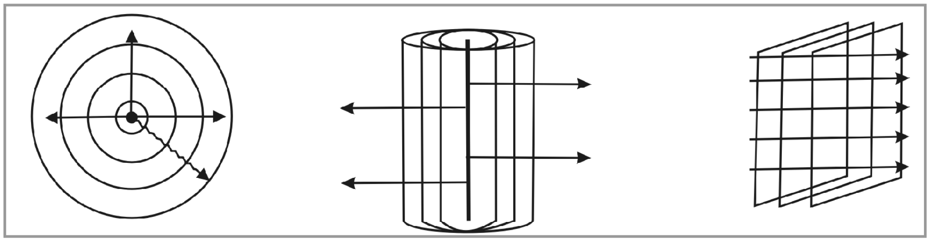
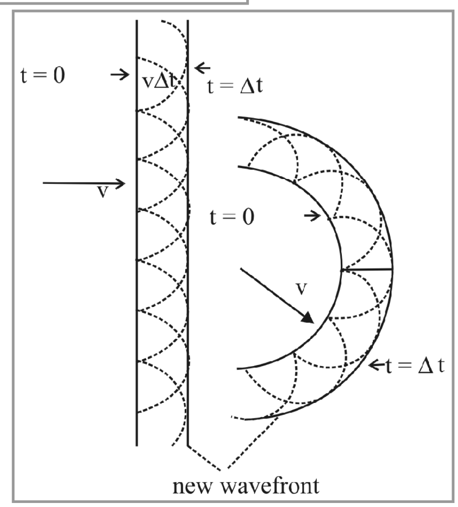
1. HUYGENS' PRINCIPLE

Huygens' Wave Theory

- A source emits light in the form of waves.
- Each point source is a centre of disturbance and waves emitted by it spread in all directions.
- The direction of propagation of the wave is normal to the wavefront (in a homogeneous medium).
- The wavefronts in the case of a point source are concentric spheres with the source at the centre.



- The wavefronts in the case of a linear source are cylindrical.
- In a region that is very far from the source, the wavefronts can be taken as parallel planes.



Huygens' Principle of Secondary Wavelets

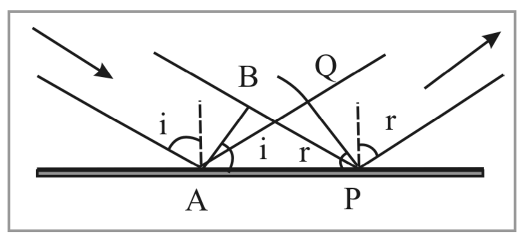
Consider light emitted by a source and one wavefront at any instant.

- Every point on a wavefront acts as a source of secondary disturbance.
- These secondary sources emit secondary wavelets.
- At a later instant the new wavefront is given by the forward geometrical envelope of the secondary wavelets.

2. REFLECTION AND REFRACTION OF PLANE WAVES

Reflection of a Plane Wave Front

Let AB be the incident wavefront and v be the velocity of the wave. When the wavelet from the point B reaches the point P, the wavelet from the point A reaches the point Q. Thus PQ is the reflected wavefront.



$$t = \frac{BP}{v} = \frac{AQ}{v}$$

Or, $BP = AQ$ …(*i*)

In ΔABP, $BP = AP \sin i$ … (*ii*)

In ΔPQA, $AQ = AP \sin r$ … (*iii*)

From (*i*), (*ii*) and (*iii*),

$\sin i = \sin r$ or, $i = r$

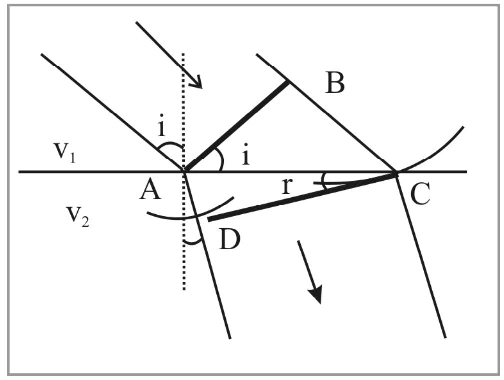
This proves that the angles of incidence and reflection are equal when light reflects from a surface.

Refraction of a Plane Wave Front

Let AB be a plane wavefront incident on the surface of separation of two media and v_1 and v_2 be the speeds of light in the two media. When the wavelet from the point B reaches the point C, the wavelet from the point A will reach the point D.

$$t = \frac{BC}{v_1} = \frac{AD}{v_2}$$

Or, $\dfrac{BC}{AD} = \dfrac{v_1}{v_2}$ …(*iv*)



In ΔACP, BC = AC sin i …(v)

In ΔACD, AD = AC sin r …(vi)

From (iv), (v) and (vi),

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} \qquad \ldots(vii)$$

But, $\frac{v_1}{v_2} = \frac{\ _2}{\ _1}$

where, μ_1 and μ_2 are the refractive indices of the two media.

Then (vii) becomes:

$$\frac{\sin i}{\sin r} = \frac{\ _2}{\ _1} \qquad \text{Or,} \qquad {}_1 \sin i = {}_2 \sin r$$

This gives the Snell's law.

1. THE DOPPLER EFFECT

- The Doppler effect is based on the principle that the frequency of a wave is different when there is a relative motion between the source and the receiver.
- Light waves are electromagnetic and do not require a medium to travel through.
- The velocity of light waves is the same in all inertial frames.
- The Doppler equation:

  $$\frac{\Delta v}{v} = -\frac{v_{radial}}{c}$$

  where, $\frac{\Delta v}{v}$ is the fractional change in frequency and v_{radial} is the component of the source velocity along the line joining the observer to the source relative to the observer.
- Since measuring of the wavelength of light in astronomy is easier than measuring the frequency, the doppler effect in light is detected by determining the apparent change in wavelength.
- If either the light source or observer are moving towards each other, the light waves are squeezed to a shorter wavelength. If they are moving apart the waves are stretched to a longer wavelength.
- For visible light, red light has a longer wavelength than blue light. A shift to a shorter wavelength is therefore called a blue shift, and a shift to a longer wavelength is a red shift.
- The light received from distant stars shows red shift suggesting that they are moving away from the earth thereby indicating the expansion of universe.

2. COHERENT AND INCOHERENT ADDITION OF WAVES

Coherent Sources

- Two sources of light are said to be coherent if the waves emitted by them have the same frequency and they are with a zero or constant phase difference. Such waves are referred to as coherent waves.
- The sources which do not satisfy the above condition are incoherent sources and the waves emitted by them are incoherent.

Constructive Interference

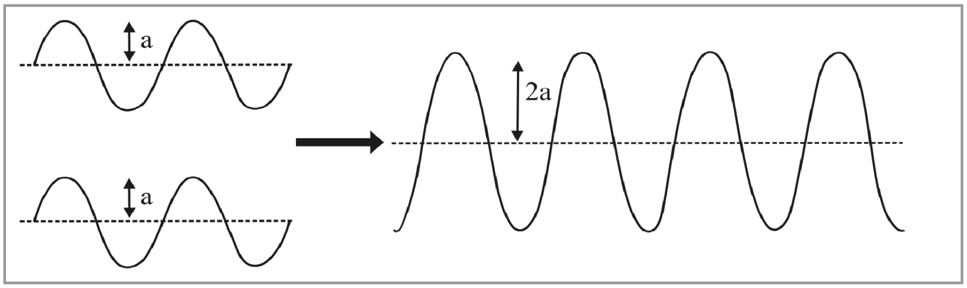
- A plane progressive simple harmonic wave with zero initial phase is represented by: $y = a \sin \omega t$
- Intensity of energy transferred by this wave over a point:

  I = ka^2
- Two coherent waves with the same amplitude, frequency and those are in phase can be given as:

  $y_1 = a \sin \omega t$

  $y_2 = a \sin \omega t$

- Their intensities: $I_1 = I_2 = ka^2$
- If these two waves reach a point simultaneously, the resultant wave: $y = y_1 + y_2 = 2a\sin\omega t$
- The resultant intensity: $I = k\,(2a)^2 = 4\,ka^2$



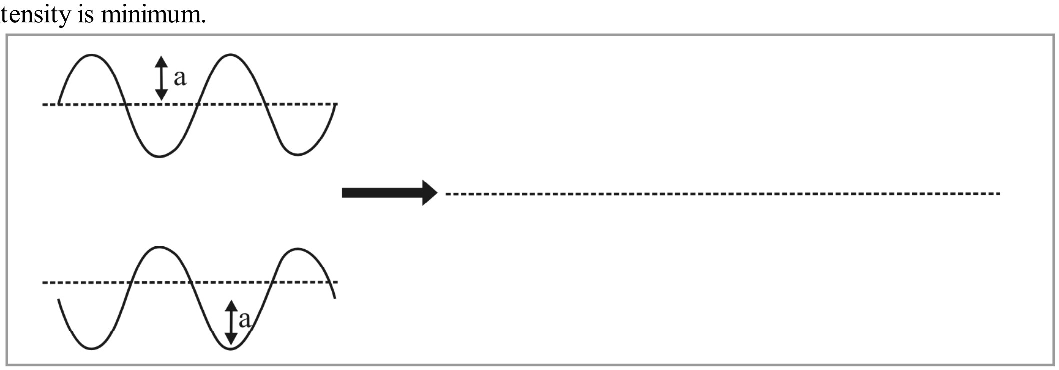
- The resultant intensity is four times the intensity due to a single wave.
- If the waves reach the point with a phase difference ($\Delta\phi$) that is an integral multiple of 2π (or with a path difference (x) that is an integral multiple of λ), then also the result is the same.
- As waves meet constructively, this is referred to as constructive interference.
- *i.e.*, for maximum intensity with constructive interference:

  $\Delta\phi = 2n\pi; \quad n = 0, \pm 1, \pm 2, \pm 3....$

Or, $x = n\lambda; \; n = 0, \pm 1, \pm 2, \pm 3....$

Destructive Interference

- Let the waves reach the point with a phase difference that is an odd integral multiple of π, then the resultant intensity is minimum.



- $y_1 = a\sin\omega t$

  $y_2 = a\sin(\omega t + \pi)$

  $y = y_1 + y_2 = a[\sin\omega t + \sin(\omega t + \pi)]$

  $$= 2a\sin(\omega t + \frac{\pi}{2})\cos(\frac{\pi}{2}) = 0$$

- The resultant intensity becomes zero, if the phase difference is an odd integral multiple of π or path difference is an odd integral multiple of $\frac{\lambda}{2}$.
- *i.e.*, for minimum intensity with destructive interference:

  $\Delta\phi = (2n+1)\pi; \quad n = 0, \pm 1, \pm 2, \pm 3....$

Or, $x = (2n+1)\frac{\lambda}{2};\ n = 0, \pm 1, \pm 2, \pm 3....$

- Generally, if two waves $y_1 = a\sin\omega t$ and $y_2 = a\sin(\omega t + \phi)$ meet at a point, the resultant wave form is given by:

  $y = 2a\cos\frac{\phi}{2}\sin(\omega t + \frac{\phi}{2})$

  The resultant intensity,

  $I = 4a^2\cos^2(\frac{\phi}{2}) = 4I_0\cos^2(\frac{\phi}{2})$

  Maximum intensity occurs for $\phi = 0, \pm 2\pi, \pm 4\pi, ...$

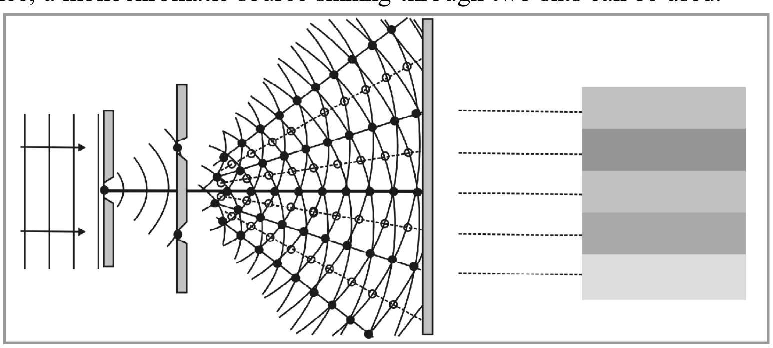
  Minimum intensity occurs for $\phi = \pm\pi, \pm 3\pi, \pm 5\pi, ...$

Coherent and Incoherent Addition of Waves

- When coherent addition of waves takes place, the phase difference at any point does not change with time and as a result, the positions of maxima and minima do not change with time. A stable interference pattern is formed.
- In the case of incoherent addition, the phase difference changes very rapidly with time and the positions of maxima and minima will also vary rapidly with time. A time- averaged intensity distribution occurs.
  The resultant intensity in this case is;
  $I = 2\,I_0$

3. INTERFERENCE OF LIGHT WAVES

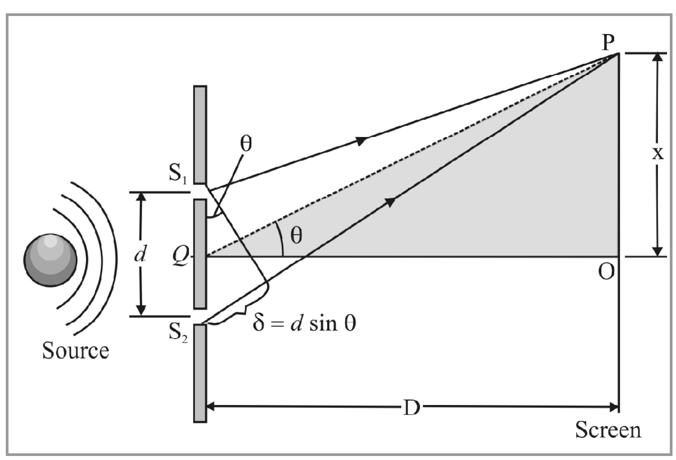
- For interference of light waves to occur:
  - The sources must be coherent, *i.e.*, they maintain constant phase with respect to each other.
  - The waves must have identical wavelengths
- To get coherence, a monochromatic source shining through two slits can be used.



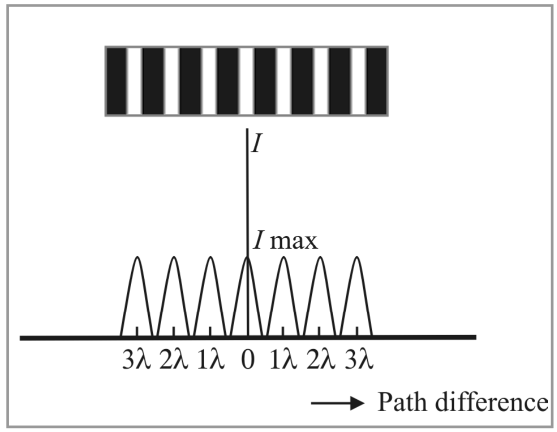
- Laser, which is monochromatic and highly directional, is useful in getting a good interference pattern. The beam should be sent through two different paths.
- Interference does not occur with light from incoherent sources.

4. YOUNG'S EXPERIMENT

- Thomas Young studied interference using a double-slit arrangement.
- A single source of monochromatic light is split into two (S_1 and S_2 in the figure), to generate two coherent sources.
- When the light from these two sources is projected on a screen, an interference pattern is observed.
- The slits are separated by a distance d and the screen is at a larger distance D from the slits.



- Light from S_1 and S_2 reach P with a path difference, $\delta = d\sin\theta$ (as clear from the figure above)
- Assume $D >> d >> \lambda$. Point P is bright if constructive interference occurs and dark if destructive interference occurs.



- $\frac{x}{D} = \tan\theta \approx \sin\theta$ for small values of θ.
- For maxima,

$\delta = n\lambda \quad , n = 0, \pm 1, \pm 2, ...$

$d\sin\theta = n\lambda$

$\Rightarrow \frac{xd}{D} = n\lambda \quad \Rightarrow x = \frac{Dn\lambda}{d}$ where, $n = 0, \pm 1, \pm 2, ...$

When n = 0, x = 0. Therefore, the point O has maximum intensity. Apart from O, the maxima occurs at distances $\frac{D\lambda}{d}, \frac{2D\lambda}{d}, \frac{3D\lambda}{d}, ...$ from O.

- For minima,

$\delta = (2n+1)\frac{\lambda}{2}, n = 0, \pm 1, \pm 2, ...$

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

$\Rightarrow \frac{xd}{D} = (2n+1)\frac{\lambda}{2} \qquad \Rightarrow x = \frac{D(2n+1)\lambda}{2d} \qquad$ where, $n = 0, \pm 1, \pm 2, ...$

The minima occurs at distances $\frac{D\lambda}{2d}, \frac{3D\lambda}{2d}, \frac{5D\lambda}{2d}, ...$ from O.

- The interference pattern is characterised with alternate dark and bright fringes (or bands) on either side of a central bright band. Graphical representation of the intensity distribution is shown below.
- Band width (or fringe width): The distance between two consecutive bright bands or dark bands. It is denoted by β.
- It can be shown that: $\beta = \frac{D\lambda}{d}$

1. DIFFRACTION

- Diffraction is the encroachment of light into the shadow region as it passes around obstacles or edges of small apertures.
- Diffraction is prominent when the width of the aperture or the size of the diffracting obstacle is comparable with the wavelength of light.
- Sound waves have longer wavelengths and they can easily bend around obstacles like buildings, walls etc.

Diffraction at a Single Slit

A diffraction pattern is formed with a central bright band with alternate bright (subsidiary maxima) and dark (subsidiary minima) bands.

- The angular position of minima is given by:

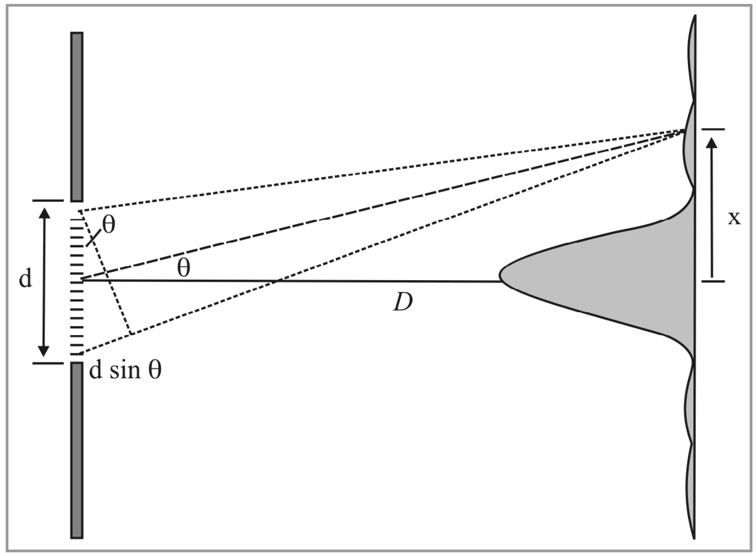
$d\sin\theta = n\lambda, \qquad n = 1, 2, 3, ...$

- For small values of θ, $\sin\theta = \theta$ and $d\theta = n\lambda$
- For first minimum, $n = 1$ and let the angular position be θ_1.

  Then, $\theta_1 = \dfrac{\lambda}{d}$
- The central maximum extends between the first minima on either side. The angular width of the central maximum θ_0 can be given as:

  $\theta_0 = 2\theta_1 = \dfrac{2\lambda}{d}$
- The angular position of subsidiary maxima is given by:

  $d\sin\theta = (2n+1)\dfrac{\lambda}{2}$, $\quad n = 1, 2, 3, \ldots$



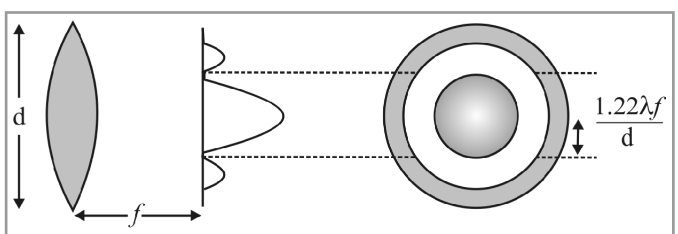
- The angular width of a subsidiary maximum is half that of the central maximum $\left(=\dfrac{\lambda}{2}\right)$.
- The intensity of subsidiary maxima decreases with distance from the central maximum.
- If the width of the slit is decreased, the subsidiary maxima shift away from the central maximum.
- With the decrease in wavelength, the diffraction bands become narrow and crowded.

Resolving Power of Optical Instruments

- The spatial resolving power of an optical instrument, such as a telescope or a microscope, is a measure of its ability to distinguish the details in the structure of the object being viewed and in particular the ability to form separate distinct images of two very small point objects which are close together.
- A converging lens cannot form a point image of a point source because of diffraction. It forms a bright region in the centre, known as the airy disc, with a series of concentric dark and bright rings.
- The minimum radius of the image disc is related to the wavelength (λ) of the illuminating light and the size of the circular aperture (d) as:

  $r = 1.22\dfrac{\lambda f}{d}$

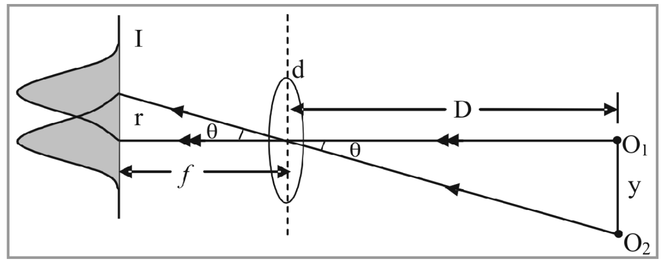
  where, f is the focal length of the lens.



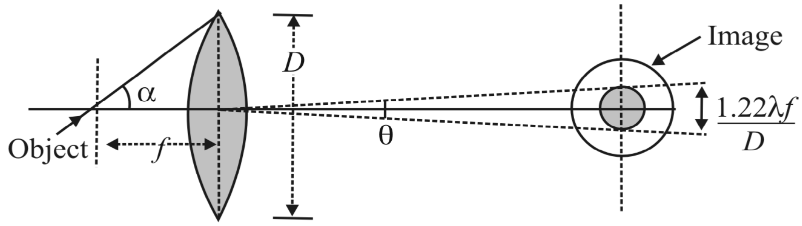
- The ability of optical instruments to form distinct images of two objects those are very close to each other is limited by diffraction.
- According to Rayleigh's criterion, two diffraction patterns with equal intensities may said to be resolved when the central maximum of one pattern is not nearer than the position of the centre of the first minimum of the neighbouring pattern.
- The angular limit of resolution θ_R will be equal to the angular separation between the central maximum and the first minimum. For a single slit of width (d) and for a monochromatic light of wavelength λ, it is given by: $\theta_R = \dfrac{\lambda}{d}$
- For circular aperture (such as lens) of diameter d, it can be deduced that, $\theta_R = \dfrac{1.22\lambda}{d}$
- Two objects at a distance D with separation y can be distinctly visible only if their angular separation is greater than or equal to the angular limit of resolution. $\theta \geq \theta_R$

When viewed through a lens, $\frac{y}{D} \geq \frac{1.22\lambda}{d}$

The following figure shows the situation when $\theta = \theta_R$



- From the expression $\theta_R = \frac{1.22\,\lambda}{d}$, it is clear that the resolving power increases as the aperture of the lens increases. For this reason, the objectives are made very large in telescopes.
- For a microscope with objective lens that subtends an angle 2α at the object:



The minimum separation between two objects so that they are distinctly visible, can be given as:

$y = \frac{1.22\lambda}{2\sin\alpha}$ (with air or vacuum between the object and the objective).

$y = \frac{1.22\lambda}{2n\sin\alpha}$ (with a medium of refractive index *n* between the object and the objective).

- Certain microscopes have oil immersion objectives owing to the fact that the resolving power can be increased using a transparent medium of greater refractive index between the object and the objective.

Validity of Ray Optics

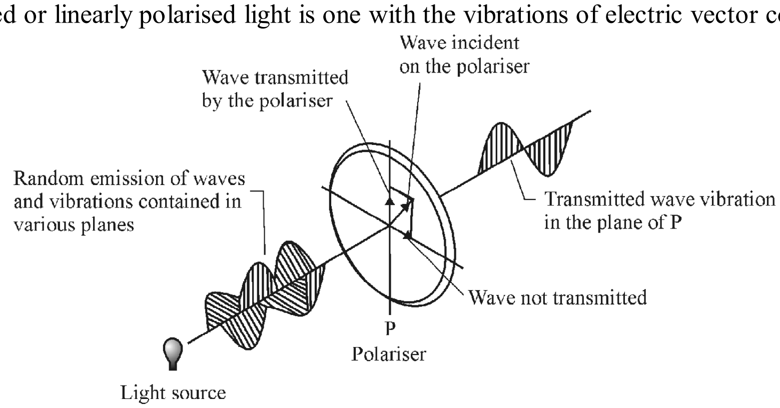
- Fresnel distance refers to the distance from the slit or aperture beyond which the divergence due to diffraction becomes significant.
- For an aperture (*a*) illuminated with monochromatic light of wavelength λ, the Fresnel distance is defined to be:

$$z_F = \frac{a^2}{\lambda}$$

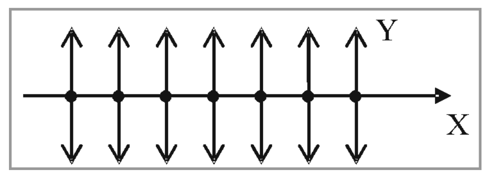
- For distances much greater than z_F, the spreading due to diffraction is dominant over that due to ray optics.
- Ray optics is valid in the limit of wavelength tending to zero.

2. POLARISATION

- Ordinary light waves can have vibrations of the electric vector $\vec{E}$ in all directions perpendicular to the direction of propagation. Usually, light coming out of a source is the resultant of all such waves and referred to as unpolarised light.
- Plane polarised or linearly polarised light is one with the vibrations of electric vector confined to one plane.

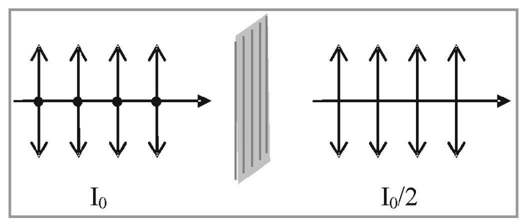


- Polarisation is the phenomenon of confining the vibrations of a wave in a specific direction perpendicular to the direction of the wave motion.
- The plane of polarisation is the plane containing the direction of vibration and wave motion.
- An unpolarised light propagated along the *x*-axis is represented as follows.
  Vibrations in the *y*-direction are indicated by the straight arrows and those in the z-direction by dots.
- When an unpolarised light is converted to a plane polarised light, its intensity gets reduced to half its initial value.
- Polarisation is the convincing proof of the transverse nature of wave. Longitudinal waves do not undergo polarisation.
- The fact that light undergoes polarisation proved beyond doubt that light is propagated in the form of transverse waves. Sound waves cannot be polarised and so they are longitudinal in nature.
- When nicol prism and polaroids are used to obtain plane polarised light from unpolarised light, then they are called polarisers.
- There can be circularly polarised or elliptically polarised light. This can be further classified as right handed and left handed.
- Circularly polarised light results from the superposition of two mutually perpendicular plane polarised lights of equal amplitudes with a phase difference of $\pi/2$. Elliptically polarised light is formed in a similar manner, but with plane polarised lights of unequal amplitudes.



Intensity of Light Emerging from a Polaroid

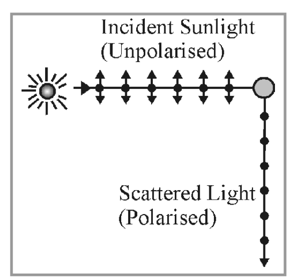
- If the vibrations of amplitude A of a plane polarised light makes an angle θ with the transmission axis of a polaroid it encounters, the emerging light will have vibrations of amplitude A cos θ parallel to the transmission axis.
  Initial intensity: $I_0 = KA^2$
  Emerging intensity: $I = K(A\cos\theta)^2 = I_0\cos^2\theta$
  This is called Malus law.



- It can be shown that if an unpolarised light is converted to a plane polarised light, then the intensity becomes half the initial value. $I = \frac{I_0}{2}$
- If the transmission axis of a polaroid is parallel to the vibrations of a plane polarised light, then no intensity is lost (as θ = 0 and cos θ = 1).
- If the transmission axis of a polaroid is perpendicular to the vibrations of a plane polarised light, then the emerging intensity is 0 (as θ = 90° and cos 90 = 0). This means that no light emerges.
- Polaroids are used to cut the intensity of light and also for the realisation of 3D pictures.

Polarisation by Scattering

- When light gets scattered from minute particles, the scattered light in directions perpendicular to the direction of incident light is completely plane polarised.



Polarisation by Reflection

- Brewster's discovery: When light is incident on a transparent surface at a particular angle, the reflected light is completely plane polarised with vibrations in a plane perpendicular to the plane of the incidence. This specific angle is called Brewster's angle and is denoted by $\mathbf{i_B}$.
- Brewster's law: The relation between Brewster's angle and the refractive index is given by Brewster's law.
  $\tan i_B = \mu$
- If light is incident from air(vacuum) on the surface of a medium, then μ gives the absolute refractive index of the medium. Otherwise, μ gives the refractive index of the second medium with respect to the first.
- The refracted light is partially polarised.
- If light is incident at Brewster's angle, the reflected and refracted rays are perpendicular to each other.

2012

1. (a) Why are coherent sources necessary to produce a sustained interference pattern? (b) In Young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$.

2. Use Huygen's principle to explain the formation of diffraction pattern due to a single slit illuminated by a monochromatic source of light.

When the width of the slit is made double the original width, how would this affect the size and intensity of the central diffraction band?

2011

1. (a) Describe briefly, with the help of suitable diagram, how the transverse nature of light can be demonstrated by the phenomenon of polarization. (b) When unpolarized light passes from air to a transparent medium, under what condition does the reflected light get polarized. **(3 Marks)**

2. Describe Young's double slit experiment to produce interference pattern due to a monochromatic source of light. Deduce the expression for the fringe width.

Or

Use Huygen's principle to verify the laws of refraction.

2010

1. What is an unpolarized light? Explain with the help of suitable ray diagram how an unpolarized light can be polarized by reflection from a transparent medium. Write the expression for Brewster angle in terms of the refractive index of denser medium. **(3 Marks)**

2. State Huygens's principle. Show, with the help of a suitable diagram, how this principle is used to obtain the diffraction pattern by a single slit.

Draw a plot of intensity distribution and explain clearly why the secondary maxima becomes weaker with increasing order (n) of the secondary maxima. **(5 Marks)**

2009

1. If the angle between the pass axis of polarizer and the analyser is 45°, write the ratio of the intensities of original light and the transmitted light after passing through the analyser. **(1 Mark)**

2. What type of wavefront will emerge from a (*i*) point source, and (*ii*) distant light source. **(1 Mark)**

3. Draw a diagram to show refraction of a plane wave front incident in a convex lens and hence draw the refracted wave front. **(1 Mark)**

4. Unpolarized light is incident on a plane surface of glass of refractive index μ at angle i. If the refected light gets totally polarized, write the relation between the angle i and refractive index μ. **(1 Mark)**

5. In a single slit diffraction experiment, when a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why.

State two points of difference between the interference pattern obtained in Young's double slit experiment and the diffraction pattern due to a single slit. **(3 Marks)**

2008

1. How does the angular separation of interference fringes change, in Young's experiment, if the distance between the slits is increased. **(1 Mark)**

2. How does the fringe width of interference fringes change, when the whole apparatus of Young's experiment is kept in a liquid of refractive index 1.3. **(1 Mark)**

3. How is a wave front defined. Using Huygens's construction, draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection.

(3 Marks)

4. (*a*) What is plane polarized light. Two polaroids are placed at 90° to each other and the transmitted intensity is zero. What happens when one more Polaroid is placed between these two, bisecting the angle between them. How will the intensity of transmitted light vary on further rotating the third Polaroid.

(*b*) If a light beam shows no intensity variation when transmitted through a Polaroid which is rotated, does it mean that the light is unpolarised. Explain briefly. **(5 Marks)**

2007

1. Define resolving power of a compound microscope. How does the resolving power of a compound microscope change when

(*i*) refractive index of the medium between the object and objective lens increases .

(*ii*) wavelength of the radiation used is increased . **(2 Marks)**

2. Define the term 'resolving power' of an astronomical telescope. How does it get affected on

(*i*) increasing the aperture of the objective lens. (*ii*) increasing the wavelength of the light used.

Justify your answer in each case. **(3 Marks)**

3. What are coherent sources. Why are coherent sources required to produce interference of light. Give an example of interference of light in everyday life. In Young's double slit experiment, the two slits are 0.03 cm apart and the screen is placed at a distance of 1.5 m away from the slits. The distance between the central bright fringe and fourth bright fringe is 1 cm. Calculate the wavelength of light used. **(5 Marks)**

4. State the condition under which the phenomenon of diffraction of light takes place. Derive an expression for the width of the central maximum due to diffraction of light at a single slit. A slit of width 'a' is illuminated by a monochromatic light of wavelength 700 nm at normal incidence. Calculate the value of 'a' for position of

(*i*) first minimum at an angle of diffraction of 30°.

(*ii*) first maximum at an angle of diffraction of 30°. **(5 Marks)**

5. State the essential condition for diffraction of light to take place.Use Huygen's principle to explain diffraction of light due to a narrow single slit and the formation of a pattern of fringes obtained on the screen. Sketch the pattern of fringes formed due to diffraction at a single slit showing variation of intensity with angle. **(5 Marks)**

6. What are coherent sources of light. Why are coherent sources required to obtain sustained interference pattern. State three characteristic features which distinguish the interference pattern due to two coherently illuminated sources as compared to that observed in a diffraction pattern due to a single slit. **(5 Marks)**

7. Define the term 'wavefront'. Draw the wavefront and corresponding rays in the case of a

(*i*) diverging spherical wave, (*ii*) plane wave.

Using Huygen's construction of a wavefront, explain the refraction of a plane wavefront at a plane surface and hence verify Snell's law. **(5 Marks)**

2006

1. Two wavelengths of sodium light 590 nm, 596 nm are used, in turn, to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of first maximum of the diffraction pattern obtained in the two cases. **(3 Marks)**

2. In Young's slit experiment, interference fringes are observed on a screen, kept at a distance D from the slits. If the screen is moved towards the slits by 5×10^{-2} m, the change in fringe width is found to be 3×10^{-5} m. If the separation between the slits is 10^{-3} m, calculate the wavelength of the light used. **(3 Marks)**

3. Explain, using Huygen' principle, how diffraction is produced by a narrow slit which is illuminated by a monochromatic light. Show that central maximum is twice as wide as the other maxima and the pattern becomes narrower as the width of the slit is increased. **(3 Marks)**

4. What is interference of light. Write two essential conditions for sustained interference pattern to be produced on the screen. **(5 Marks)**

5. Draw a graph showing the variation of intensity versus the position on the screen in Young's experiment when (*a*) both the slits are opened and (*b*) one of the slits is closed.

What is the effect on the interference pattern in Young's double slit experiment when:

(*i*) screen is moved closer to the plane of slits.

(*ii*) separation between two slits is increased. Explain your answer in each case. **(5 Marks)**

6. What is diffraction of light. Draw a graph showing the variation of intensity with angle in a single slit diffraction experiment. Write one feature which distinguishes the observed pattern from the double slit interference pattern.
How would the diffraction pattern of a single slit be affected when:
(*i*) the width of the slit is decreased.
(*ii*) the monochromatic source of light is replaced by a source of white light. **(5 Marks)**

7. What are coherent sources of light. State two conditions for two light sources to be coherent. Derive a mathematical expression for the width of interference fringes obtained in Young's double slit experiment with the help of a suitable diagram. **(5 Marks)**

8. (*a*) State Huygens' principle. Using the geometrical construction of secondary wave- lets, explain the refraction of a plane wave front incident at a plane surface. Hence verify Snell's law of refraction.
(*b*) Illustrate with the help of diagrams the action of (*i*) convex lens and (*ii*) concave mirror on a plane wave front incident on it. **(5 Marks)**

2005

1. What are coherent sources. How does the width of interference fringes in Young's double slit experiment change when
(*a*) the distance between the slits at screen is decreased. (*b*) frequency of the source is increased.
Justify your answer in each case. **(3 Marks)**

2. (*a*) How is a wavefront different from a ray. Draw the geometrical, shape of the wavefronts when (*i*) light diverges from a point source, and (*ii*) light emerges out of a convex lens when a point source is placed as its focus.
(*b*) State Huygens' Principle. With the help of a suitable diagram, prove Snell's law of refraction using Huygens' Principle. **(5 Marks)**

3. (*a*) In Young's double slit experiment, deduce the conditions for (*i*) constructive, and (*ii*) destructive interference at a point on the screen. Draw a graph showing variation of the resultant intensity in the interference pattern against position 'x' on the screen.
(*b*) Compare and contrast the pattern which is seen with two coherently illuminated narrow slits in Young's experiment with that seen for a coherently illuminated single slit producing diffraction. **(5 Marks)**

4. Using Huygen's principle, draw a diagram to show propagation of a wave-front originating from a monochromatic point source. Describe diffraction of light due to a single slit. Explain formation of a pattern of fringes obtained on the screen and plot showing variation of intensity with angle θ in single slit diffraction. **(5 Marks)**

5. What is meant by a linearly polarised light. Which type of waves can be polarised. Briefly explain a method for producing polarised light. Two polaroids are placed at 90^0 to each other and the intensity of transmitted light is zero. What will be the intensity of transmitted light when one more polaroid is placed between these two bisecting the angle between them. Take intensity of unpolarised light as I. **(5 Marks)**

2004

1. Define the term 'wavefront'. **(1 Mark)**

2. Two identical coherent waves, each of intensity I, are producing an interference pattern. Write the value of the resultant intensity at a point of (*i*) constructive interference and (*ii*) destructive interference. **(1 Mark)**

3. What is meant by coherent sources of light. Can two identical and independent sodium lamps act as coherent sources. Give reason for your answer. **(2 Marks)**

4. Draw a diffraction pattern due to a single slit illuminated by a monochromatic source of light. Light, of wavelength 500 nm, falls, from a distant source on slit 0.50 mm wide. Find the distance between the two dark bands, on either side of the central bright band, of the diffraction pattern observed, on a screen placed 2 m from the slit. **(2 Marks)**

5. (*a*) State two conditions to obtain sustained interference of light.
(*b*) In Young's double slit experiment, using light of wavelength 400 nm, interference fringes of width 'X' are obtained. The wavelength of light is increased to 600 nm and the separation between the slits is halved. If one wants the observed fringe width on the screen to be the same in the two cases, find the ratio of the distance between the screen and the plane of the interfering sources in the two arrangements. **(3 Marks)**

6. Which special characteristic of light is demonstrated only by the phenomenon of polarisation. Distinguish clearly between linearly polarized light and unpolarized light. Light is incident, at the Brewster angle, from air, on to a transparent medium. How are the resulting reflected and refracted rays oriented with respect to each other. Obtain a relation between the refractive index of the medium and the Brewster angle. What is the nature of polarisation, of the reflected light, in this case. **(5 Marks)**