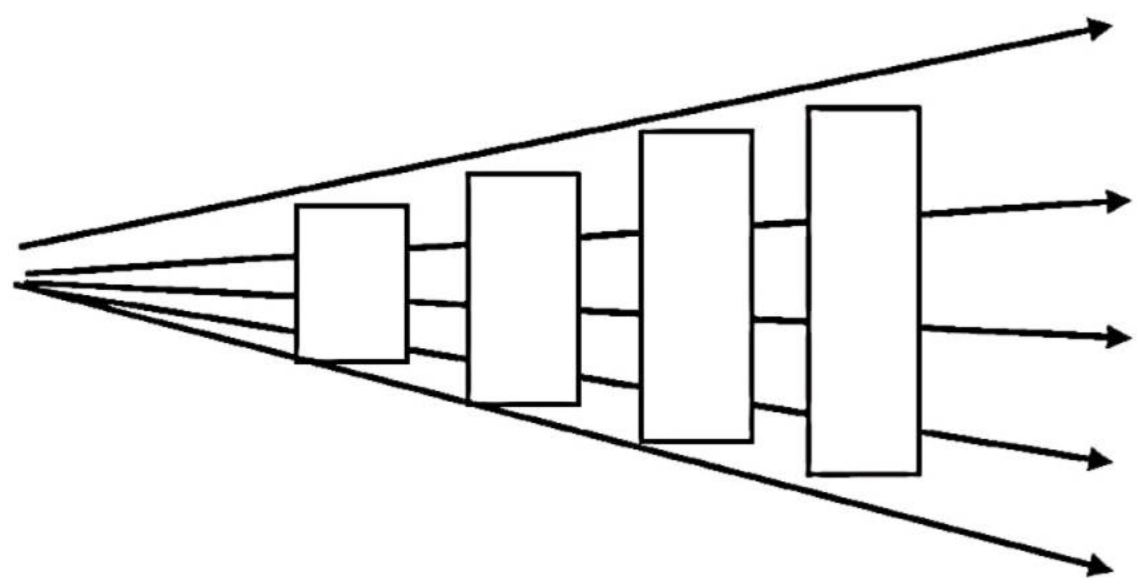
Chapter = 09

Nature of Light

THEORY NOTES

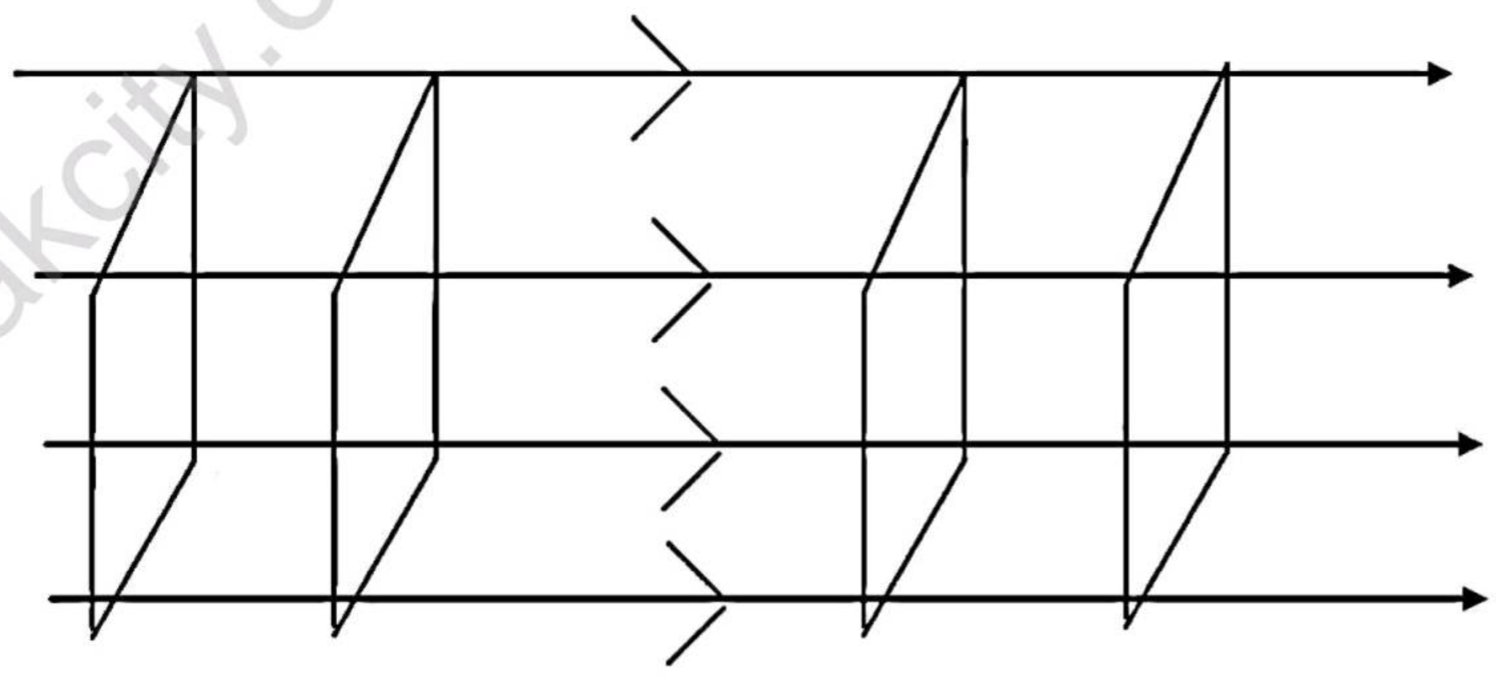
WAVE FRONT AND HUYGEN'S PRINCIPLE

WAVE FRONT:



Whenever a wave passes through a certain medium, its particles execute simple harmonic motion. The focus of at the points in the medium having same phase of vibrations is called a wave front.

In case of a point source of light in a certain homogenous medium the wave front will be concentric spheres with center as the source S. such a wave front is known as spherical a Wave Front.



At a very large distance from source, a small portion of a spherical wave front is nearly a plane, Such a portion of the wave front is called a plane wave front.

In case of light, a Ray is known as the direction in which a wave propagates and it is always normal to the wave front. Thus a please wave front represents a parallel pencil of rays.

HUYGEN'S PRINCIPLE:

Huygen's principle consists of two parts:-

(i) The first part states that every point on a wave front can be considered as a source of secondary spherical wave-lets.

(ii) The secondary wavelets travel with the speed equal to the source of wavelets.

In figure AB represents the position of a spherical front at a particular instant. To get the position of the new wave front after t second we take some points on the wave front AB, according to the first principle. If the wave travels a distance vt in time t sec, then draw the secondary wavelets with radius v t. By the second part of the principle draw a plane CD tangential to these wavelets, then CD will be the new wave front after time t.

INTERFERENCE OF WAVES:

When two waves superpose one another they either enhance the effect of one another or they reduce their effect at that point. This phenomenon is called interference of waves.

CONSTRUCTIVE INTERFERENCE:-

When two waves meet such that the crest of one wave coincides with the crest of other wave, and the trough of one wave coincides with the trough other wave, the resulting crests and troughs are enhanced. Such interference is called constructive interference. For constructive interference the path difference between them must be integral multiple of λ i.e.

$$Path\ difference = m\lambda$$

where $m = 0; \pm 1; \pm 2; \pm 3, \ldots$

DESTRUCTIVE INTERFERENCE:

When two waves meet such that the crest of one wave coincides with the trough of the other wave and the trough of one wave coincides with the crest of the other wave, the resulting crests and troughs are reduced. Such interference is called destructive interference. For destructive interference the path difference between them must be odd multiple of $\lambda/2$ i.e.

$$Path\ difference = (m + \frac{1}{2})\lambda$$

Where $m = 0; \pm 1; \pm 2; \pm 3 \ldots$

CONDITIONS OF INTERFERENCE OF LIGHT:

For interference of light the following conditions must be observed.

1. The sources of light must be monochromatic and coherent.
2. The slits must be narrow of the order of wavelength of light.
3. The slits must be separated by a small distance.

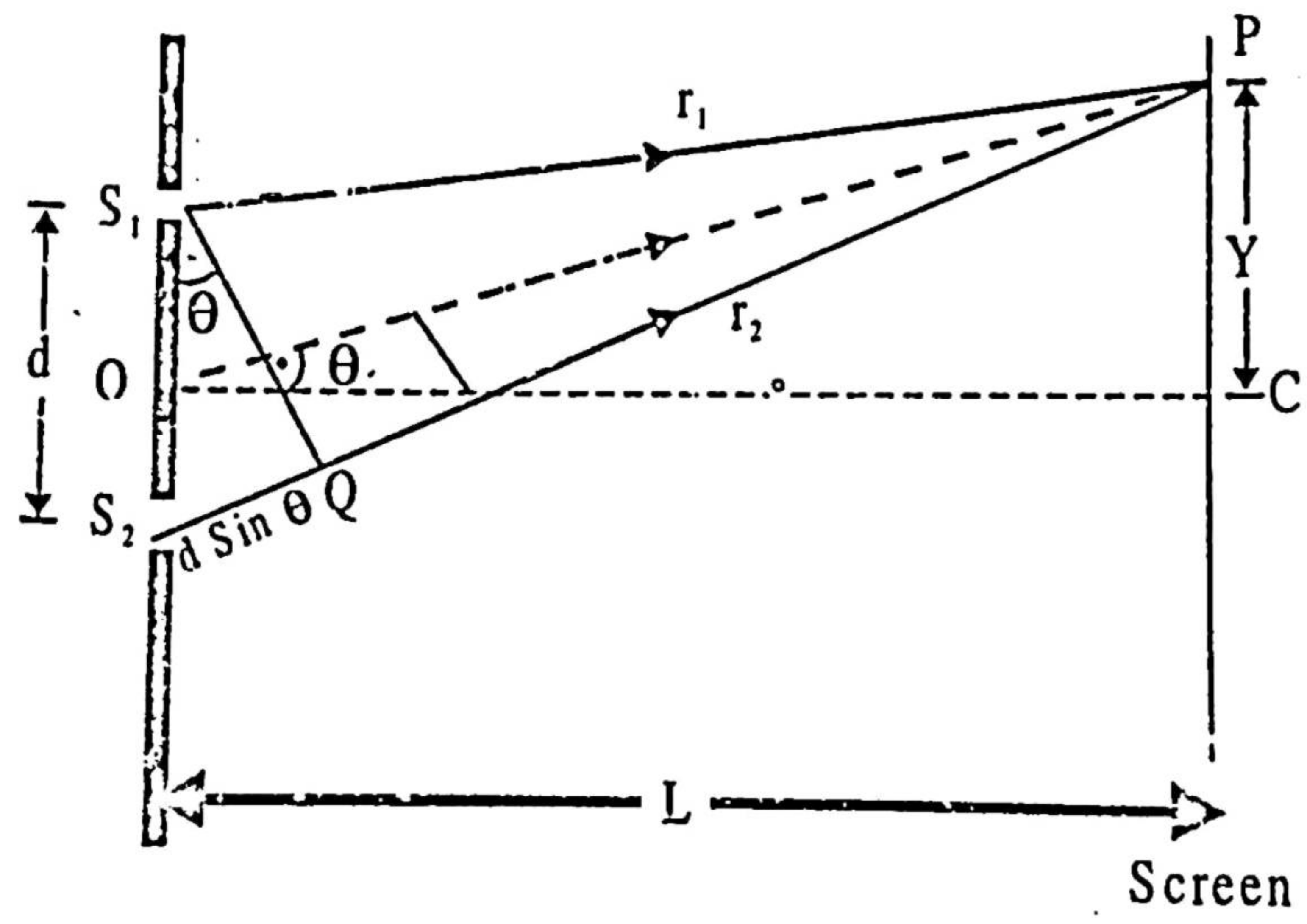
YOUNG'S DOUBLE SLIT EXPERIMENT

The fringes obtained by Young's double slit experiment are the result of interference of light waves. The conditions for interference are:

(i) Monochromatic light must be used.

(ii) The slits must be narrow of the order of wavelength of light and two sources of light must be coherent.

(iii) The two sources must be very close to each other is the wavelength of light is very small, otherwise the bright and dark pattern in front of the source would be two fine to see and interference pattern will be visible.



Light from a monochromatic source falls on the slits S and illuminate the two slits S_1 and S_2 separated by a small distance d. Since the light diverging from the slit S_1 has exactly the same frequency as the light diverging from S_2 act as two close coherent sources interference takes places at the screen placed at a distance L form the double slits.

If O be the central point on the screen then the path difference between S_1O and S_2O will be zero and the constructive interference will take place at O.

Waves traveling from the slit S_2 to any point P on the screen travel a distance $S_2P = r_2$ and from the slit S_1 travel a distance $S_1P = r_1$ the intensity of light at P will be the result of the superposition of the waves coming from S_1 and S_2. The path difference

Between the waves from S1 and S_2 is given by Path difference $= PS_2 - PS_1$

$= (r_2 - r_1)$

$= d \sin\theta$

IN CONSTRUCTIVE INTERFERENCE:

If the path difference is an integral multiple of λ, Constructive interference will take place at P. Hence for constructive interference.

$$d \sin\theta = m\lambda \text{ (Maxima)}$$

Where λ is the wave length of light used and m is the order of the fringe that is

$$m = 0, +1, +2, +3, +4, ...$$

The central bright fringe at $\theta = 0$ ($m = 0$) is called zero order maximum.

IN DESTRUCTIVE INTERFERENCE:

If the path difference is an odd multiple of λ, the waves arriving at P will be out of phase and hence Destructive interference will take place at P. for destructive interference.

$$d \sin\theta = (m + \tfrac{1}{2})\lambda \text{ (Minimum)}$$

$$m = 0, +1, +2, +3, +4, ...$$

The position of bright and dark fringes is measured from the central bright fringe. Since the distance L is very large from the slits as compared to the distance between the slits, hence the angle θ is very small. Thus for small angles.

$$\sin\theta \cong \tan\theta = Y/L \text{ (From the triangle } \Delta OQP)$$

Now,

Path diff. = d Y/L

POSITION OF BRIGHT FRINGES:

For bright fringes the path difference is given by

$$d \sin\theta = m\lambda$$

or $$d\,Y/L = m\lambda$$

or $$\boxed{Y = \frac{m\lambda L}{d}}$$

=> $$Y = 0, \frac{\lambda L}{d}, 2\frac{\lambda L}{d}, 3\frac{\lambda L}{d}, 4\frac{\lambda L}{d}, \ldots$$

These are the positions of bright fringes

POSITION OF DARK FRINGES:

For dark fringes the path difference is given by

$$d \sin\theta = (m+1/2)\lambda$$

or $$d\,Y/L = (m+1/2)\lambda$$

or $$\boxed{Y = \frac{(m+\frac{1}{2})\lambda L}{d}}$$

=> $$Y = \frac{\lambda L}{2d}, 3\frac{\lambda L}{2d}, 5\frac{\lambda L}{2d}, \ldots$$

These are the positions of dark fringes

FRINGE SPACING:

The distance between two dark or two bright fringes is called Fringe spacing. The fringe spacing Δx is given by.

The position of 1st bright fringe =0

The position of 2nd bright fringe $= \frac{\lambda L}{d}$

$$\Delta x = \frac{\lambda L}{d} - 0$$

or

$$\boxed{\Delta x = \frac{\lambda L}{d}}$$

If L, d and Δx are known the value of the wavelength λ can be calculated. The fringe spacing depends upon the wavelength of light used as L and d are constant for a given experiment.

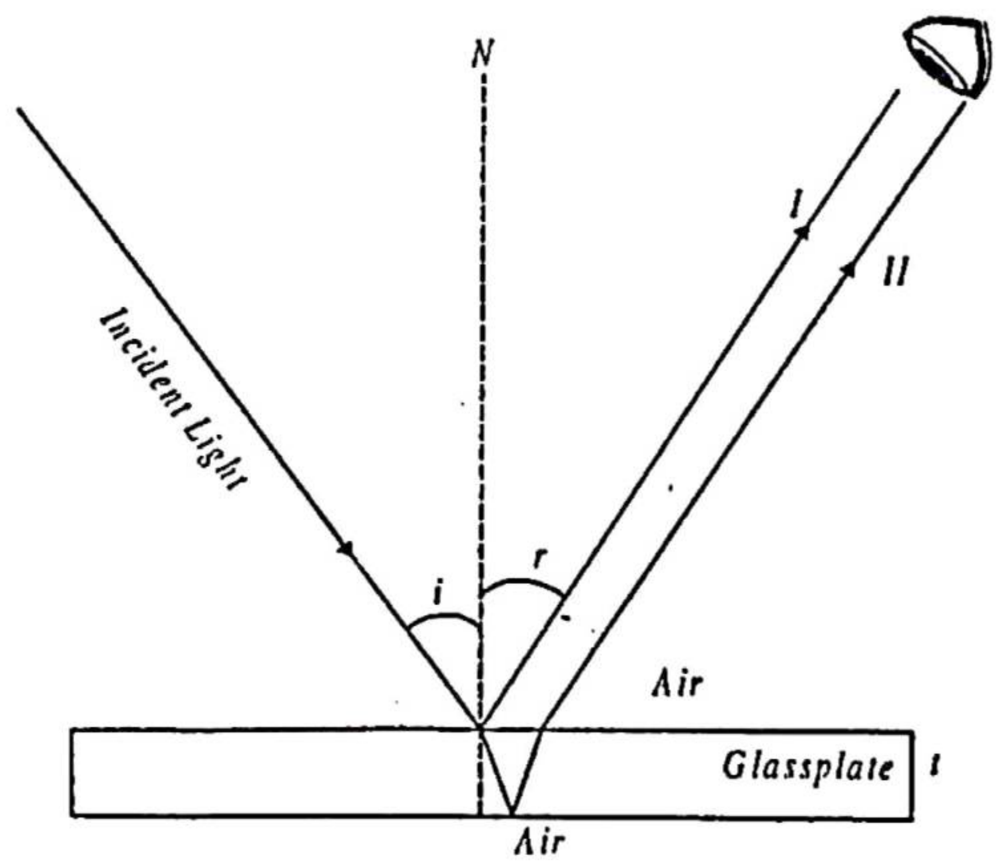
INTERFERENCE IN THIN FILM

Constructive and destructive interference of light waves is also the reason why thin films, such as soap bubbles, show colorful patterns. This is known as thin-film interference, because it is the interference of light waves reflecting off the top surface of a film with the waves reflecting from the bottom surface. To obtain a nice colored pattern, the thickness of the film has to be on the order of the wavelength of light.

Reflection of light waves, when light waves (transverse waves) strike at the boundary of a denser medium, the crest returns as a trough and the trough returns as a crest. There is a change in its phase by a or 180^o or a path difference of ½ λ. On the contrary when it strikes at the boundary of rarer medium, the crest returns as a crest and trough returns as a trough. There is no change in its phase. The wave length of light in a medium is changed by a factor. I/n if λ be the wavelength of light in air and λ_n be its wavelength in a medium of refractive index n, then.

$$\lambda_n = \frac{\lambda}{n}$$

When light falls on a film of a transparent medium of thickness then a part of the light is reflected from the upper surface of the film and the change in the path difference of ½ λt akes place (phase is reversed) Some of the light is refracted into the medium of the film, which is reflected from the lower surface of the film. Since it is reflected from the rare medium, hence there is no change is its phase (ray 1 and 2)If the light rays are normal incident on the film, then the path difference between ray 1 and 2 is "2t". where t is the thickness of the film.



Path difference = 2t

FOR CONSTRUCTIVE INTERFERENCE :

Due to the phase change of 180^0 the conditions for constructive and destructive interference are reversed. Therefore, for constructive interference

$$Path\ difference = (m + \frac{1}{2})\lambda_n$$

or $$2t = (m + \frac{1}{2})\lambda_n$$

or $$2t = (m + \frac{1}{2})\frac{\lambda}{n}$$

or $$\boxed{2tn = (m + \frac{1}{2})\lambda}$$

FOR DESTRUCTIVE INTERFERENCE :

Due to the phase change of 180^0 the conditions for constructive and destructive interference are reversed. Therefore, for destructive interference

$$Path\ difference = m\ \lambda_n$$

or $$2t = m\lambda_n$$

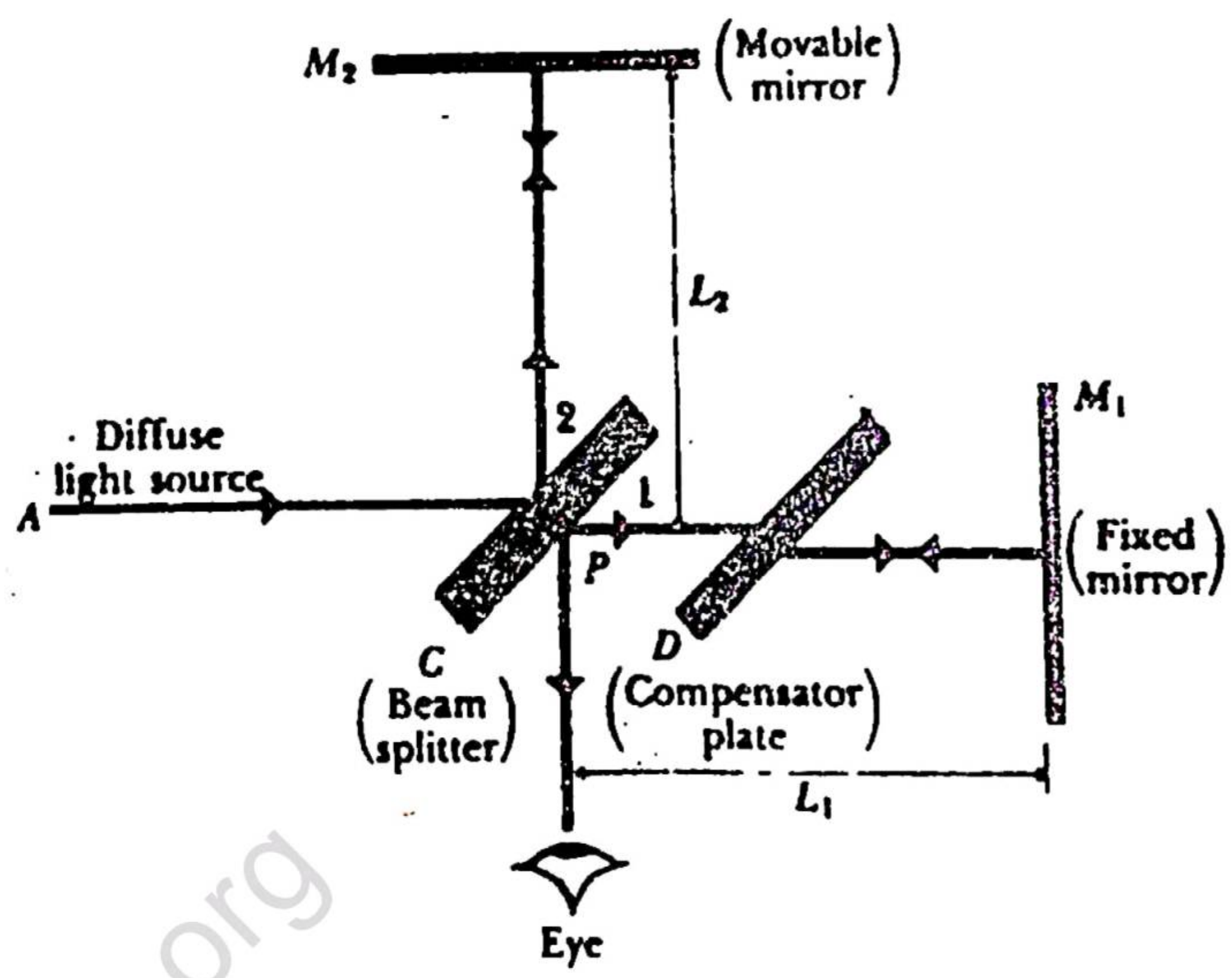
or $$2t = m\ \frac{\lambda}{n}$$

or $\boxed{2tn = m\lambda}$

MICHELSON'S INTERFEROMETER

INTRODUCTION:

Michelson's interferometer was invented by and American physicist A.A Michelson.In case of a Michelson's interferometer we use an extended source of monochromatic light in comparison with Young's double slit experiment where we use two narrow slits.Figure shows the principle diagram of Michelson's interferometer.



PROCEDURE:

Light from an extended source strikes the glass plate C the right side of which has a thin coating of silver. Part of this light is reflected from the silvered surface at P to the mirror M_2 and back through the silvered surface to the observer's eye. The remainder of the light passes through the silvered surface and through the compensator plate D and is reflected from the mirror M_2. It then returns through D and I reflected from the silvered surface of C to the observer eye. Both the plates C and D are of early same thickness so that the rays 1 and 2 through the same thickness of glass. The plate C is called beam splitters.

If the distances L_1 and L_2 are exactly equal and the mirrors M_1 and M_2 are not perpendicular then a wedge film will be obtained under this conditions the virtual image of M_1 and mirror M_2 behave as the two surface of a wedge shaped film. The interference fringes are obtained in the same way as in case of thin wedge shaped film.

CALCULATION OF WAVELENGTH :

Let the extended source be monochromatic of wavelength λ and the mirror M_2 is moved through $\lambda/4$, the path difference is changed by $\lambda/2$, and a dark fringe will appear in place of bright fringe. If now the mirror M_2 is moved through $\lambda/2$, the path difference is changed by λ and a dark fringe will replace a bright fringe. If the fringes are seen, through a telescope, and 'm' bright fringes pass through the cross wire when the mirror M_2 is moved through X then

$$x = m\frac{\lambda}{2}$$

Or $\boxed{\lambda = \frac{2x}{m}}$

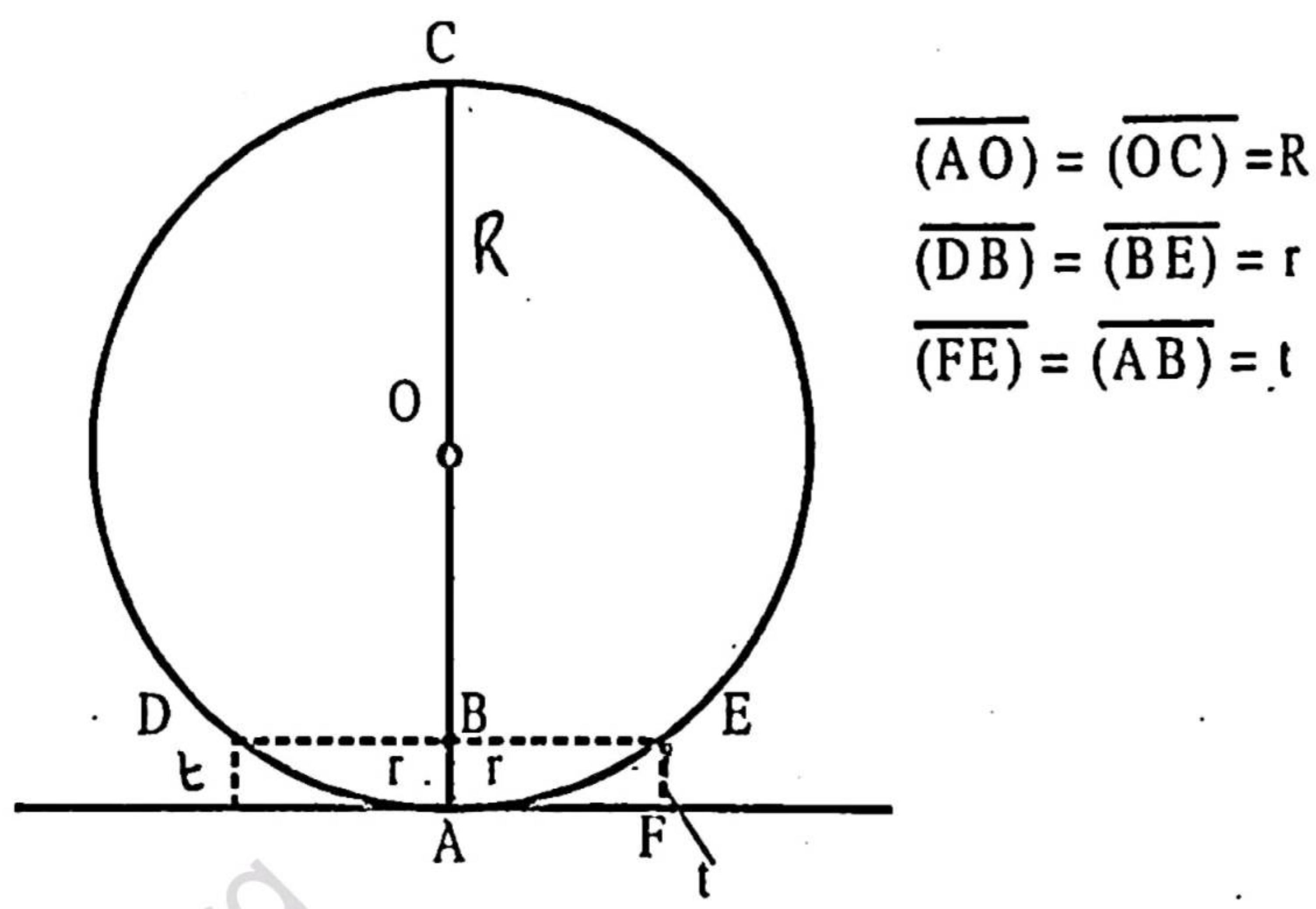
If m is large then X is also large and can be measured with good precision and hence a precise value of λ can be obtained.

NEWTON'S RINGS

DEFINITION:-

The principle of Newton's rings is based on the interference of wedge shaped film. A plano-convex lens is placed on a plane and smooth glass plate. An air film is enclosed between the lens and the glass plate. The thickness of the air film is zero at the point of contact 'A' and increase as we move outward.

Light is allowed to fall on the glass plate which is inclined at an angle of 45^0. The light is reflected from lower surface of the glass, plate and falls normally on the lens. After passing through the lens the light is reflected from the upper and lower surface of the air film. The light reflected from the upper surface of the air film, does not suffer while light reflected from the lower surface of the air film (upper surface of the glass) suffers a phase change of 180o (if the thickness of the air film is such that the path difference between ray No. 1 and Ray No.2 is an integral multiple of λ, destructive interference will take place at those points. If the thickness of the air film is such that the path difference between ray No.1 and Ray No.2 is an integral multiple of λ destructive interference will take place at those points. If the thickness of the film is such that the path difference between ray No.1 and Ray No.2 is an integral multiple of λ, destructive interference will take place at those points. If the thickness of the film is such that the path difference between ray No.1 and Ray No.2 is odd multiple of λ/2 constructive interference will take place at those point of contact, hence the interference fringes will be circular, (dark and bright circles) when seen through the reflected light, the center will be dark. These circles are called Newton's rings.



According to the geometrical theorem ,the product of intercepts of intersecting chord is equal to the product of section of diameter then,

$$\overline{BE} \times \overline{DB} = \overline{AB} \times \overline{BC}$$

$$r \times r = t(2R - t)$$

$$r^2 = 2Rt - t^2$$

As t is small then t^2 will be so small so that it can be neglected, then

$$r^2 = 2Rt$$

=> $t = \frac{r^2}{2R}$ --------(i)

FOR CONSTRUCTIVE INTERFERENCE:(BRIGHT RING)

The condition for constructive interference in thin film interference is,

$$2tn = (m + \frac{1}{2})\lambda$$

putting the value of "t" from eq(i),we get,

$$2\left(\frac{r^2}{2R}\right)n = \left(m+\frac{1}{2}\right)\lambda$$

$$r^2 = \left(m+\frac{1}{2}\right)\lambda R \qquad \text{(For air n=1)}$$

or $$r = \sqrt{\left(m+\frac{1}{2}\right)\lambda R}$$

For "Nth" bright ring

$$\boxed{r_N = \sqrt{\left(N-\frac{1}{2}\right)\lambda R}}$$

FOR DESTRUCTIVE INTERFERENCE:(DARK RING)

The condition for destructive interference in thin film interference is,

$$2tn = m\lambda$$

putting the value of "t" from eq(i),we get,

$$2\left(\frac{r^2}{2R}\right)n = m\lambda$$

$$r^2 = m\lambda R \qquad \text{(For air n=1)}$$

or $$\boxed{r = \sqrt{m\lambda R}}$$

In case of dark ring , for 1st dark ring m=1 because for m=0 , r=0.

DIFFRACTION OF LIGHT

According to geometrical optics when light falls on an opaque body it casts it shadow of the same shape, and

1. No light enters into the region of shadow and
2. Outside the shadow, the screen in uniformly illuminated

However, it is found when light falls on sharp edges and narrow slits, the light bends into the shadow showing that light can bend inside the geometrical shadows. "The bending of waves around the corners of obstacles, sharp edges or narrow slits is called diffraction".

There are two types of Diffraction.

i. Fresnel's Diffraction ii. Fraunhofer Diffraction

FRESNEL DIFFRACTION:

If the source of light and screen are at finite distance from the aperture, the diffraction obtained is called Fresnel diffraction.

FRAUNHOFER DIFFRACTION:

If the source of light and screen are at infinite distance from the aperture, the rays reaching the slit will be parallel to one another, and then the diffraction is called Fraunhofer diffraction.

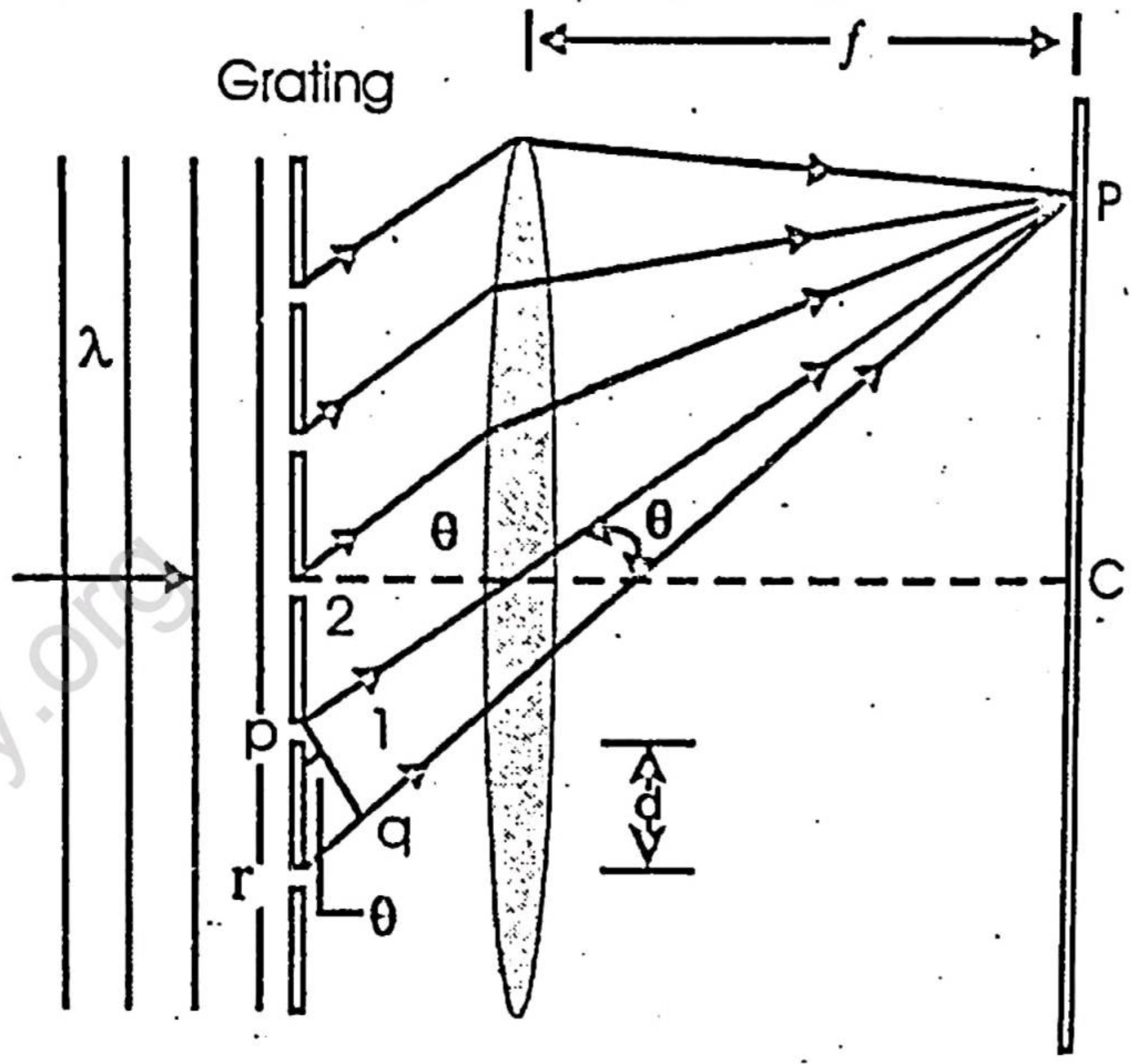
Fraunhofer diffraction can be obtained in the laboratory by putting a convex lens in between source and slit at a distance of its focal length from the screen to focus them on the screen.

DIFFRACTION GRATING

DEFINITION:

If instead of a single slit there are large number of slits parallel to one another with equal width, such an arrangement is called diffraction grating.A diffraction grating consists of a glass piece with a number of parallel opaque lines marked on it there is transparent portion which acts as slit. The distance between two lines on a grating is called grating element it is equal to the length of the grating divided by the number of lines on it, the grating element 'd' is given by

$$d = \frac{length\ of\ grating}{number\ of\ opaque\ lies}$$



In the figure if 'n' width of the opaque line and 'b' is width of the opening then grating element is given by.

$$d = (a + b)$$

EXPLANATION:

A diffraction grating is shown in the figure. A parallel beam of monochromatic light is normal incident upon it, which sends out waves from each slit. A convex lens is placed in the path of diffracted waves which bring them together at a point on the screen in a certain direction waves of particular wavelength which are in phase reinforce each other and focus at a point in chase of white light.

If the parallel rays of light after diffraction differ in path difference by λ, they will interfere constructively at P.

For constructive interference the path difference between any two adjacent rays must be zero or an integral multiple of λ.

Path difference = $m\lambda$

$(a + b)\sin\theta = m\lambda$

or $d\sin\theta = m\lambda$

The central maximum has a path difference equal to zero, hence it is called zero order.

The first order maximum occurs when .... $d\sin\theta = 1\lambda$

The second order maximum occurs when .... $d\sin\theta = 2\lambda$

The third order maximum occurs when.............. $d\sin\theta = 3\lambda$

The m^{th} order diffraction occurs when

$$\boxed{d \sin\theta \;=\; m\lambda}$$

Where m called the order of spectrum and has values

$m = 0, \pm, \pm 1, \pm 2, \pm 3,..$

DIFFRACTION OF X-RAYS

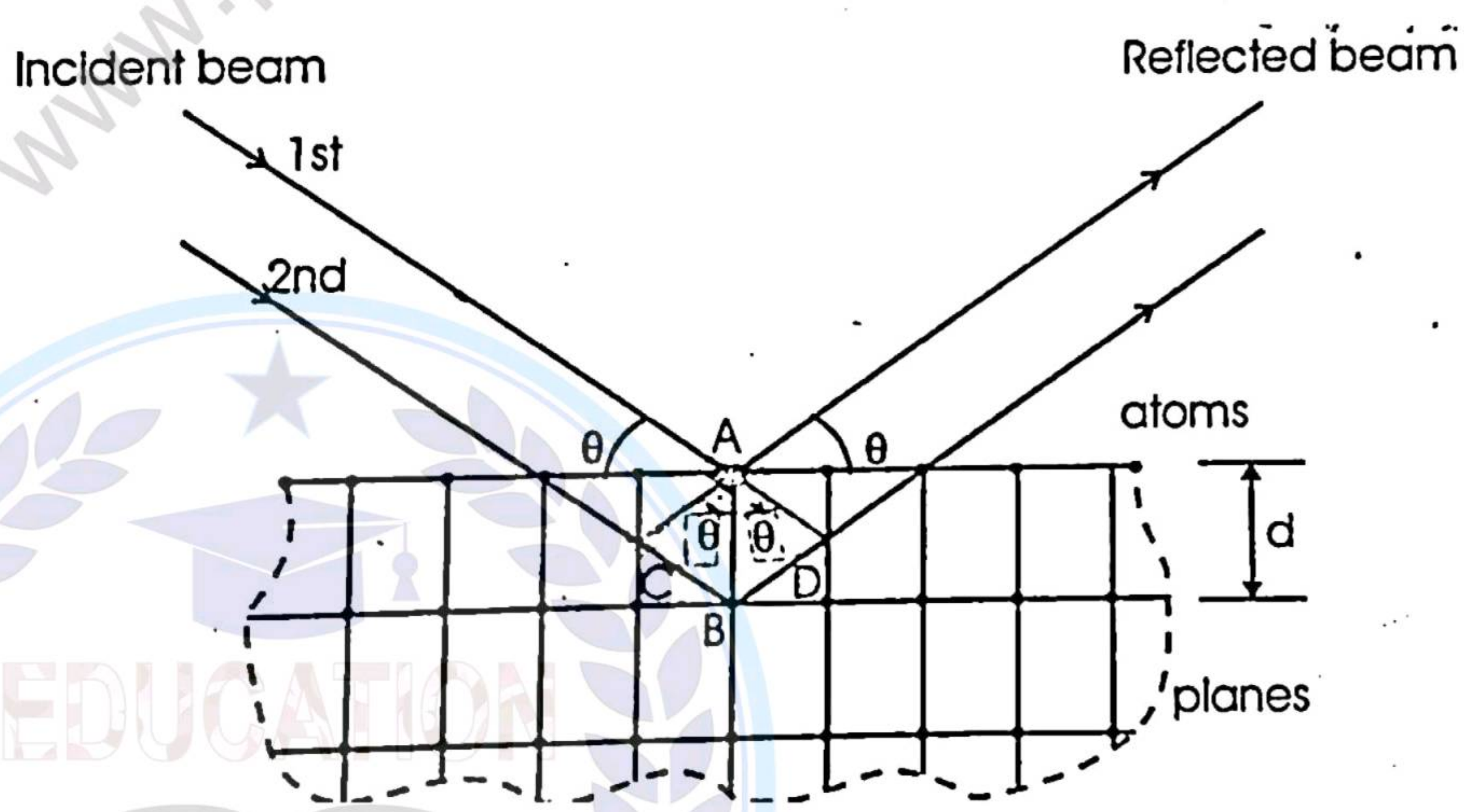
X rays have very Short wavelength less than that of visible and ultraviolet light. Therefore diffraction of X - rays cannot be observed with the help of common grating as X-rays pass through the slits of grating. However it is possible to obtain it rays diffraction by making use of crystals such as rock salt in which the atoms are uniformly spaced planes and separated by a distance of the order of 2 -5 A°. Therefore the diffraction of X - rays takes place when they incident on the crystals as shown in fig."

Suppose parallel Lattice planes having spacing 'd' between each other. It is clear from figure that 2nd ray covers more distance as compared to 1st ray and the path difference between two reflected rays is,

Path diff = BC + BD - (i)

In right angled Δ BAC,

$$Sin\ \theta = \frac{\overline{BC}}{\overline{AB}}$$



$$Sin\ \theta = \frac{\overline{BC}}{d}$$

$$\overline{BC} = dSin\ \theta$$

Similarly,

$$\overline{BD} = dSin\ \theta$$

Putting values in eq(i),we get

$$Path\ Diff = dSin\ \theta + dSin\ \theta$$

$$Path\ Diff = 2dSin\ \theta \text{ ---------(ii)}$$

Now, For constructive interference,

$$Path\ Diff = m\lambda \text{ ---------------(iii)}$$

Comparing eq(ii) and eq(iii)

$$\boxed{dSin\ \theta = m\lambda}$$

This is known is Braw's Law.Now if 'd' the interplanar distance of crystal is known where 'm' and "θ" are experimentally measured then wave length of x ray light used can be calculated with the help of this equation.

POLARIZATION OF LIGHT

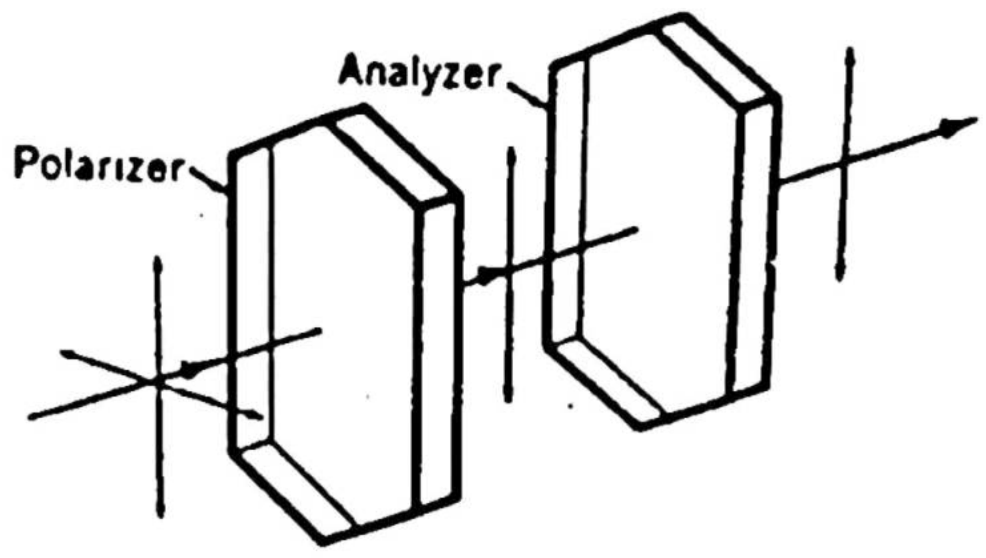
The interference and diffraction phenomena verify the wave nature of light but these phenomena do not provide any information about the type of light waves.

It is polarization phenomenon which tells us that light waves are transverse in nature.Actually, there is a periodic fluctuation in electric and magnetic fields along the propagation of light waves. These fields vary at right angles to the direction of the propagation of the light wave. so light wave is a transverse wave and this makes it possible to produce and detect polarized light.

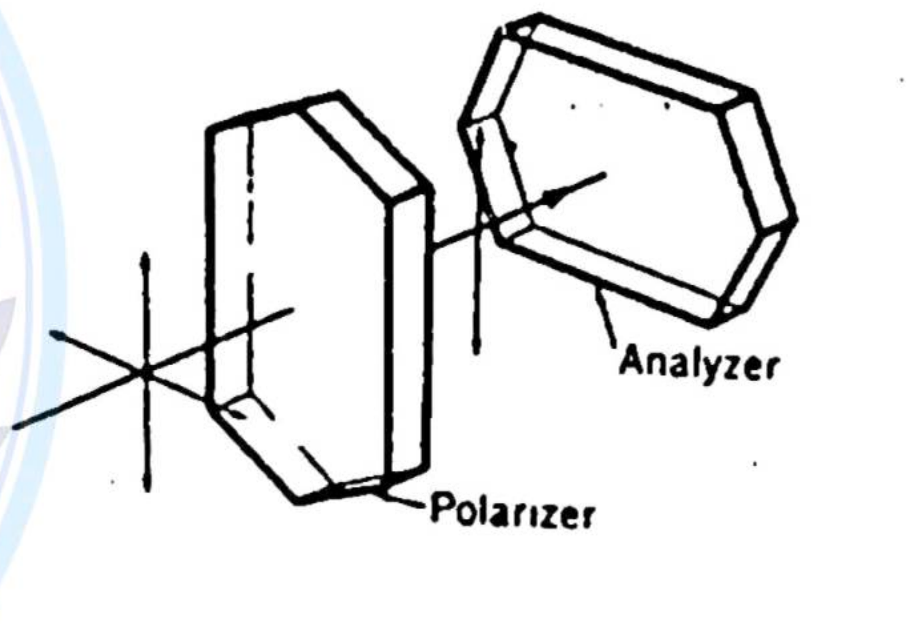
Unpolarized light means ordinary light whose waves have electric and magnetic vibrations in all directions in a plane perpendicular to the direction of propagation of light. Polarized light means light waves having vibrations in certain directions 'y' perpendicular to the direction of propagation of light. Tourmaline crystals are often used to polarize the light and to analyse the polarized light. A tourmaline crystal has its crystallographic axis parallel to its face and it transmits" only those vibrations of light waves which are parallel to the axis of crystal.

When unpolarized light is incident on two tourmaline crystals placed with their crystallographic axes parallel,the light beam is transmitted. If however, one of the crystal is rotated with respect to other the emergent beam becomes dimmer and ultimately light is totally cut off when the axes of the two crystals become perpendicular to each other. On further rotation, the light reappears and becomes brighter ,when the axes of crystals again parallel as shown in fig.

When a beam of light passes through crystal one component of the vibration is absorbed and the other component is transmitted.



Consequently the emerging beam differs from incident light in the sense that all the vibrations are in one direction. Such a beam is said to be plane polarized. When it falls on a second crystal, vibrations can only pass if they are parallel to the transmission direction of the crystal i.e. crystallographic axis of the crystal.It means that polarization of light is due to selective absorption by tourmaline of all light waves vibrating in one particular plane. The first crystal is known as polarizer where as the second crystal is known as analyzer.



APPLICATIONS OF POLARIZATION OF LIGHT:

(i) The simplest application of polaroid is curtain less windows. An outer polarizing disc is fixed in position and an inner disc may be rotated to adjust the amount of light admitted.

(ii) In photography it is often desirable to enhance the effect of sky and clouds. Since light from the blue sky is partially polarized by scattering, suitable orientation polarization discs in front of the camera lens will serve as a sky filter.

(iii) Control of headlight glass in night driving is possible if each car has light polarizing viewer.

M.C.Qs.

1. The wave theory of light was proposed by:
(a) Galileo (b) Huygens
(c) Kepler (d) Newton

2. Yellow light of a single wavelength can't be:
(a) Reflected (b) Refracted
(c) Dispersed (d) Polarized

3. The characteristic property of light wave which does not vary with the medium is:
(a) Frequency (b) Amplitude
(c) Velocity (d) Wavelength

4. The waveform of waves will be spherical when the rays of light are:
(a) parallel (b) perpendicular
(c) monochromatic (d) not parallel

5. Color of light is determined by its.
(a) Frequency (b) Amplitude
(c) Speed (d) Wavelength

6. When a transverse wave travelling through a rare medium is reflected from a dense medium, then phase change produced in it will be equal to:
(a) 0° (b) 90° (c) 180° (d) 360°

7. The locus of all points in the same phase of vibration is:
(a) Wave front (b) Interference
(c) Diffraction (d) Polarization

8. A thin layer of oil on the surface of water looks colored due to:
(a) Polarization of light.
(b) different elements presenting the oil
(c) Interference of light
(d) The transmission of light

9. When Newton's rings are observed by reflected light , the centre of rings appear dark due to
(a) phase reversal only
(b) path difference zero only
(c) intensity of light being maximum
(d) both phase reversal and path difference being zero.

11. The experimental evidence of transverse nature of light is:
(a) diffraction (b) interference
(c) polarization (d) dispersion

12. In Newton's rings seen throughout reflected light:
(a) The central spot is dark
(b) The central spot is bright
(c) The last spot is dark
(d) The last spot is bright

13. The number of lines per cm of a diffraction

grating is 4000. Its grating element is:
(a) 2.5×10^{-4} cm (b) 2.5×10^{-6} cm
(c) 4×10^{2} cm (d) 4×10^{5} cm

14. The phenomenon of interference come out because wave obey:
(a) The impulse moment theorem
(b) The 1st law of thermodynamics
(c) The inverse square law
(d) The principle of superposition

15. Which of the following is used to plane polarize light?
(a) A sheet with small opening
(b) A thick glass sheet
(c) A plano-convex lens (d) A paper sheet

16. The conditions of interference in thin film are reversed due to:
(a) Diffraction (b) Phase coherence
(c) Refraction (d) Phase reversal

17. This equation represents Bragg's Law:
(a) $m\lambda = 2d \sin\Theta$ (b) $m\lambda = d \sin\Theta$
(c) $2m\lambda = d \sin\Theta$ (d) $2m\lambda = 3d \sin\Theta$

18. Which of the following phenomenon produce the colors in soap bubble?
(a) Interference (b) Polarization
(c) Diffraction (d) Dispersion

19. The path difference in destructive interference must be:
(a) $d = 0, 2\lambda, 3\lambda$ (b) $d = \lambda/2, 3\lambda/2, 5\lambda/2$
(c) $d = 0, \lambda/6, 3\lambda/6, 5\lambda/6$ (d) $d = 0, 3\lambda/4, 5\lambda/4$

20. Monochromatic yellow light is unable to show:
(a) reflection (b) refraction
(c) dispersion (d) interference

21. According to Maxwell theory, light travels in the form of:
(a) transverse wave (b) longitudinal wave
(c) mechanical wave (d) electromagnetic wave

22. One condition for interference is that the two sources should be coherent and:
(a) Close together (b) at a far off distance
(c) Opposite to each other (d) Coinciding

23. In Young's double slit experiment; the condition for the constructive interference is that the path diff. must be:
(a) an odd multiple of the half wavelength
(b) an odd multiple of the whole wavelength
(c) an integral multiple of the wavelength
(d) an even number of the wavelength

24. Width of the interference fringes in young's double slit experiment increase with increase in:
(a) Slit separation (b) Wave length
(c) order of the fringes (d) frequency of the source

25. The property which enables waves to bend around the edge of an opening or obstacle in its path is called:
(a) Dispersion (b) Diffraction
(c) Super position (d) Interference

26. Which of the following are types of diffraction?
(a) Interfering and non interfering
(b) Transparent – semi transparent
(c) Fresnel - Fraun hoffer diffraction
(d) Johnson- element diffraction

27. A plate with a number of tiny holes or thin lines is called ____.
a) Sheet b) Sieve

c) Grating d) Collimator

28. A lens which converges a parallel beam of light is called ____.
a) Concave b) Convex
c) Plane lens d) Compound lens

29. The wave theory of light cannot explain:
a) polarization b) Photoelectric effect
c) Interference d) Diffraction

30. Electromagnetic wave consist of oscillatory electric field and magnetic field. Both fields are:
(a) Parallel to each other
(b) Parallel to the direction of propagation
(c) Perpendicular to each other
(d) None of these

PAST PAPER M.C.Qs.

2022

4.Bragg's law is:
mλ = 2d sinΘ *mλ = d sinΘ *2mλ = d sinΘ *2mλ = 3d sinΘ

11.Huygen's Principle is used to determine:
*speed of light ***position of wave front*** *polarization *refractive index

15.Wave front near the point source is:
* Plane *** Spherical** * Conical * Cylindrical

17.The bending of light around sharp obstacle is called:
* Interference ***Diffraction*** *Polarization * Refraction

2021

(xxiii) The equation represents Bragg's law:
mλ = 2d sinΘ *mλ = d sinΘ *2mλ = d sinΘ *2mλ = 3d sinΘ

(xxiv) In Young's double slits experiment, the condition for the constructive interference is that the path difference must be
*An odd multiple of the half wavelength
*An odd multiple of the quarter wavelength
An integral multiple of the wavelength
*An even multiple of one third the wavelength

(xxx) The fringe spacing in Young's double slit experiment is:
* dλ / L ***λL/d*** * Ld/λ *Lλd

xxxiv) The motion of number of lines per cm of a diffraction grating are 4000, its grating element is:

***2.5×10^{-4} cm** *2.5×10^{-6} cm *4×10^{-2} cm *4×10^{5}cm

2019

3.The waveform of waves will be spherical when the rays of light are:

* parallel *perpendicular *monochromatic ***not parallel**

11. When a transverse wave travelling through a rare medium is reflected from a dense medium, then phase change produced in it will be equal to:

*0° *90° ***180°** *360°

2018

9. When Newton's rings are observed by reflected light , the centre of rings appear dark due to *phase reversal only *path difference zero only

* intensity of light being maximum *** both phase reversal and path difference being zero.**

11. The experimental evidence of transverse nature of light is:

*diffraction *interference *** polarization** * dispersion

2017

12. The number of lines per cm of a diffraction grating is 4000. Its grating element is:

***2.5×10^{-4} cm** *2.5×10^{-6} cm *4×10^{2} cm *4×10^{5} cm

2016

6. The conditions of interference in thin film are reversed due to:

*Diffraction *Phase coherence *Refraction ***Phase reversal**

8. This equation represents Bragg's Law:

***$m\lambda = 2d \sin\Theta$** *$m\lambda = d \sin\Theta$ *$2m\lambda = d \sin\Theta$ *$2m\lambda = 3d \sin\Theta$

2015

9. Newton's rings illustrate the phenomenon of:

*Polarization *diffraction *** interference** * dispersion

12. In thin film interference, the positions of constructive and destructive interference are interchanged due to:

*Phase coherence ***Phase reversal** *Diffraction *Interference

15. Polarization of light due to tourmaline crystals takes place because of:

*Reflection *** Absorption** * Refraction * Collision

2014

8. Diffraction of light is a special type of:

* reflection *refraction ***interference** *polarization

14. In Young's double slit experiment, the fringe spacing is:

*$d\lambda/L$ ***$L\lambda/d$** *Ld/λ * λLd

2013

11. Monochromatic yellow light is unable to show:

*reflection *refraction **<u>*dispersion</u>** *interference

<u>2012</u>

7. According to Maxwell theory, light travels in the form of:

*transverse wave * longitudinal wave

* mechanical wave **<u>* electromagnetic wave</u>**

10. Huygens's principle is used to:

*determine the speed of light **<u>* locate the wave front</u>**

* expressed polarization * find the refractive index

<u>2011</u>

2. The wave theory cannot explain:

*polarization **<u>* photo electric effect</u>**

* interference * diffraction

8. Electromagnetic waves consist of oscillating electric and magnetic fields, both are:

*parallel to each other **<u>*perpendicular to each other</u>**

*non parallel to each other *none of these

<u>2010</u>

8. In Young's double slit experiment; the condition for the constructive interference is that the path diff. must be:

*an odd multiple of the half wavelength

* an odd multiple of the whole wavelength

<u>* an integral multiple of the wavelength</u>

* an even number of the wavelength

TEXTBOOK NUMERICALS

Q.1: How many fringes will pass a reference point if the mirror of a Michelson's interferometer is moved by 0.08 mm. The wavelength of light used is 5800 A°.

<u>Data:</u>

No. of Fringes= m = ?

Distance moved = $\Delta x = 0.08$ mm=8 x 10^{-5} m

Wavelength = $\lambda = 5800\ A^0 = 5.8 \times 10^{-7} m$

<u>Solution:</u>

$$\Delta x = \frac{m\lambda}{2}$$

$$m = \frac{2\Delta x}{\lambda}$$

$$m = \frac{2\times 8 \times 10^{-5}}{5.8\times10^{-7}}$$

$$\boxed{\lambda = 276}$$

<u>Result:</u> 276 fringes will pass the reference point.

Q.2: In a double slit experiment the separation of the slits is 1.9 mm and the fringe spacing is 0.31mm at a distance of 1 metre from the slits. Find the wavelength of light?

Data:

Slits separation = d =1.9 mm= 1.9 x 10^{-3} m

Fringe Spacing = Δx = 0.31 mm=0.31 10^{-3} m

Distance of screen from slits =L = 1 m

Wavelength of Light = λ = ?

Solution:

The Fringe spacing is given by

$$\Delta x = \frac{\lambda L}{d}$$

$$0.31 \times 10^{-3} = \frac{\lambda(1)}{1.9 \text{ x } 10^{-3}}$$

$$\lambda = 0.31 \times 10^{-3} \times 1.9 \text{ x } 10^{-3}$$

$$\boxed{\lambda = 5.89 \times 10^{-7} m}$$

Result: The wavelength of light used is $5.89 \times 10^{-7} m$

Q.3: Interference fringes were produced by two slits 0.25 mm apart on a screen 150 mm from the slits. If eight fringes occupy 2.62 mm. What is the wavelength of the light producing the fringes?

Data:

Slits separation = d =0.25 mm = 2.5 x 10^{-4}m

Fringe Spacing = $\Delta x = \Delta x/8$ =

=2.62 10^{-3} / 8 = 3.27 x 10^{-4}m

Distance of screen from slits =L = 150 mm =0.15 m

Wavelength of Light = λ = ?

Solution:

The Fringe spacing is given by

$$\Delta x = \frac{\lambda L}{d}$$

$$\lambda = \frac{\Delta x \times d}{L}$$

$$\lambda = \frac{3.27 \times 10^{-4} \times 2.5 \times 10^{-4}}{0.15}$$

$$\boxed{\lambda = 5.45 \times 10^{-7} m}$$

Result: The wavelength of light used is $5.45 \times 10^{-7} m$

Q.4: Green light of a wavelength 5400 A° is diffracted by grating having 2000 line/cm. (a) Compute the angular deviation of the third order image. (b) Is a 10th order image possible?

Data:

Order = m = 3

Wavelength = $\lambda = 5400\ A = 5.4 \times 10^{-7} m$

Angle =θ = ?

No. of lines per cm = n =2000 lines/cm

Solution:

$$grating\ element = \frac{length\ of\ grating}{No.of\ Lines}$$

$$d = \frac{1}{n}$$

$$\boxed{d = \frac{1}{2000} = 5 \times 10^{-4} cm = 5 \times 10^{-6} m}$$

(a) $m\lambda = dSin\theta$

$$(3)(5.4 \times 10^{-7}) = 5 \times 10^{-6} Sin\theta$$

$$Sin\theta = \frac{(3)(5.4 \times 10^{-7})}{5 \times 10^{-6}} = 0.324$$

$$\theta = Sin^{-1}(0.324)$$

$$\boxed{\theta = 18.9^0}$$

(b) For 10th order image:

$$m\lambda = dSin\theta$$

$$(10)(5.4 \times 10^{-7}) = 5 \times 10^{-6} Sin\theta$$

$$Sin\theta = \frac{(10)(5.4 \times 10^{-7})}{5 \times 10^{-6}} = 1.08$$

$$\theta = Sin^{-1}(1.08)$$

$$\boxed{\theta = Not\ Possible}$$

Result: The angular deviation of 3rd order image is 18.9^0 and 10th order is not possible.

Q.5: Light of a wavelength 6x10^{-7} m falls normally on a diffraction grating with 400 lines per mm. At what angle to the normal are the 1st , 2nd and 3rd order spectra produced?

Data:

Order = m = 1,2,3

Wavelength = $\lambda = 6 \times 10^{-7} m$

Angle =θ = ?

No. of lines per cm = n =400 lines/mm

Solution:

$$grating\ element = \frac{length\ of\ grating}{No.of\ Lines}$$

$$d = \frac{1}{n}$$

$d = \frac{1}{400} = 2.5 \times 10^{-3} mm = 2.5 \times 10^{-6} m$

(a) When m = 1

$m\lambda = dSin\theta$

$(1)(6 \times 10^{-7}) = 2.5 \times 10^{-6}\ Sin\theta$

$Sin\theta = \frac{(1)(6\times10^{-7})}{2.5\times10^{-6}} = 0.24$

$\theta = Sin^{-1}(0.24)$

$\theta = 13.8^0$

(b) When m = 2

$m\lambda = dSin\theta$

$(2)(6 \times 10^{-7}) = 2.5 \times 10^{-6}\ Sin\theta$

$Sin\theta = \frac{(2)(6\times10^{-7})}{2.5\times10^{-6}} = 0.48$

$\theta = Sin^{-1}(0.48)$

$\theta = 28.6^0$

(b) When m = 3

$m\lambda = dSin\theta$

$(3)(6 \times 10^{-7}) = 2.5 \times 10^{-6}\ Sin\theta$

$Sin\theta = \frac{(3)(6\times10^{-7})}{2.5\times10^{-6}} = 0.72$

$\theta = Sin^{-1}(0.72)$

$\theta = 46^0$

Result: The angular deviation of 1st order image is 13.8^0 , 2nd order is 28.6^0 and for 3rd order is 46^0.

Q.6: If a diffraction grating produced a 1st order spectrum of light of wavelength $6x10^{-7}$ m at an angle of 20^o from the normal. What is its spacing and also calculate the number of lines per mm?

Data:

Order = m = 1

Wavelength = $\lambda = 6 \times 10^{-7}$ m

Angle = $\theta = 20^o$

Grating Element = d = ?

No. of lines per mm = n = ?

Solution:

$m\lambda = dSin\theta$

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

$d = \frac{(1)(6 \times 10^{-7})}{Sin\ 20^0}$

$d = 1.75 \times 10^{-6} m$

Or

$d = 1.75 \times 10^{-3}\ mm$

$No. of\ Lines = \frac{length\ of\ grating}{grating\ element}$

$n = \frac{1}{d}$

$n = \frac{1}{1.75 \times 10^{-3}} = 571 \frac{lines}{mm}$

Result: The grating element is $1.75 \times 10^{-3}\ mm$ and no. of lines are $571 \frac{lines}{mm}$

Q.7: Newton's rings are formed between a lens and a flat glass surface of wavelength $5.88x10^{-7}$ m. If the light passes through the gab at 30^o to the vertical and the fifth dark ring is of diameter 9 mm. What is the radius of the curvature of the lens?

Data:

No. of Ring = N = 5

Radius of ring = r = 9 mm = 9×10^{-3}m

(Correction)

Wavelength of light = $\lambda = 5.89 \times 10^{-7} m$

Angle with the vertical = $\theta = 30°$

Radius of curvature = R = ?

Solution:

The radius of Nth dark ring is given by

$r = \sqrt{\frac{N\lambda R}{\cos\theta}}$

.

$9 \times 10^{-3} = \sqrt{\frac{5\times5.89\times10^{-7}\times R}{\cos 30°}}$

S.O.B.S

$(9 \times 10^{-3})^2 = \frac{5\times5.89\times10^{-7}\times R}{0.866}$

$R = \frac{(9\times10^{-3})^2\times0.866}{5\times5.89\times10^{-7}}$

$R = 23.8\ m$

Result: The radius of curvature of the lens used is $23.8\ m$

Q.8: How far apart are the diffracting planes in a NaCl crystal for which X-rays of wavelength 1.54 A° make a glancing angle of 15° -54' in the 1st order?

Data:

Order of maximum= m = 1

Glancing angle $=\theta = 15$ degrees 54 minutes

$$=\theta = 15 + \frac{54}{60} = 6 + 0.9$$

$$\theta = 15.9°$$

Wavelength of x rays= $\lambda = 1.54\ A° = 1.54 \times 10^{-10} m$

Distance between the atomic planes = d = ?

Solution:

According to Bragg's Law

$$m\lambda = 2dsin\theta$$

$$d = \frac{m\lambda}{2\sin\theta}$$

$$d = \frac{1 \times 1.54 \times 10^{-10}}{2\sin 15.9°}$$

$$\boxed{d = 2.81 \times 10^{-10} m}$$

Result: The between the atomic planes is $2.81 \times 10^{-10} m$.

Q.9: A parallel beam of X-rays is diffracted by rocksalt crystal the 1st order maximum being obtained when the glancing angle of incidence is 6 degree and 5 minutes. The distance between the atomic planes of the crystal is 2.8×10^{-10} m. Calculate the wavelength of the radiation.

Data:

Order of maximum= m = 1

Glancing angle $=\theta = 6$ degrees 5 minutes

$$=\theta = 6 + \frac{5}{60} = 6 + 0.083$$

$$\theta = 6.083^0$$

Distance between the atomic planes = d = 2.8×10^{-10} m

Wavelength of x rays= $\lambda = ?$

Solution:

According to Bragg's Law

$$m\lambda = 2dsin\theta$$

$$\lambda = \frac{2dsin\theta}{m}$$

$$\lambda = \frac{2 \times 2.81 \times 10^{-10} \times \sin(6.083)}{(1)}$$

$$\boxed{\lambda = 5.93 \times 10^{-10} m}$$

Result: The wavelength of x rays will be $5.93 A°$.

PAST PAPER NUMERICALS

2021

Q.2 (ii) Textbook problem 8

2019

Q.2(v) 271 fringes passed through a reference point when a movable mirror of Michelson interferometer is moved by 0.08mm.Find the wavelength used in A^0.

Data:

No. of Fringes= m= 271

Distance moved = Δx = 0.08 mm= 8×10^{-5} m

Wavelength = λ=?

Solution:

$$\Delta x = \frac{m\lambda}{2}$$

$$\lambda = \frac{2\Delta x}{m}$$

$$\lambda = \frac{2 \times 8 \times 10^{-5}}{271}$$

$$\lambda = 5.9 \times 10^{-7} m$$

$$\boxed{\lambda = 5900\ A^0}$$

Result: The wavelength used is $5900\ A^0$.

Q.2(xii) A diffraction grating produces 3rd order spectrum of light of wavelength 7000 A° at an angle of 30° from the normal. What is the grating element? Calculate the number of lines per cm.

Data:

Order = m = 3

Wavelength = λ = 7000 A° = 7 x 10^{-7} m

Angle = θ = 30°

Grating Element = d = ?

No. of lines per cm = n = ?

Solution:

$$m\lambda = dSin\theta$$

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

$$d = \frac{(3)(7 \times 10^{-7})}{Sin\ 30^0}$$

$$\boxed{d = 4.2\ \times 10^{-6} m}$$

Or

$$d = 4.2\ \times 10^{-4}\ cm$$

$$No. of\ Lines = \frac{length\ of\ grating}{grating\ element}$$

$$n = \frac{1}{d}$$

$$\boxed{n = \frac{1}{4.2\ \times 10^{-4}} = 2381 \frac{lines}{cm}}$$

Result: The grating element is $4.2\ \times 10^{-4}\ cm$ and no. of lines are $2381 \frac{lines}{cm}$

2018

No Numerical

2017

2(vi) If the radius of 5th dark ring Newton's ring is 3mm when light of wavelength 5.89 x 10^{-7}m is used, what will be the radius of curvature of the lower surface of the lens used?

Data:

No. of Ring = N = 5

Radius of ring = r = 3 mm = 3 x10^{-3}m

Wavelength of light = $\lambda = 5.89 \times 10^{-7} m$

Radius of curvature = R = ?

Solution:

The radius of Nth dark ring is given by

$$r = \sqrt{N\lambda R}$$

$$3 \times 10^{-3} = \sqrt{5 \times 5.89 \times 10^{-7} \times R}$$

S.O.B.S

$$(3 \times 10^{-3})^2 = 5 \times 5.89 \times 10^{-7} \times R$$

$$R = \frac{(3 \times 10^{-3})^2}{5 \times 5.89 \times 10^{-7}}$$

$$\boxed{R = 3.05\ m}$$

Result: The radius of curvature of the lens used is $3.05\ m$.

2(xi) If a diffraction grating produced a 3rd order spectrum of light of wavelength 7x10^{-7} m at an angle of 30° from the normal. What is its spacing and also calculate the number of lines per mm?

Data:

Order = m = 3

Wavelength = λ = 7 x 10^{-7} m

Angle = θ = 30°

Grating Element = d = ?

No. of lines per cm = n = ?

Solution:

$$m\lambda = dSin\theta$$

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

$$d = \frac{(3)(7 \times 10^{-7})}{Sin\ 30^0}$$

$$\boxed{d = 4.2\ \times 10^{-6} m}$$

Or

$$d = 4.2\ \times 10^{-3}\ mm$$

$$No. of\ Lines = \frac{length\ of\ grating}{grating\ element}$$

$$n = \frac{1}{d}$$

$$\boxed{n = \frac{1}{4.2\ \times 10^{-3}} = 238 \frac{lines}{mm}}$$

Result: The grating element is $4.2\ \times 10^{-3}\ mm$ and no. of lines are $238 \frac{lines}{mm}$

2016

Q.2 (xv) Textbook Numerical 2

2015

Q.2 (xv) Textbook Numerical 9

2014

Q.2 (vii) Textbook Numerical 4

2013

No Numerical

2012

Q.2(v) In a double slit experiment, eight fringes occupy 2.62mm on a screen 145 mm away from the slits. The wave length of light is 545nm. Find the slit separation.

Data:

Slits separation = d =1.9 mm= ?

Fringe Spacing = $\Delta x = \Delta x/8$ =

=2.62 10^{-3} / 8 = 3.27 x 10^{-4}m

Distance of screen from slits =L = 145 mm =0.15 m

Wavelength of Light = λ = 545 nm =545 x 10^{-9}m

Solution:

The Fringe spacing is given by

$$\Delta x = \frac{\lambda L}{d}$$

$$d = \frac{\lambda L}{\Delta x}$$

$$d = \frac{545 \times 10^{-9} \times 0.15}{3.27 \times 10^{-4}}$$

$$\boxed{d = 2.5 \times 10^{-4} m}$$

Result: The slit separation is $2.5 \times 10^{-4} m$

2011

Q.2 (vii) Textbook Numerical 6

2010

Q.2 (xiv) If the radius of the 14th bright Newton's ring is 1 mm and the radius of curvature of the lens is 125 mm, calculate the wavelength of the light.

Data:

No. of Ring = N = 14

Radius of ring = r = 1 mm = 1 x10^{-3}m

Wavelength of light = λ =?

Radius of curvature = R = 125 mm = 0.125 m

Solution:

The radius of Nth dark ring is given by

$$r = \sqrt{N\lambda R}$$

$$1 \times 10^{-3} = \sqrt{14 \times \lambda \times 0.125}$$

S.O.B.S

$$(1 \times 10^{-3})^2 = 14 \times \lambda \times 0.125$$

$$\lambda = \frac{(1 \times 10^{-3})^2}{14 \times 0.125}$$

$$\boxed{\lambda = 571 \times 10^{-9}\ m}$$

Result: The light of wavelength used is 571 nm.