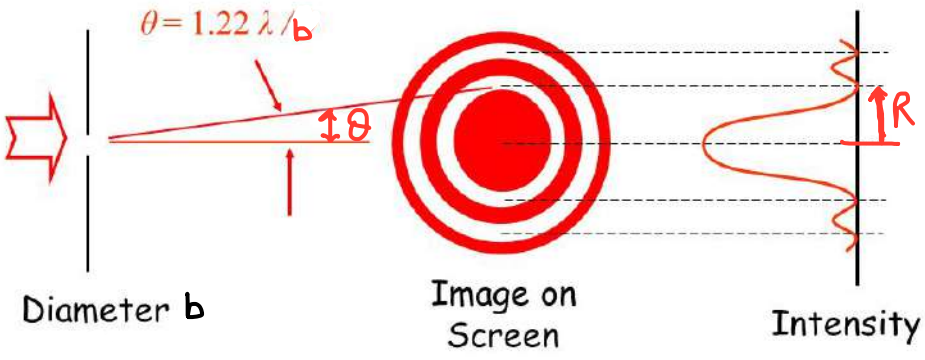
★ As Width Increases, Width of CM decreases and intensity Increases $\frac{2\lambda D}{a}$

Diffraction from Circular hole (Pin hole) (fraunhofer diffraction)





Diffraction through a **circular** aperture of diameter b



Radius of Central maxima

* $R = \frac{1.22\lambda D}{b}$, $\sin\theta = \frac{1.22\lambda}{b}$

D → distance b/w hole and Screen

b → diameter of hole

* Radius of image of point object formed by eye lens or lens of telescope

$$R = \frac{1.22\lambda D}{b}$$, diameter of image = 2R

here D is distance of image from lens

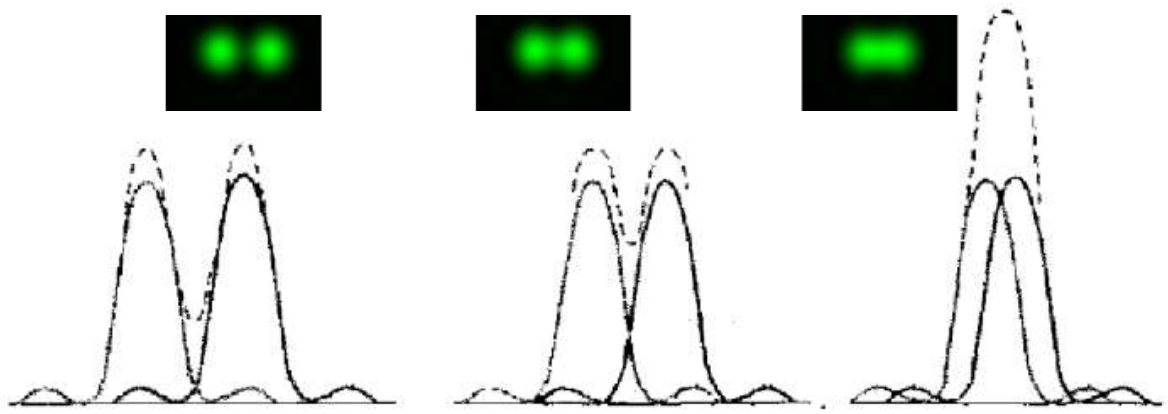
b ⟶ Aperture diameter of lens

Generally D for telescope is f

for eye D → distance b/w eye lens and ratina

LIMIT OF RESOLUTION

The fact that a lens forms a disc image of a point source, puts a limit on resolving two neighboring points imaged by a lens.



well resolved just resolved unresolved.

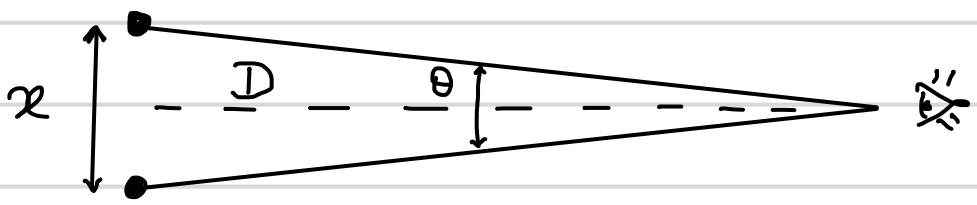
For two objects to be barely resolved, the angular separation between them should be at least:

$$\theta_R = \sin^{-1}\left(\frac{1.22\lambda}{b}\right)$$

minimum Angle resolved

$$\sin\theta = \frac{1.22\lambda}{b} = \frac{x}{D}$$

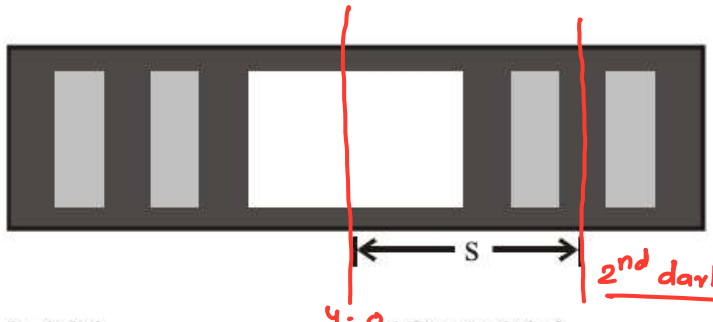
$$x = \frac{1.22\lambda D}{b}$$



b → diameter of eye lens
or diameter of telescope lens

75. Light of wavelength 600 nm is incident upon a single slit with width 4×10^{-4} m. The figure shows the pattern observed on a screen positioned 2 m from the slits. Determine the distance s.

तरंगदैर्ध्य 600 nm वाला प्रकाश 4×10^{-4} m चौड़ाई वाली एकल स्लिट पर आपतित होता है। स्लिटों से 2 m दूर रखे पर्दे पर प्राप्त प्रतिरूप चित्र में दर्शाया गया है। दूरी s ज्ञात कीजिये।



$S = \frac{2\lambda D}{a}$

(A) 0.002 m (B) 0.003 m (C) 0.004 m (D) 0.006 m

Ans. (D)

Sol. θ for II dark fringe is $\frac{2\lambda}{a}$

$\frac{\lambda D}{d} \leftarrow \beta_1 \left\{ \text{YDSE} \right.$ 4000 Å, d = 1mm, D = 1m

$\frac{2\lambda D}{a} \leftarrow \beta_2 \left\{ \text{Single slit expen} \right.$ 4000 Å, a = 0.1 mm, D = 1m

$$\therefore \quad s = \left(\frac{2\lambda}{a}\right) D = \frac{2\left(600 \times 10^{-9}\right) 2}{4 \times 10^{-4}} = 0.006 \text{ m}$$

76. The image of a star (effectively a point source) is made by a convergent lens of focal length 1m and diameter of aperture 5.0 cm. If the lens is ideal and the effective wavelength in image formation is taken as 5×10^{-5} cm, the diameter of the image formed will be nearest to:

(A) zero (B) 10^{-6} cm (C) 10^{-5} cm (D) 10^{-3} cm

Ans. (D)

Sol. $R = \frac{1.22\lambda D}{b}$ → f

$$\Rightarrow \text{Diameter} = 2\left(\frac{1.22 \times 5 \times 10^{-7} \times 1}{5 \times 10^{-2}}\right) = 2.44 \times 10^{-5} \text{ m}$$

$$= 2.44 \times 10^{-3} \text{ cm}$$

D → f

Q. find minimum distance b/w two point objects which are at distance 10m from eye, for which eye can see both objects seperatly

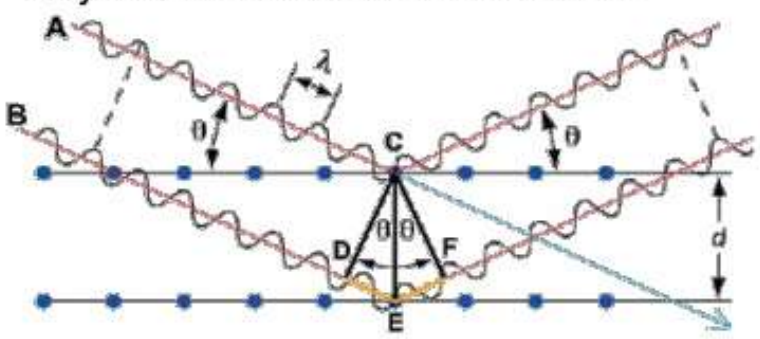
$\lambda = 550nm$, eye lens diameter = 5mm

Soln

$$x = \frac{1.22\lambda D}{b} = \frac{1.22 \times 550 \times 10^{-9} \times 10}{5 \times 10^{-3}}$$

Bragg Law

- Bragg considered crystals to be made up of parallel planes of atoms. Incident waves are reflected specularly from parallel planes of atoms in the crystal, with each plane reflecting only a very small fraction of the radiation



$$EF = d\sin\theta$$

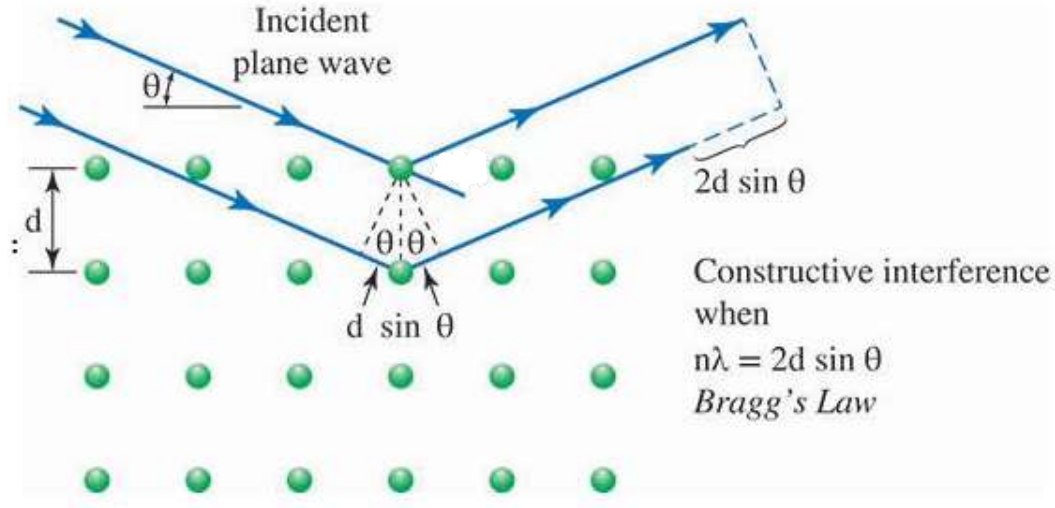
$$DE = d\sin\theta$$

$$DE + EF = 2d\sin\theta$$

$$n\lambda = 2d\sin\theta$$

- **Co**nstructive interference of the radiation from successive planes occurs when the path difference is an integral number of wavelenghts. This is the Bragg Law.

Bragg's Law is used to describe the scattering of X-rays from the atoms of a crystalline solid. The angle of diffraction is related to the angle and wavelength of the incident X-ray beam as well as the spacing between planes of atoms that comprise the solid, referred to as the *d-spacing*.



Path difference

$$\Delta x = 2d\sin\theta = 2d\cos i$$

$\theta \rightarrow$ angle with surface

$i \rightarrow$ angle of incidence

for Constructive interference

$$2d\sin\theta = 2d\cos i = n\lambda$$

* Shows Same pattern for both light (x-Rays) and high speed electron beam if

$$\lambda_{light} = \lambda_{electron} = \frac{h}{\sqrt{2m\,k.E.}} = \sqrt{\frac{150}{V}}\,\text{Å} = \frac{12.27}{\sqrt{V}}\,\text{Å}$$

accelerating voltage

$$\lambda_{light} = \frac{12400\,\text{Å}}{E} \rightarrow \text{Energy of photon in ev}$$

$k.E_e = 50\text{eV}$

$V = 50$

59. A nickel crystal is used as a diffraction grating for x-rays. Then the same crystal is used to diffract electrons. If the two diffraction patterns are identical, and the energy of each x-ray photon is E = 20.0 kev. What is the kinetic energy of each electron?

एक निकल क्रिस्टल को x-किरणों के लिये विवर्तन ग्रेटिंग के रूप में प्रयुक्त किया जाता है। इसी क्रिस्टल का उपयोग इलेक्ट्रॉनों के विवर्तन के लिये किया जाता है। यदि दोनों विवर्तन प्रतिरूप एकजैसे हो तथा प्रत्येक x-किरण फॉटोन की ऊर्जा E = 20.0 kev हो तो प्रत्येक इलेक्ट्रॉन की गतिज ऊर्जा होगी ?

Ans. 391 eV

Sol^n

$$\lambda_{light} = \lambda_{electron}$$

$$\frac{12400\ \text{Å}}{20\times10^3} = \frac{12.27\ \text{Å}}{\sqrt{V}}$$

$V = 391$ volt $\Rightarrow$ K.E of electron = 391 eV