SYLLABUS (SECOND SEMESTER)

Unit 1 :- Geometric optics

Aberrations in lenses - Chromatic Aberration - Achromatic combination of lenses - Monochromatic defects - Spherical aberration Astigmation ; coma ; curvature & Distortion - Minimising aberration.

Unit - 2 :- Interference

The Superposition Principle, condition for interference, classification of interference methods - Youngs double slits experiment - Theory, Intensity in interference pattren, phase change on reflection, Lloyds single mirror, interference due to plane llel wedge shaped films, colours in thin films, Newton rings, Determination of wavelength of light using newton's ring.

Unit - 3 :- Diffraction

Fresnel & fraunhoffer diffraction phenomena, Difference b/w interference & diffraction, Fraunhoffer diffraction of single slit, Diffracting grating, Determination of wavelength of light using grating, limits of resolution for telescope & microscope, Zone plate - construction & its composition with convex lens.

Unit - 4 :- Polarization

Polarized light, production of plane polarized light by reflection, Double reflection ; Brewster's law ; Malus law ; Nicol prism ; Nicol prism as Polarizer & analyzer. Quater wave plate, Half wave plate, production & detection of plane, circularly & elliptically polarized light ; optical activity, detection of specific rotation by Laurent's half shade polarimeter

Unit - 5 :- Lasers & Fiber optics

Lasers - characteristics ; stimulated & spontaneous emission, population inversion ; laser principle ; Ruby laser ; He-Ne laser, Applications of lasers, introduction to fibres (Different types of fibres ; principles of fiber communication [illegible] treatment only) Advantages of optical fibre communication

2/06/22

Wave optics.

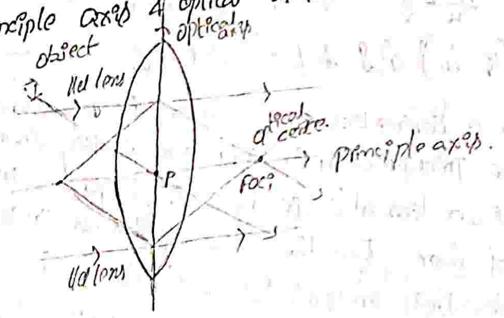
* Image formed by reflection.

lens :
- () - convex
-)(- concave
- D - convex
-](- concave.
- D) - concave & convex

Fundamentals :-
* Principle axis
* optical axis
* foci (F)
* Focal length (f)
* Radius of the curvature (R)
* optical centre (P)
* object distance (u)
* virtual /image distance (v)

Rule for formation of image.
* ||el rays should passes through foci.
* Rays pass through optical centre, it doesn't deviate.

=> Principle axis & optical axis.



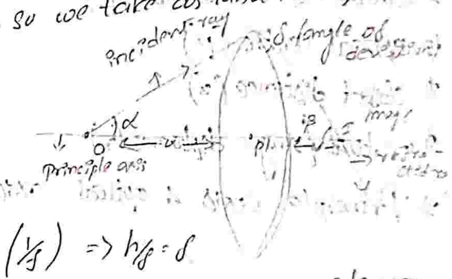
Aberration :
occured by 2 ways ;
* due to light (chromatic aberration)
* due to optical system (Monochromatic aberration)

Aberration
- C.A
  - longitudinal CA
  - lateral CA
- M.C.A
  - Sperical abberation (v+)
  - CoMA
  - curvature
  - Distortion.
  - Astigmatism.

* For minimize aberration is done by
1. Achromatic doublet.
2. contact.
3. Distance.

Deviation produced by thin lens :

* α, β angles are very small. so we take as $\tan\alpha$ & $\tan\beta$.



$\alpha = \tan\alpha = \frac{AP}{PB} = \frac{h}{-m}$

$\beta = \tan\beta = \frac{AP}{PI} = \frac{h}{v}$

$\delta = \alpha + \beta = \frac{h}{-u} + \frac{h}{v}$

$\delta = h\left(\frac{1}{v} - \frac{1}{u}\right) \Rightarrow \delta = h\left(\frac{1}{f}\right) \Rightarrow h/f = \delta$

Consider a convex lens as shown in the fig. Consider an object 'O' on the principle axis, the light ray coming from the object incident on lens at a point 'A' with height 'h'. Incase of lenses is not there then the light ray travels in straight line along the directions on 'OA'. But due to the presence of the lens the light ray refract in the lens & forms an image at a point 'I' on the principle axis on the other side of lens. Consider the angle b/w the line 'OA' & the refracted ray is 'δ'. This angle is known as angle deviation.

Let us consider the angle b/w incident ray & principle axis is α & the angle b/w refracted ray and principle axis is β. Now we consider object distance is '-u' & image Distance is (v) from the optical centre of the lens.

from the fig:-

$\delta = \alpha + \beta \longrightarrow ①$

Since α & β are very small, then we write as $\alpha \simeq \tan\alpha$ & $\beta \simeq \tan\beta$.

from ΔAOP & ΔAIP, we can write as

$\alpha \simeq \tan\alpha = \frac{AP}{PO} = \frac{h}{-u}$ | $\beta \simeq \tan\beta = \frac{AP}{PI} = \frac{h}{v}$

Sub the above α, β value in eq ①

$$\delta = \frac{h}{-u} + \frac{h}{v}$$

$$\delta = h\left(\frac{1}{v} - \frac{1}{u}\right)$$

$$\delta = h\left(\frac{1}{f}\right) \quad \left[\because \frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right]$$

$$\boxed{\therefore \delta = \frac{h}{f}}$$ from this $\delta \propto h$

$\delta \propto \frac{1}{f}$

ABERRATIONS

* The deviation from the actual size, shape & position of an image produced by a lens are called ABERRATIONS.
* These aberrations are caused mainly
  * Due to light (C.A)
  * Due to optical system

1) Due to light:- If the light is non mono chromatic, then the image becomes multi coloured. This defect is known as chromatic aberrations.

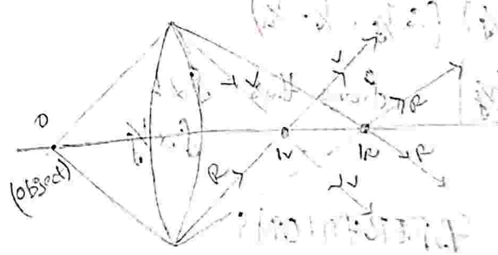
2) Aberrations occur due to optical system:- If the light is monochromatic (Na lamp) several defects in the shape of image are formed. This defect is known as monochromatic aberrations.

Chromatic aberrations:- The image of which object is formed by a lens is multicoloured / Blurred. This defect is known as chromatic aberration. These are 2 types.

* longitudinal chromatic aberrations (change occurs in position)
* lateral chromatic aberrations (change occurs in shape)

1) Longitudinal chromatic aberrations:- The formation of images of different colours in different position along the principle axis known as longitudinal ch. ab.

example:-



* A white object 'O' is placed on the principle axis of the lens. The violet & red coloured images formed at I_V & I_R respectively a along the principle axis as shown in above fig.
* The distance b/w I_V & I_R is a method of longitudinal C.A.

$$\boxed{\therefore LGCA = I_R - I_V}$$

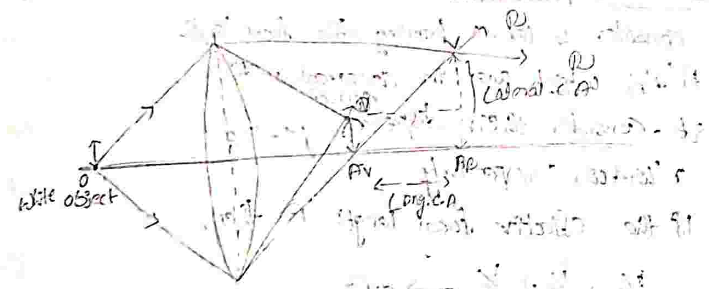
② Lateral chromatic aberration :-

* The formation of images of different colours formed of different sizes. This defect is known as L. C. A.

* From the fig, a convex lens and an object 'AB' placed infront of the lens. The lens forms the image of an object 'AB' as 'B_vA_v' & 'B_RA_R' respectively in violet & red colours, the image of other colour lies b/w them.

∴ The distance difference is $B_RA_R - B_vA_v$ is measured of L.C.A

∴ $\boxed{\text{Lateral C.A} = B_RA_R - B_vA_v}$

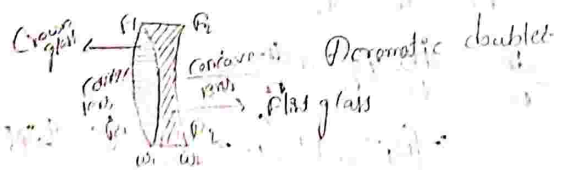


Conditions of Chromatic aberrations :-

Acromatic Doublet / Acromalet :-

Minimization / removal of chromatic aberration known as Acromalet.

⇒ Suitable combination of convex lens & concave lens &, cancel ... are called AD / Acromalet by free from chromatic aberrations. such combo is called AD / Acromalet



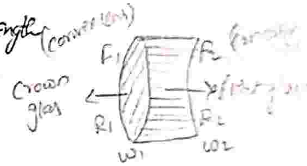
When white light is incident on convex lens the blue / violet enter into the lens then red image with a concave lens the image with a concave lens.

red image will enter into the lens than blue image. This says that if suitable concave convex lenes are combined. Then the dispersion produced by one can be cancelled by other lenses and bringing all colours approximately focus point. such combinations is called Acromatic aberration.

To achieve acromatic doublet the convex lens is of crown glass (with low dispersion & high focal length & then lens is made up of flint glass (with high dispersion & low focal length) are used.

Conditions (Acromatism when two lenses are in contact) :-

Consider 2 lenses having the focal length 'F_1' & 'F_2' which are in contact with it. Consider their dispersive powers 'ω_1 & ω_2' respectively.



If the effective focal length 'F', then,

$$\frac{1}{F} = \frac{1}{F_1} + \frac{1}{F_2} \longrightarrow eq①$$

Differentiate eq ①, we get

$$d\left(\frac{1}{F}\right) = d\left(\frac{1}{F_1} + \frac{1}{F_2}\right)$$

$$\frac{-dF}{F^2} = \frac{-dF_1}{F_1^2} + \frac{-dF_2}{F_2^2}$$

$$\frac{dF}{F^2} = \frac{dF_1}{F_1^2} + \frac{dF_2}{F_2^2}$$

$$\frac{dF}{F^2} = \frac{dF_1}{F_1} \times \frac{1}{F_1} + \frac{dF_2}{F_2} \times \frac{1}{F_2}$$

$$= \left(\omega_1 \times \frac{1}{F_1}\right) + \left(\omega_2 \times \frac{1}{F_2}\right) \quad (\because \text{Dispersive power of lens } \omega = dF/F)$$

$$= \frac{\omega_1}{F_1} + \frac{\omega_2}{F_2} \rightarrow eq②$$

But $dF = 0$ (i.e condition for achromatic doublet);

$\Rightarrow \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$

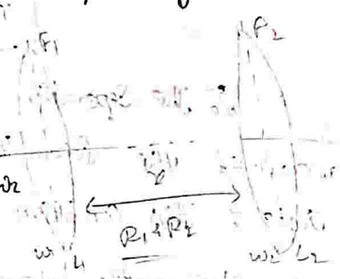
$\Rightarrow \frac{\omega_1}{f_1} = \frac{-\omega_2}{f_2} \Rightarrow \frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2}$

$\therefore$ The dispersive power of the two lenses are always +ve. Hence to satisfy the above condition 'f_1 & f_2' must be of opp signs.

i.e one convex lens & other one is concave lens.

Conditions (Acromatism when 2 lenses are depended by a distance).

Consider 2 lenses having their focal length 'f_1 & f_2' which are separated by a distance 'x' on the principle axis. Consider their dispersive power ω_1 & ω_2 respectively. If the effective focal length 'F' is



$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2} \rightarrow (1)$$

Differenciated on both sides.

$$-\frac{dF}{F^2} = \frac{-df_1}{f_1^2} + \frac{-df_2}{f_2^2} - x\left(\frac{1}{f_1}\left(\frac{-df_2}{f_2^2}\right) + \frac{1}{f_2}\left(\frac{-df_1}{f_1^2}\right)\right)$$

$$-\frac{dF}{F^2} = \frac{-df_1}{f_1^2} - \frac{df_2}{f_2^2} + \left(\frac{x}{f_1}\frac{df_2}{f_2^2} + \frac{x}{f_2}\left(\frac{df_1}{f_1^2}\right)\right)$$

$$-\frac{dF}{F^2} = \frac{-df_1}{f_1^2} - \frac{df_2}{f_2^2} + \frac{x}{f_1 f_2}\left(\frac{df_2}{f_2}\right) + \frac{x}{f_1 f_2}\left(\frac{df_1}{f_1}\right)$$

$$-\frac{dF}{F^2} = \frac{-df_1}{f_1} \times \frac{1}{f_1} - \frac{df_2}{f_2} \times \frac{1}{f_2} + \frac{x}{f_1 f_2}(\omega_2) + \frac{x}{f_1 f_2}(\omega_1)$$

$$-\frac{dF}{F^2} = \frac{\omega_1}{f_1} - \frac{\omega_2}{f_2} + \frac{x}{f_1 f_2}(\omega_1 + \omega_2) \rightarrow (2)$$

But $dF = 0$ (condition for acromation).

$$-\frac{\omega_1}{f_1} = \frac{\omega_2}{f_2} + \frac{x}{f_1 f_2}(\omega_1 + \omega_2) = 0$$

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = \frac{x}{f_1 f_2}(\omega_1 + \omega_2)$$

$$\frac{\omega_1 f_2 + \omega_2 f_1}{f_1 f_2} = \frac{x}{f_1 f_2}(\omega_1 + \omega_2)$$

$$\boxed{\therefore x = \frac{\omega_1 f_2 + \omega_2 f_1}{\omega_1 + \omega_2}}$$

If 2 lenses are made with same mechanical material then

$\omega_1 = \omega_2 = \omega$.

$$x = \frac{\omega_1 f_2 + \omega_2 f_1}{\omega_1 + \omega_2} \Rightarrow x = \frac{\omega(f_1 + f_2)}{2\omega}$$

$$\boxed{x = \frac{f_1 + f_2}{\omega}}$$

$\therefore$ The seperation b/w 2 lenses must be equal to the mean of the focal length of 2 lenses.

Note :- This condition is used in Huygen's eye piece.

Mono Chromatic Aberration :-

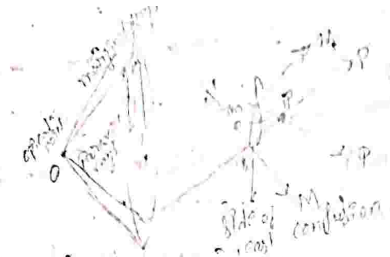
* These aberration are formed single wavelength colour light rays which are incident on a optical system.

Def :- The defects is observed in the image even though the light is monochromatic. This defect is known as monochromatic aberration.

* 5 types :-
  * Spherical aberresion.
  * COMA
  * Curvature of fields
  * Astigmatism
  * Dispotion.

1) Spherical aberresion :- The inability of the lens to form a point image on an axial point object is called spherical aberresion.

when a point 'O' is placed on the principle axis



of the lens: it is illuminated with monochromatic light. Then the rays which are incident nearer the incident rays (paraxial rays). come to focous at Ip & the rays which are incident far the axis (marginal rays) come to focus at Im.
& the rays which are incident far the axis come to focous in Im. When a screen is placed in b/w Im & Ip, then a circular disc is obtained. If the screen is moved b/w Ip & Im. The size of the disc is minimum in the position AB where. The paraxial & marginal rays crossed with each other. This is called as circle of least confusion.

⟹ Sperical aberation - can be classified in two types.

* Longitudinal spherical aberation - difference b/w Im & Ip. is a measure of longitudinal spherical aber.

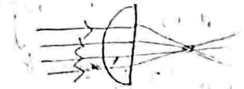
* Lateral spherical aberration - Radious of the circle of least confussion is measure of lateral spherical aber.

METHODS OF MINIMIZATION OF SPERICAL ABERRESIONS

* 5 methods:-
  * By using stops/slits:
  * By using 2 lenses in contact.
  * By using plano convex lens.
  * By using 2 plano convex lens. seperated by a distance
  * By using crossed lens.

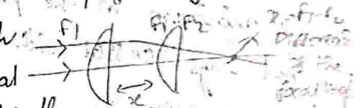
* By using stop/slits :- In this method either the marginal rays / paraxial rays are cut off by a stops/slits that means to stop either marginal / paraxial rays of lens.

* By using 2 lenses in contact :- In this method the sperical aberrations from convex lens is +ve and for concave lens is -ve lens by a suitable combination of convex & concave lens in contact. The sperical aberation can be eliminated.



* By using plano convex lens :- A specific aberation can be eliminated with a thin plano convex lens in such away that the curvature of the lens is facing the incident lens.

* By using plano concave lens one seperated by a distance:- When two plano concave lens which are seperated by a distance equal to the difference of their focal lengths. Then the combination can be eliminate spherical aberation completly.



* By using crossed lens :- It can be observed mathematically in case of lens. That it is satisfied the condition. This defect in the minimize.

$$\boxed{\frac{R_1}{R_2} = \frac{2\mu^2 - \mu - 4}{\mu(2\mu + 1)} = \frac{1}{6}}$$

Where R_1, R_2 are radious of the curvature of the lenses refractive index of the lenses.

∴ The lens satisfying this condition is known as crossed lens $\boxed{\mu = 1.5 \ \& \ \frac{R_1}{R_2} = \frac{1}{6}}$

27) COMA :-

Let us assume that the lens has made up of consi- ntric circular zones. The rays from point object A after passing through the different zones (1,1) (2,2) (3,3) etc. of the lens come. To focus at different points i_1, i_2, i_3 etc. as result - The point objects image look like conect. Hence, this operation is called COMA.

Reasons
Resonance :- * Different zones of the lens produced dif- ferent lateral magnification.

* Each zone forms the image of a point in the form a circle.

Elimination :- * Coma may be minimized by using suitable stops placed at a suitable distance from the lens. This restricts the outer zones & allow only the central zone to refract the face.

* Coma may be minimized by d/sg. assigning lenses of suitable shapes & materials.

Astigmation :- In the point object is placed very far to the principal axis of lens then the formed aberson is called Astigmation.

The plain containing the point object 'A' & the plain marginal plane $(m_1 m_2)$. The plane ⊥ to the meridial plane & containing the principle axis is called Asital plains.

The rays in the meridial plain $(Am_1 Am_2)$ & the rays in the plane, are focus form images at the point $m_1 s_1$ $(A S_1 A S_2)$

If the screen is moved b/w m & S then an irregular patch of the light formed.

At point C the image forms as a circle. This circle is called the circle of least confussion this circulation is called Sositic plane.

Elimination :-

* Astigmatism can be minimized by using a propare stops at suitable distance from the lens.

* Astigmatism can be minimized by suitable convex & concave lens is in contact.

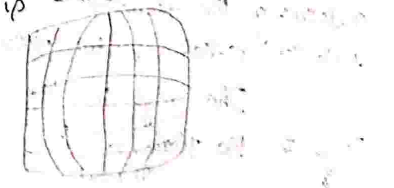
* Because astigmation convex lens is concave lens is negative this convex lens as astigmatism.

Distration :- The image of a square object placed ⊥ to the principle axis of lens is not the same that means its gets distracted. This defect is known as distraction.

This diffect argues due to the fact that the same lens produces different magnification for different forms is different.

* Distractions are two types :- * Parallel shaped distraction
* pin cusion shaped distraction

* Paralled Shaped distraction :- When the image of the rectangular object formed by convex lens look like ller shape image when this distraction is called llel shaped distraction



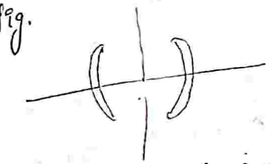
In this distraction, the magnification decreases with increasing axial distance from the centre of the lens.

* **Pin cushion shaped distraction:** When the image of the rectangular object formed by convex lens look like pin cushion shaped. This distraction is called pin cushion distraction.

In this distraction, the magnification increases with increasing axial distance from the centre of the lens.

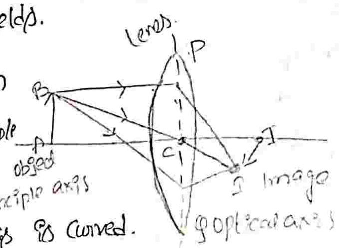
Removal of distraction:

* This defect can be minimized by using thin lenses.
* This defect can be minimized by using ortho scopic doublet. as shown in below fig.



Curvature of fields: The image of a extended plain object formed by the lens is in curved shape. This defect is called curvature of fields.

· From the fig, if a screen is placed at ⊥r to the principle axis of the lens, then the image II' will not be focused but this is curved. This defect is called curvature of field.



This defect arises due to fact that point away from the axis such as 2' are at greater distance from the centre c of the axial point A. there fore the image I' formed at a smaller distance I.

Removal of curvature: It can be minimized by using thin lenses, are 2 by using suitable stops 3. by using axial lenses 4 when to lenses placed. it should satisfy below condition

$$\boxed{\mu_1 f_1 + \mu_2 f_2 = 0}$$

* Unit :
LASER & FIBRE OPTICS.

LASER ⟹

L - Light
A - Amplification
S. Stimulated
E - Emission.
R - Radiation.

1960
TH Maymman
Red laser
(LASER) Ruby laser

Properties
* high coherence
* high directionality
* Mono chromaticity
* high intensity

laser :
In 1960, T.H. Maymman developed a first laser device it is often as Ruby laser. Ruby laser emit red light of 6943 A° wavelength

* The word LASER is an acronym stands for Light amplification by Stimulated Emission of Radiation.

Defination : laser is a device that generates an intense beam of coherent, mono chromatic, powerful, & collimeted beam of light.

Properties :
The most important features of lasers are * coherence.
* Mono cromaticity.
* Directionality.
* Intensity.

Coherence : In laser, electron transition occurs artificially i.e in Specific time. All the photons emitted from laser light Source have Same energy, Same frequency, Wavelength. Hence the light Waves of laser of Single wavelength are Colour. this property is called coherence.

Deffination : 2 Waves are prefectly coherence if they have Same/Constant phase difference & Same frequency

Directionality : In lazer light all photons will travel in same direction. There fore lazer light emits light in only one direction. This is called Directionality of lazer light.
The width of lazer beem is narrow. Hence a lazer beem travels to long distance without Spreading.
eg : If an ordinary light travels a distance of 2km on it splits about 2km in diameter. On the other hand, a lazer light travels a distance 2km it splits the diameter 2cm.

20/07/2022

Mono chromaticity (Single colour) : In lazers all protons emit from same set of energy levels in different atoms hence the lazer light maintains constant wavelength & frequency, this property is called Mono chromaticity.

Intensity : In a lazer beam has very narrow width. almost all of its energy is highly concentrated into a small region. Hence lazer light has greater intensity. When compared to ordinary light.
eg : If you look at a 100 Watt bulb from a distance of 50cm the power entering your eye is less than 1/1000 of a watt. If we at 1 watt lazer directly from a distance of 50cm then all the power from lazer beem would enter into your eye. ~~~ even a one watt lazer beam would appear many times 1000 times more intense than bulb

Applications of lazer light :

lazer light has various unique properties such as coherence, Monochromaticity, Directionality, intensity because of these lazer's are used in various applications

\# lazers in Medicine :

→ used for bloodless surgery.

→ used for destroying stones in kidney.

⇒ used in Cancer diagnosis and therapy.

⇒ used in fibre optics, endoscope to detect ulcers in instintes.

⇒ used to remove tumors.

→ used in cosmetic treatment such as acne treatment, ... treatments etc.

\# lazers in Science & technology :

⇒ with the help of lazer, to count the no. of atoms in a substance

⇒ used in computers to retrive & store information from a C.D.

⇒ used to measure the pollutant gases of the atmosphere.

⇒ used in computer Pendrives printers

⇒ used for detecting earth quakes & under water nuclear blasts.

\# lazers in Military :

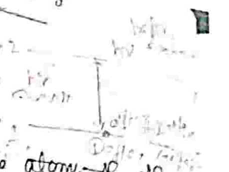
\# lazer range finders are used to distance to an object.

⇒ used as a Screetive illuminators for reconnations during night with high precaisions.

⇒ used to dispose the energy of a warhead the missiles by damaging

⇒ used in 'LIDARS' to apparently measure the distance.

Stimulated absorbtion / Induce absorption :



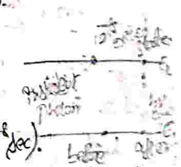
Let us consider 2 energy states E_1 & E_2 of an atom let before absorbing the atom is said to be groun dstate (E_1). If an amount of energy $h\nu$ is given to the atoms, then the electron absorbs that energy & goes to E_2 state is called excited state. This absorbtion of energy is stimulated absorption / induced absorption.

* The electron stay in the exited state for 10^{-8} sec. This time is called life time of exited state.

Emission of radiation : When electron jump from exited state (E_2) to ground state (E_1), then an atom emits some of its energy $(E_2 - E_1) = h\nu$. This is called emission of radiation.

* 2 types: → Spontaneous emission. → Stimulated emission.

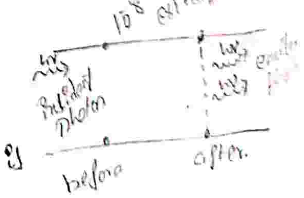
1) Spontaneous emission :



We know that electron cant stay in exited state(E_2) more than its life time (10^{-8} sec). So, it takes transition from state E_2 to ground state E_1 on its own by emitting energy $\boxed{E_2 - E_1 = h\nu}$. This process is called spontaneous emission of radiation.

Defination : Emission of radition from exited state to ground state with out an external influence / force.

2) Stimulated emission :



We know that an average life time of an atom in E_2 state is

10^{-8} sec. During this short ... of time ... photon of energy $h\nu$ is incident on the atom as shown in above fig. Also an atom jumps to lower state by emitting an additional photon of same frequency ($h\nu$). Hence 2 photons have same phase & same energy as that of incident stimulated photon. This process is called stimulated emission of radition.

Defination:- Emission of radiation from higher energy level / excited state to lower energy level / ground level caused by incident photons is called stimulated Emission.

$\boxed{Q}$

* The process of forced emission of photons caused by incident photon is called stimulated Emission.

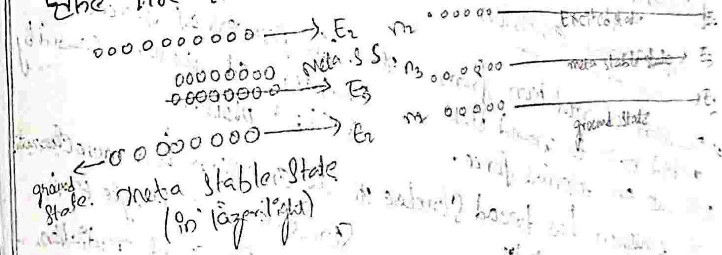
Differences b/w Sp.E & St.E

Spontaneous emission	Stimulated emission
* Emission of radition from excited state to ground state with out an external force.	* The process of forced emission of photons caused by incident photon.
* The emission has broad structure i.e many wave lenths.	* The emission has monochromatic structure i.e single w.l
* It is incoherent radiation.	* It is coherent radiation.
* " " has less intensity	* " has high intensity.
* " " " directionality & more angular spread.	* " " " directionality & less angular spread.
eg:- light from sodium vapour lamp / mercury vapour lamp.	eg:- light from lazer source.

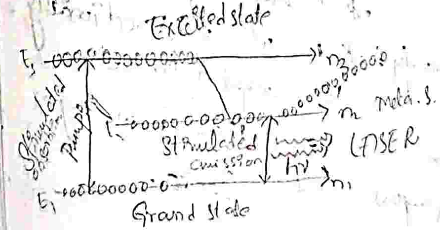
Population Inversion:- Making the no.of atoms in excited state (n_2) is more than no.of atoms in ground state (n_1) is population inversion. ($n_2 > n_1$)

* Process of achiving population inversion is called Pumping.
* There are different methods of pumping
  - ⇒ optical pumping (ruby lazer)
  - ⇒ electric discharge (He, Ne lazer)
  - ⇒ Direct conversion (Semi conductor lazer)
  - ⇒ Chemical Reaction (CO_2 lazer).

* In order to achive the population inversion, the electron should stay more time in the excited state, i.e more than 10^{-8} sec. This type of state is called (Meta Stable State). The life time of metastable state in order of 10^{-3} sec.



Principle of lazer:-



LASER can obtain in three steps:-
* Pumping.
* Population inv
* Stimulated emission.

Pumping :- Supplying energy $E_3 - E_1 = h\nu$ to the electron in ground state having energy E_1 sending them to the excited state having energy E_3, is called Pumping. It is nothing but stimulated absorption.

Population Inversion :- The electrons in excited state E_3 can't stay more time in that state so they come to metastable state E_2. By spontaneous emission. Here electrons stay more time in metastable state. So the population inversion occurs in E_2 & E_1 (i.e. $n_2 >> n_1$).

Stimulated Emission :- Here one of the electron in the metastable state E_2 transfer to ground state E_1 by spontaneous emission by emitting a photon of energy $(E_2 - E_1 = h\nu)$. This photon of energy triggers the other electron in meta stable state for stimulated emission & give lazer.

FIBRE OPTICS

01/08/2022

Intro :- Fibre optics is the fastest communication system in which trapa transparent dielectric medium act as transmission medium and light act as signal carrier.

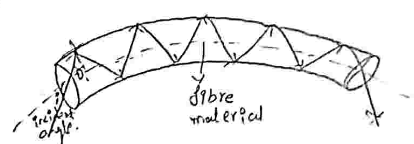
* Fibre optics is a technology related to transportation of optical energy. In guiding media specifically named as fibre optics.

* The communication through the optical fibre is called as light wave communication / optical communication.

Fibre optics :- The guiding medium to light is called optical fibre.

* optical fibre is a hair thin cylindrical fibre of glass / transparent plastic.

* principle :- optical fibres are based on principle of Total internal Reflection i.e optical fibre can transmit light from one end to other as a result of repeated total internal reflection.

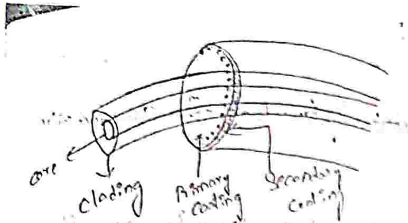


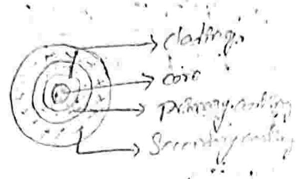
When the light is incident one end of the fibre & makes an angle 'ϕ' with the axis this ray incident on the boundry of the fibre with an angle of incident 'θ' more than its critical angle 'θ_c'. So, T.I.R's placed at the boundry. This type of T.I.R is repeated & the light ray reaches to the other end of fibre.

Structure of Fibre optics :-

* Fibre optics con optical fibre consists of 3 section

1) The core
2) The cladding
3) The outer Jacket





core : An optical fibre consists of inner cylinder made up of glass / transparent di electric material is called CORE. Light travels through this core, because it has high refractive index (μ_1). the diameter of core varies from micrometers (5 μm to 100 μm)

cladding : core is surrounded by a co-axial layer of low refractive index (μ_2) is called cladding. It helps the light to take total internal reflections in the core. Diameter of cladding is 125 μm

outer jacket : To provide strength & protection for the fibre, the two plastic coatings are given above the cladding & these are called Primary & secondary coating.

* Medical Sector < spectrophotometry / position sensing
* Communication < transmit telephone signals, internet communication / light cable television signals.
* Defense purpose < Immunity of electromagnetic interference, / The ability to span long distances without repeaters.
* INDUSTRIES < Welding application to cut steel for buildings.

ADVANTAGES OF FIBER OPTICS :

* A.O.F are very cheaper
* These communication is the fastest system than other communication system.
* As optical fibres are dielectrics. There is no for electric shock.
* The energy loss for unit lenth is very small in this communication.
* As they have very wide band width two many modes of sy signals can be transmitted.
* optical fibres are flexible and they are in light weight
* optical fibres are protected from interfacing with electro magnetic radiation.
* They can stand with from extream temparatures.
* Since the fibres are made of silica, Raw material avai availability is aboundent.

Types of optical fibres :

Optical fibres are classified into 2 different types

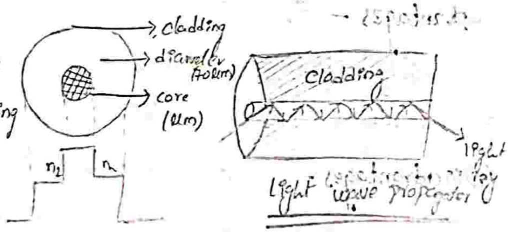
* Basing on modes of propagation. < SMF, MMF
* Basing on Refractive index of the core < Step index, Graded index

Basing on Modes of Propagation :

Basing on Modes of propagation m-the optical fibres are Converted into two types

* Single Mode fibre optics
* Multi mode fiber optics.

Single Mode Fiber optics - When only a single mode is transmitted through an optical fibre, then it is called as single mode fiber optics.

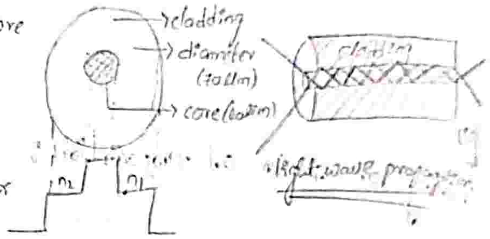


SMF has smaller core diameter (5um) & high cladding diameter (70um). The distance b/w the refractive index of the core & cladding is very small. But there is no depression, in this fiber light is used to the fiber through diode lasers.

Advantages - SMF can support only one mode of propagation. Hence this fibre optics are suitable for long distance communication such as telephone lines

Disadvantages - The fabrication of this fibre optics is difficult & costly.

Multimode fibre optics : When more than one mode is transmitted through an optical fibre then it is known as multimode fibre as shown in fig.



The MFO has larger core diameter 40m & cladding diameter is 70um. The difference in refractive index b/w core & cladding is relatively larger than in that of single mode fiber optics. This is known as multi mode fibre optics. MFO allows large no of modes for the light rays travelling through it. There is more dispersion due to multimode dispersion. In this fibre the light is passed into the fibre optics through LED source.

Advantages - Diameter of the core is high then propagation of light in the fibre easily.

* Fabrication is less difficult. So it is not costly.

Disadvantages - These are not suitable for long distance communication due to large depression & distrubances of the signal

Based on Refractive Index :

Based on Refractive Index the optical fibers are divided into 2 types.

* Step index fiber optics
* Graded index fiber optics

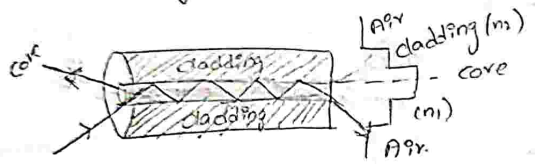
Step index fiber optics : When the refractive index of core, cladding & air in optical fiber vary step by step. Then the it is known as step index fiber optics

* It is again divided into two types

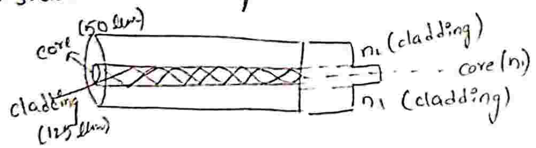
They are 2 types: * Step index single mode fiber optics.

* Step index multi mode fiber optics

a) **Step index single mode fiber optics:** In this fibre has a core diameter of 5 µm to 10 µm to 4 an external cladding diameter of 50 µm to 125 µm. The core has a uniform refractive index of cladding. The refractive profile & the light ray propagation in step index single mode fibre are shown below.



b) **Step index multi mode fiber optics:** In this fibre has a much longer core diameter, therefore more no. of modes of propagation of light can be possible. In this fibre has a core has diameter of 50 µm to 200 µm & the external cladding diameter of 125 µm to 300 µm. It has a core material with uniform refractive index & a cladding material of lower refractive index than that of core. The refractive index profile & ray propagation on step index multi mode fibre as shown in below fig.

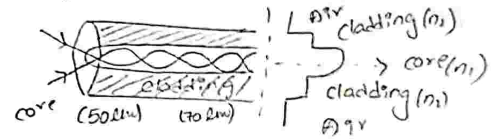


Advantages:
Relatively, easy to manufacture
cheaper than other types
longer life time than laser diode

Disadvantages:
* lower band width.
* High dispersion
* Smearing of signal pulse

Graded index fibre optics: If the core has a non uniform refractive index that gradually decreases from the centre towards the core cladding, these fibre is called graded index fibre optics.

Here the cladding has a uniform refractive index. The core & cladding diameters are about 50 µm & 70 µm respectively in case of multi mode. The light rays propagates through it in the form of skew or helical rays. The refractive index profile & the light ray propagation in the graded index fibres are shown below.



Advantages:
* Dispersion is low
* Band width is greater than step-index multi mode fibre.
* Easy to couple with optical source

Disadvantages
* It has very expensive
* very difficult to manufacture

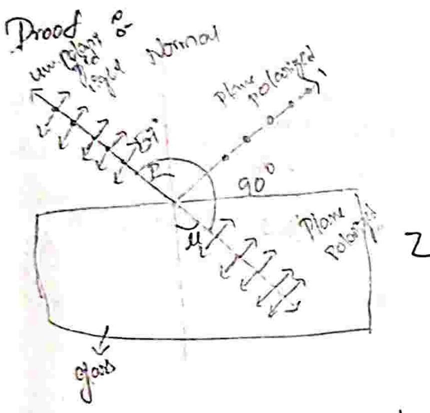
Methods of polarization :

Brewster Method / Polarization by reflection :

Statement :- The tangent of the angle of polarization (p) is numerically equal to the refractive index (μ) of the medium
i.e. $\boxed{\mu = \tan p}$.

This is known as Brewsters law. He also proved that the reflected & refracted ray are $\perp^r$ to each other.

Proof :



Let a beam of unpolarized light is incident on glass surface at polarizing angle as shown in fig. The polarizing angle of air medium is 57°. A part of light is reflected while a part is refracted.

From brewsters law $\boxed{\mu = \tan p} \rightarrow ①$

From Snell's law $\boxed{\mu = \frac{\sin p}{\sin r}} \rightarrow ②$

from eq ① & ②,

$$\tan p = \frac{\sin p}{\sin r}$$

$$\frac{\sin p}{\cos p} = \frac{\sin p}{\sin r}$$

$$\cos p = \sin r$$

$$\sin r = \sin(90° - r)$$

$$\boxed{r + p = 90°}$$

Hence reflected & refracted rays are at right angle to each other.

Polarization by double refraction :

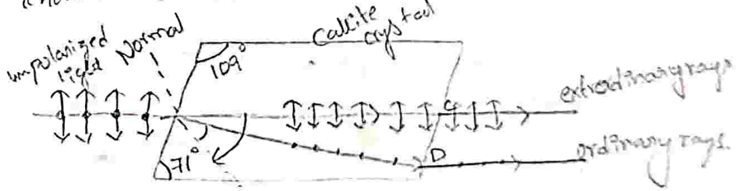
Statement : When a beam of unpolarized light is passed through a crystals like calcite / quartz / tourmaline etc, then the refracted light is split up into 2 refracted rays (i.e. ordinary rays & extraordinary rays). this phenomena is called Double refraction.

* The crystal showing this property is called double refracting crystal.

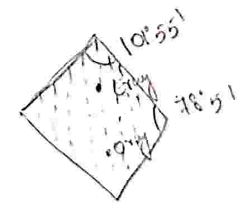
⟹ The refracted light ray which always obeys the laws of refraction having $\perp^r$ vibration is called ordinary ray. It travels with same velocity in all directions.

⟹ The refracted light ray which doesn't obey the laws of refraction having $\parallel$el vibration is called extraordinary ray. It travels with different velocities in different directions.

So, both rays are plane polarized. This phenomena is known as Double refraction.



Eg :



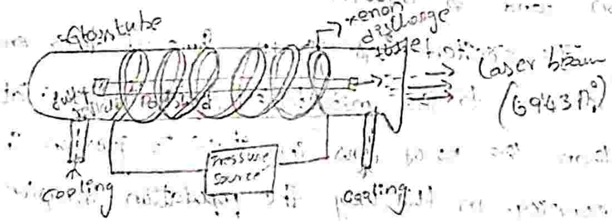
An ink dot is marked on a white paper & calcite crystal is placed over it. Now looking through the top of

The crystal as shown in fig 13 is the crystal is slowly rotated. Top of the crystal surface 2 images are observed as shown in fig b. If the crystal is slowly rotated, one of the 2 images remains stationary, whereas other moves round the 1st image. The stationary image is due to ordinary ray, the other image is produced by extraordinary rays.

Types of LASERS:

1) Ruby laser: The ruby laser is the 1st laser constructed & demonstrated by T.H Maiman in 1960.

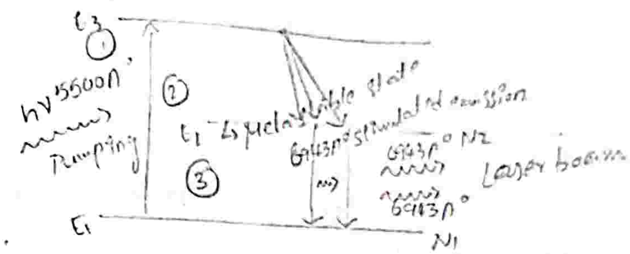
Ruby is a crystal of Al_2O_3 in which some aluminium (Al) atoms are replaced by chromium (Cr) atoms. The active material in the ruby is chromium ions (Cr^{+3}). When the ruby crystal contains about 0.05% Cr^{+} its colour is pink.



The experiment arrangement consists of a ruby rod of 10cm length & 1cm diameter. The end faces of the rod are made perfectly ||el & high polished. One end face is fully silvered & that it completely reflects. The opp face is partially silvered & it reflects partially. It is surrounded by a helical xenon flash tube which provides the light energy for pumping.

The only ... energy ... only a part of energy is used in pumping of Cr^{+} ions, while the remaining energy converts into heat. For this purpose a cooling arrangement is used.

Working:



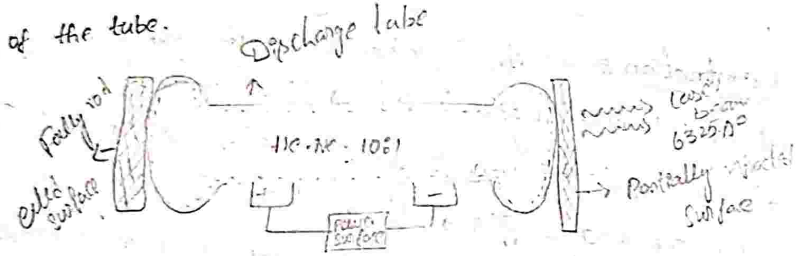
Ruby laser is a three layered laser. From fig E_1, E_2, E_3 representing energy of Cr^{+3} ions. In normal state the Cr^{+3} in lower energy level in E_1. When the ruby crystal is irradiated with xenon glass tube the Cr^{+3} are excited to upper energy level E_3, where the light absorption band is 5500 Å.

The excited ions give up some of their energy into the crystal & drop to the metastable state. It has relatively longer time than the no. of ions in state E_2 goes on increasing while due to pumping. In this way the population inversion established b/w metastable state (E_2) & ground state. When an ion passes spontaneously from the metastable state to ground state it emits a photon of wavelength 6943 Å. This photon travels through the ruby rod. It is reflected back and fro by the silver ends until it stimulates an excited atom. The excited atom emitting a photon & return to ground state. This emitted photon is same in phase with stimulated photon. This results in an amplifying laser beam with wavelength 6943 Å.

Helium - Neon laser : [He-Ne laser]

He-Ne laser was first successful gas laser & it is also a continous laser. It was built by W. Bennet, Harriot & Ali Javan in 1948. It consists of mixture of He-Ne in 10:1 ratio as a active medium.

Construction :- The gas laser consists of a discharge tube of length about 80cm & diameter of about 1.5cm. This tube is filled with the mixture of He-Ne in the ratio 10:1. A perfect reflector is placed at one end of the tube & a partial reflector is placed at the other end of the tube.



These 2 reflectors are perfectly parallel. Two electrods are inserted into the gas & connected to a power supply for electron discharge.

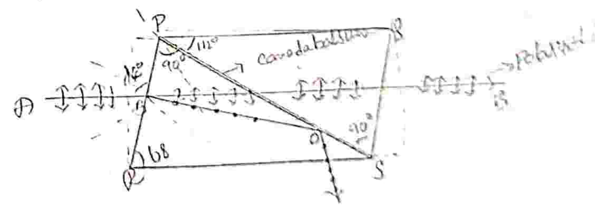
21/08/23

Nicol Prism

Principle :-
It is based on principle of double refraction. When unpolarised light is passed through a uniaxial crystal it splits up into plain polarised ordinary ray (O ray) & extordinory ray (E ray) using some methods. If one of the 2 rays is eliminated. The ray emerging through the crystal will be polarised.

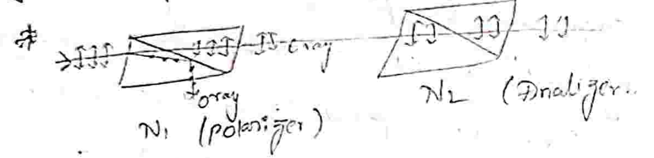
Construction :- A Nicol prism is constructed from calcite crystal whose length is 3 times than its breadth & angles in the principle section should be 68° & 112° then the crystal cut into 2 pieces plane ⊥ to the principle section. The surfaces are grounded & as well as & phases PR & PS. The surfaces are grounded & polished optically flat & then cemented together canada balsam ($\mu = 1.55$) lies b/w the refractive index of canada balsam ($\mu = 1.55$) lies b/w the refractive index of O ray ($\mu = 1.66$) & refractive index of E ray ($\mu = 1.49$). This material canadabalsum act as denser medium for E ray and rarer medium for O ray.

Construction is Nicol prism as shown below.

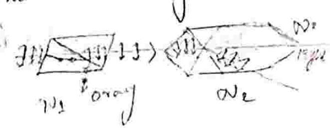


When a beam of light ray (unpolarized light) OB enters the plane PR, it is double refracted into ordinary polarized light ray as BO & extraordinary polarized light ray as BE. Where the ordinary ray is completely reflected Canada balsam surface, because it incident with an angle greater than 69° & is absorbed but E-ray is not totally reflected. Hence emerges from the crystal. Thus only E-ray is transmitted & polarised.

uses :-
Nicol prism act as a polarizer & Analizer.
#



When 2 Nicol prisms are arranged co-axially then the 1st Nicol prism produces plain polarized light is known as polarizer & 2nd Nicol prism analizes the polarized light & Hence it is known as Analizer. If the principle section 2 Nicols N_1 & N_2 ||el to each other as shown above fig then the E-ray is transmitted. ~~rotated~~ rotated. intensity of the second prism is gradually decreases & when 2 Nicols are at of E-ray is gradually ~~rotated~~ rotated. intensity $\perp^r$ to each other (90°) i.e they are in crossed position no light has comes from second prism hence the given light is examined through a rotating Nicols prism & it shows as a variation of intensity with minimum intensity is zero. The given light is plain polarized.



Mallus law

Statement :- The intensity of plain polarised light transmitted through analizer is directly proportional to sq. of the cosin of the angle b/w polarizer and Analizer.

i.e $\boxed{I_\theta \propto \cos^2\theta}$

Proof :- let OP be the 'a' be the amplitute of the incident plane from a polarizer. 'θ' be the angle b/w the polarizer & Analizer. From the fig. amplitude of the incident plain polarized light

can be resolved into two components. i.e $a\cos\theta$ ||lel to the plain of transmission of analizer & $a\sin\theta$ is $\perp^r$ to the component $a\cos\theta$ transmitted through the analizer.

i.e intensity of the that light is given by

$$\boxed{I_\theta = a^2\cos^2\theta} \rightarrow eq\ (2)$$

If 'I' be the intensity of incident polarized light then

$$\boxed{I = a^2} \rightarrow eq\ (1)$$

From eq (1), (2) we get,

$$I_\theta = I\cos^2\theta$$

$$\therefore \boxed{I_\theta \propto \cos^2\theta}$$

Hence, Mallus law is verified.

case 1 : When $\theta = 0°$, i.e 2 planes are llel. then, $\cos\theta = 1$

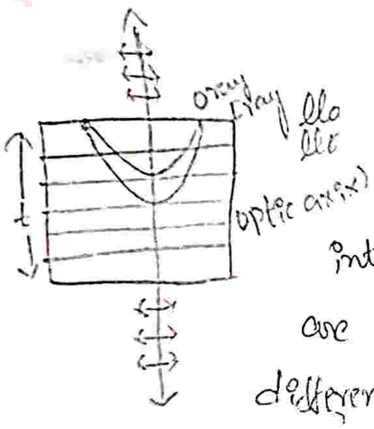
$\therefore \boxed{I_\theta = 1}$ (max intensity)

case 2 : When $\theta = 90°$, i.e 2 planes are $\perp^r$. then, $\cos\theta = 0$

$\therefore \boxed{I_\theta = 0}$ (low intensity).

Quater wave plate :

Defination :- If the thickness of crystal plate cut with faces parallel to optic axis, it introces a phase difference $\pi/2$ / path difference $\lambda/4$ then it is called quater wave plate.



Consider a calcite cut with optic axis llel to the surface when a plain unpolarised light falls normally on a uniaxial calcite plate, the light spits int O ray & E ray plain polarized light. they are travelling the same path with different velocities. The velocity of 'E' ray is greater than the velocity of 'O' ray. If 't' be the thickness of the plate, μ_o & μ_E are refractive inderes of ordinary & extordinary ray the path difference b/w O ray & 'E' ray.

$\Rightarrow \mu_o t + \mu_E t = (\mu_o - \mu_E) t$ $(\because \mu_o > \mu_E)$

For a quater wave plate this distance should be $\lambda/4$

$\therefore (\mu_o - \mu_e) t = \lambda/4 \Rightarrow \boxed{t = \frac{\lambda}{4(\mu_o - \mu_E)}}$

Half wave plate :-

Defination :