Optics

Ray Optics :

C1 Law of Rectilinear Propagation of Light.

It states that light propagates in straight lines in homogeneous media. It is due to very smaller wavelength of light

C2 Types of image & types of objects :

(i) **Real image :** If reflected (or refracted) rays converge to a point (i.e. intersect there), the point is a real image.

(ii) **Virtual image :** If reflected (or refracted) rays appear to diverge from a point, the point is a virtual image.

(iii) **Real object :** If the incident rays diverge from a point, the point is a real object.

(iv) **Virtual object :** If incident rays are appear to converge at a point behind the mirror (or lens), the point is a virtual object.

C3 Laws of Reflection

(i) The incident-ray, the reflected-ray and the normal to the reflecting surface at the point of incidence all lie in the same plane.

(ii) The angle of reflection (r) is equal to the angle of incidence (i) i.e. i = r.

These laws are applicable to all reflecting surfaces either plane or curved.

C4 Reflection From Plane Surface

(i) When a real object is placed in front of a plane mirror, the image is always erect, virtual and of same size as the object. It is at same distance behind the mirror as the object is infront of it.

(ii) The image formed by a plane mirror suffers **lateral-inversion** i.e., in the image formed by a plane mirror left is turned into right and vice-versa with respect to object a shown in the figure.

(iii) **Deviation** (δ) is defined as the angle between directions of incident ray and emergent ray.

If a ray is incident at an angle i, then the deviation is given by $\delta = 180 - (i + r) = (180 - 2i)$

The deviation is maximum for normal incidence. $\delta_{max} = 180^0$ when i = 0

(iv) Keeping the incident ray fixed, if the mirror is rotated through an angle θ, about an axis in the plane of mirror then the reflected ray rotates through an angle 2θ.

(v) If a person of height h wants to see his full image in a plane mirror, the minimum height of the mirror should be h/2, whatever be the distance of the person from the mirror. The mirror should be placed such that its upper edge is midway between the head and the eye of the person and the lower edge is midway between his feet and eye.

(vi) Number of images of an object in two mirrors inclined to each other at angle θ is given by

$$(n) = \begin{cases} \mathbf{k} & \textbf{if k is odd} \\ \mathbf{k-1} & \textbf{if k is even} \end{cases} \quad \text{where } \mathbf{k = \frac{360}{\theta}}.$$

<u>**Practice Problems :**</u>

1. Plane mirrors A and B are kept at an angle θ with respect to each other. Light falls on A, is reflected, then falls on B and is reflected. The emergent ray is opposite to the incident direction. Then the angle θ is equal to

(a) 30^0 (b) 45^0 (c) 60^0 (d) 90^0

2. An object is placed in front of the plane mirror. The mirror is approaching the object at 10 cm/s. The image of the object has the velocity with respect to mirror is

(a) 5 cm/s (b) 10 cm/s (c) 15 cm/s (d) 20 cm/s

[Answers : (1) d (2) b]

C5 Reflection from Curved Surfaces : To calculate the image distance and height of image due to reflection from curved surface, we will use the following formula

1. Mirror formula : $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ **2. Lateral Magnification,** $m=\frac{-v}{u}$

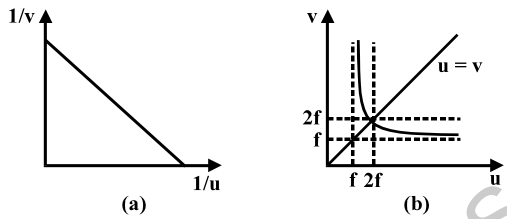
Important Points :

(i) As focal-length of a spherical mirror f (= R/2) depends only on the radius of mirror and is independent of wavelength of light and refreactive index of medium. Hence the focal length of a spherical mirror in air or water and for red or blue light is same. This is also why the image formed by mirrors do not show chromatic aberration.

(ii) In case of spherical mirrors if object distance (x_1) and image distance (x_2) are measured from focus instead of pole then the relation between x_1 and x_2 is given by $x_1x_2 = f^2$. The graph between x_1 and x_2 is hyperbola. This result is called **'Newton's formula'.**

(iii) In case of spherical mirrors if we plot a graph between -

(a) (1/u) and (1/v) the graph will be a straight line with intercept (1/f) . This is shown in figure.



(a) Graph between 1/u and 1/v is a straight line
(b) Graph between u and v is a hyperbola

(b) u and v the graph will be a hyperbola as for u = f; v = ∞ and for u = ∞, v = f. A line u = v will cut this hyperbola at (2f, 2f). This all shown in figure.

<u>**Practice Problems :**</u>

1. An object 5 cm tall is placed 1 m from a concave spherical mirror which has a radius of curvature of 20 cm. The size of the image is

(a) 0.11 cm (b) 0.50 cm (c) 0.55 cm (d) 0.60 cm

2. A thin rod of length f/3 lies along the axis of a concave mirror of focal length f. One end of its image touches an end of the rod. The length of the image is

(a) f (b) f/2 (c) 2f (d) 1.5 f

3. The distance of an object from theconvex mirror of focal length 20 cm such that an image (1/4)th of the size of the object is formed

(a) 40 cm (b) 50 cm (c) 60 cm (d) 70 cm

4. If object begins to move with speed v_0 then the speed of its image w.r.t. mirror of focal length f when the object is at the distance u is given by

(a) $-\left(\frac{f}{u-f}\right)^2 v_0$ **(b)** $\left(\frac{f}{u-f}\right)^2 v_0$ **(c)** $-\left(\frac{f}{u-f}\right) v_0$ **(d)** $\left(\frac{f}{u-f}\right) v_0$

[Answers : (1) c (2) b (3) c (4) b]

C6 Refraction :

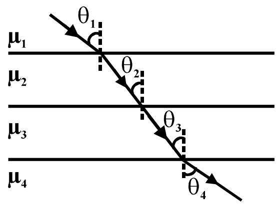
Laws of Refraction (Snell's Law)

(i) The incidence ray, the refracted ray and the normal to the refracting surface at the point of incidence all lie in the same plane.

(ii) The ratio of the sines of the angle of incidence (i) and the angle of refraction (r) is a constant quantity μ for two given media, which is called the refractive index of the second medium with respect to the first.

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

When light propagates through a series of layers of different medium as shown in the figure,



A series of transparent layers of different rafractive indices

then the **Snell's law** may be written as

$$\mu_1\sin\theta_1 = \mu_2\sin\theta_2 = \mu_3\sin\theta_3 = \mu_4\sin\theta_4 = \text{constant}$$

In general, $\mu\sin\theta$ = constant

Practice Problems :

1. **A beam of monochromatic blue light of wavelength 4200 Å in air travels in water (n = 4/3). Its wavelength and frequency in water is**

(a) **2800 Å , 7.1 ×10^{14} Hz** **(b)** **5600 Å, 7.1 ×10^{14} Hz**

(c) **3150 Å , 7.1 ×10^{14} Hz** **(d)** **4000 Å, 7.1 ×10^{14} Hz**

[Answers : (1) c]

~~C7 Apparent shift~~

The apparent shift in the position of the source is $s = h - h' = h\left(1 - \frac{1}{\mu}\right)$.

If there are n numbers of slabs with different regractive indices are placed between the observer and the object, then the total apparent shift is equal to the summation of all the individual shifts.

$s = s_1 + s_2 + ... + s_n$

or $$s = h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right) + ... + h_n\left(1 - \frac{1}{\mu_n}\right)$$

If the shift comes out to be positive, the image of the object shifts toward the observer, and vice-versa.

Practice Problems :

1. **An air bubble inside a glass slab appears to be 6 cm deep when viewed from one side and 4 cm deep when viewed from the opposite side. The thickness of the slab is**

(a) **10 cm** **(b)** **6.67 cm** **(c)** **15 cm** **(d)** **12 cm**

2. **A glass hemisphere of radius 0.04 m and refractive index 1.6 is placed centrally over a cross mark on a paper (i) with the flat face, and (ii) with the curved face in contact with the paper. In each case the cross mark is viewed directly from above. The positions of the images will be**

(a) **(i)** **0.04 m from the flat face**
(ii) **0.025 m from the flat face**

(b) **(i)** **at the position of the cross mark**
(ii) **0.025 m below the flat face**

(c) **(i)** **0.025 m from the flat face**
(ii) **0.04 m from the flat face**

(d) **0.04 m from the highest point of the hemi sphere for both (i) and (ii).**

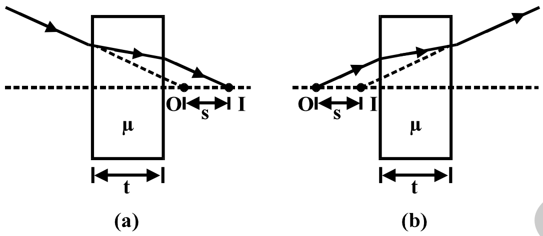
3. A bird in air looks at a fish vertically below it inside water. The height of the bird above the surface of water is h and the depth of the fish below the surface of water is d. If the refractive index of water is n, then the distance of the fish as observed by the bird is

(a) $h+\frac{d}{n}$ **(b)** $h-\frac{d}{n}$ **(c)** $h-\frac{2d}{n}$ **(d)** $h-\frac{d}{2n}$

[Answers : (1) c (2) b (3) a]

C8 Important Points :

(i) When the glass slab of thickness t and refractive index μ is placed in the path of a convergent beam as shown in the figure, then the point of convergence is shifted by $\mathbf{s = t\left(1-\frac{1}{\mu}\right)}$



(ii) When the same glass slab is placed in the path of the divergent beam as shown in figure, then the path of divergence also gets shifted by $\mathbf{s = t\left(1-\frac{1}{\mu}\right)}$

C9 Total Internal Reflection and Critical Angle :

Total internal reflection can occur when the light will travel from denser medium to rarer medium and angle of incidence should be greater than the critical angle. The critical angle is defined as the angle of incidence at which the angle of refraction will be π/2.

Applying Snell's law at the critical angle $\mu_2 \sin \theta_c = \mu_1$ or $\boldsymbol{\theta_c = \sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)}$

<u>Practice Problems :</u>

1. A ray of light traveling in glass (μ = 3/2) is incident on a horizontal glass - air surface at the critical angle C. If a thin layer of water (μ = 4/3) is now poured on the glass air surface, the angle at which the ray of light emerge into air at the water - air surface is

(a) 40.4^0 **(b)** 58.3^0 **(c)** 65.2^0 **(d)** 90^0

2. A point source of light is placed 4 m below the surface of a liquid of refractive index 5/3. The minimum diameter of a disc, which should be placed over the source, on the surface of the liquid to cut off all light coming out of water, is

(a) ∞ **(b)** 6 m **(c)** 4 m **(d)** 3 m

3. A ray of light from a denser medium strikes a rarer medium at angle of incidence i. The reflected and the refracted rays make an angle of 90^0 with each other. The angles of reflection and refraction are r and r' respectively. The critical angle is

(a) $\sin^{-1}(\tan r)$ **(b)** $\cos^{-1}(\tan i)$ **(c)** $\sin^{-1}(\tan r')$ **(d)** $\tan^{-1}(\sin i)$

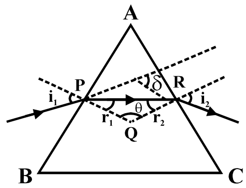
[Answers : (1) b (2) b (3) a]

C10 Prism

(i) **Angle of prism** or **refracting angle** (A) of prism means the angle between the faces on which light is incident and from which it emerges,

If the faces of a prism on which light is incident and from which it emerges becomes parallel, angle of prism will be zero and as incident ray will emerge parallel to itself, deviation will also be zero i.e., the prism will act as a slab.

(ii) **Deviation Produced by a Prism**



$\delta = i + e - A$

The deviation produced by small angle of prism is given by $\delta = A(\mu - 1)$

(iii) **Minimum deviation**

Theory and experiment show that δ will be minimum when the angle of incidence equal to the angle of emergence. The refractive index of the prism is given by $\mu = \dfrac{\sin i}{\sin r} = \dfrac{\sin\left[\dfrac{\delta_{min} + A}{2}\right]}{\sin\left[\dfrac{A}{2}\right]}$

Note that if the prism is equilateral or isosceles then the ray inside the prism is parallel to its base.

(iv) **Maximum deviation**

Maximum deviation occurs when the angle of incidence i is maximum ($i_{max} = 90^0$)

$\therefore \quad \delta_{max} = 90 + e - A$

(v) **Condition of No Emergence**

A ray of light will not emerge out of a prism (whatever be the angle of incidence) if $A > 2\theta_c$, that is, if $\mu > \text{cosec}(A/2)$.

(vi) **Condition of Grazing Emergence**

If a ray can emerge out of a prism, the value of angle of incidence i for which angle of emergence $e = 90^0$ is called the condition of **grazing emergence.**

The value of i for grazing emergence is given by $\mathbf{i = \sin^{-1}[\sqrt{(\mu^2 - 1)}\sin A - \cos A]}$

<u>**Practice Problems :**</u>

1. A ray of light passes through an equilateral prism such that the angle of emergence is equal to the angle of incidence and each is equal to (3/4)th of the angle of prism. The angle of deviation is

(a) 45^0 (b) 39^0 (c) 20^0 (d) 30^0

2. The refracting angle of a prism is A and the refractive index of the material of the prism is cot (A/2). The angle of minimum deviation is

(a) $180^0 - 3A$ (b) $180^0 + 2A$ (c) $90^0 - A$ (d) $180^0 - 2A$

3. A ray of light is incident at angle i on one surface of a prism of small angle A and emerges normally from the opposite surface. If the refractive index of the material of the prism is μ, the angle of incidence i is nearly equal to

(a) A/μ (b) A/2μ (c) μ A (d) μ A/2

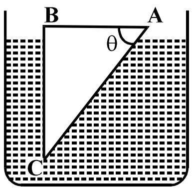
4. The angle of a prism is 60^0 and the refractive index of the material of the prism is √2. The angle of incidence for minimum deviation is

(a) 45^0 (b) 60^0 (c) 30^0 (d) $\sin^{-1}(2/3)$

5. If the refracting angle of a prism is 60^0 and the minimum deviation is 30^0, then the angle of incidence is

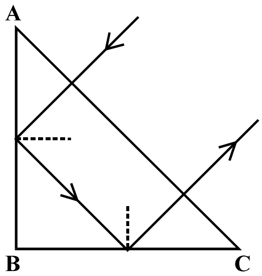
(a) 30^0 (b) 60^0 (c) 45^0 (d) 90^0

6. A glass prism of refractive index 1.5 is immersed in water (refractive index 4/3). A light beam incident normally on the face AB is totally reflected to reach the face BC, if



(a) $\sin\theta \geq 8/9$ (b) $\sin\theta \leq 2/3$ (c) $2/3 < \sin\theta < 8/9$ (d) none of these

7. A ray falls on a prism ABC (AB = BC) and travels as shown in the figure. The minimum refractive index of the prism material should be



(a) 4/3 (b) $\sqrt{2}$ (c) 3/2 (d) $\sqrt{3}$

8. A ray of light undergoes deviation of 30^0 when incident on an equilateral prism of refractive index $\sqrt{2}$. The angle made by the ray inside the prism with the base of the prism is

(a) 15^0 (b) 0^0 (c) 45^0 (d) 30^0

9. Ray cannot pass through a prism whose refracting angle is A. If the critical angle of the the material of the prism is C, then

(a) A < 2C (b) A ≥ 2C (c) A ≥ C (d) A < C

[Answers : (1) d (2) d (3) c (4) a (5) c (6) a (7) b (8) b (9) b]

C11 Refraction on Curved Surfaces :

General formula for refraction at curved surface is given as : $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

where u is the position of the object from the pole
v is the position of the image from the pole
R is the radius of curvature of the surface
μ_1 is the refractive index of the medium in which ray is incident
μ_2 is the refractive index of the medium in which ray is refracted.

<u>Practice Problems :</u>

1. A ray of light falls on the surface of a spherical glass paper-weight making an angle α with the normal and is refracted in the medium at an angle β. The angle of deviation of the emergent ray from the direction of the incident ray is

(a) (α – β) (b) 2(α – β) (c) (α – β)/2 (d) (α + β)

[Answers : (1) b]

C12 Importan points for the lens :

1. Lens Formula : $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

2. Lateral Magnification, $m = \frac{v}{u}$

3. Lensmaker's formula $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

4. **Power of Lens**

Power of a lens is defined as the reciprocal of focal length, where f is measured in metre. If f is in metre then the power P of the lens in dioptres is given, $P = \frac{1}{f}$. The unit of power is dioptre.

Practice Problems :

1. An object 15 cm high is placed 10 cm from the optical centre of a thin lens. Its image is formed 25 cm from the optical centre on the same side of the lens as the object. The height of the image is

(a) 2.5 cm (b) 0.2 cm (c) 16.7 cm (d) 37.5 cm

2. A thin symmetric convex lens of refractive index of the material 1.5 and radius of curvature 0.5 m is immersed in water of refractive index $\frac{4}{3}$. Its focal length will be

(a) 0.20 m (b) 4.00 m (c) 2.00 m (d) 0.02 m

3. Focal length of a convex lens is maximum for

(a) blue light (b) yellow light (c) green light (d) red light

4. Chromatic aberration in a lens is caused by

(a) reflection (b) interference (c) diffraction (d) dispersion

5. The focal-lenght of lens depends on

(a) wavelength of the light used (b) refractive index of medium

(c) refractive index of material of lens (d) radius of curvature

[Answers : (1) d (2) c (3) d (4) d (5) a, b, c, d]

C13 Equivalent Focal Length of Lens Combination

If n number of lenses of focal lengths $f_1, f_2, f_3, \ldots . f_n$ are joined together then the equivalent focal length of the combination is given by $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \ldots . + \frac{1}{f_n}$

In terms of power $p = p_1 + p_2 + \ldots . + p_n$

Sign Convention

Focal length of converging lens is taken as positive and that of the diverging lens is taken as negative.

Practice Problems :

1. A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of the combination in dioptres is

(a) – 1.5 (b) – 6.5 (c) + 6.5 (d) + 6.67

2. An achromatic combination is to be made using a convex and a concave lens. The two lenses should have

(a) their powers equal

(b) their refractive indices equal

(c) **their dispersive powers equal**

(d) **the product of their powers and dispersive powers equal**

[Answers : (1) a (2) d]

C14 Equivalent Focal Length of Lens Mirror Combination

The combination acts like a mirror whose equivalent focal length is given by $\frac{1}{F} = \frac{2}{f_l} + \frac{1}{f_m}$

where f_l = focal length of lens and f_m = focal length of mirror

Sign Convention

Focal length of converging lens or mirror is positive; and that of diverging lens or mirror is negative.

Practice Problems :

1. An equiconvex lens of glass (μ_g = 1.5) of focal length 10 cm is silvered on one side. It will behave like a

(a) **concave mirror of focal length 10 cm**

(b) **convex mirror of focal length 5.0 cm**

(c) **concave mirror of focal length 2.5 cm**

(d) **convex mirror of focal length 20 cm**

[Answers : (1) c]

C15 Optical Instruments

1. **Simple microscope :** It is a converging lens of small focal length f. The magnification of this microscope is given by (a) when the image is at the near point (at the distance D = 25 cm from the lens) then the magnification is given by $1 + \frac{D}{f}$. (b) when the image at infinity then magnification is given by $\frac{D}{f}$. In both cases the nature of the image is virtual, erect and enlarged.

2. **Compound microscope :** It consists of two converging lens, one is objective of smaller focal length (f_0) and an eyepiece of larger focal length (f_e). The final image formed is virtual, enlarged and inverted. The magnification of this microscope is given by (a) when the image is at the near point (at the distance D = 25 cm from the lens) then the magnification is given by $\left(\frac{L}{f_0}\right)\left(1 + \frac{D}{f_e}\right)$. (b) when the image at infinity then magnification is given by $\left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$. Here L is the length of the tube of compound microscope.

3. **Astronomical telescope :** Magnifying power m of a telescope is the ratio of the angle β subtended at the eye by the image to the angle α subtended at the eye by the object. $\mathbf{m} = \frac{\beta}{\alpha} = \frac{f_0}{f_e}$, where f_0 and f_e are the focal lengths of the objective and eyepiece, respectively.

Practice Problems :

1. An astronomical telescope has an angular magnification of magnitude 5 for distant objects. The separation between the objective and the eyepiece is 36 cm and the final image is formed at infinity. The focal length f_0 of the objective and f_e of the eye piece are

(a) **f_0 = 45 cm and f_e = – 9 cm** **(b)** **f_0 = 50 cm and f_e = 10 cm**

(c) **f_0 = 7.2 cm and f_e = 5 cm** **(d)** **f_0 = 30 cm and f_e = 6 cm**

2. Four lenses with focal lengths ± 15 cm and ± 150 cm are being placed for use as a telescopic objective. The focal length of the lens which produces the largest magnification with a given eyepiece is

(a) – 15 cm (b) + 150 cm (c) – 150 cm (d) + 15 cm

3. The magnification produced by the objective lens and the eye lens of a compound microscope are 25 and 6 respectively. The magnifying power of this microscope is

(a) 19 (b) 31 (c) 150 (d) $\sqrt{150}$

4. The focal length of the objective and the eye-piece of a compound microscope are 1 cm and 5 cm respectively. An object placed at a distance of 1.1 cm from the objective has its final image formed at 25 cm from the eye-piece. The distance between the objective and the eye-piece is

(a) 15.17 cm (b) 25 cm (c) 10.25 cm (d) 20 cm

[Answers : (1) d (2) b (3) c (4) a]

WAVE OPTICS

C16 Huygen's Principle

1. Every point on a wavefront vibrates in same phase with same frequency
2. Every point on a wavefront acts like a new independent source and sends at a spherical wave, called a secondary wave.
3. Wavefronts move in space with the velocity of wave in that medium.

Using the Huygen's principle we prove the law of refraction and reflection.

Practice Problems :

1. In Huygen's wave theory, the locus of all the points in the same state of vibration is called a :

(a) half period zone (b) vibrator (c) wavefront (d) ray

[Answers : (1) c]

C17 Coherent Sources and Interference

Two sources are coherent if they have the same frequency and a constant phase difference. In this case, the total intensity I is not just the sum of individual intensities I_1 and I_2 due to the two sources but includes an interference term whose magnitude depends on the phase difference ϕ. The resultant test intensity is given

by $\mathbf{I = I_1 + I_2 + \underbrace{2\sqrt{I_1 I_2}\cos\phi}_{\text{Interference term}}}$

For incoherent sources $I = I_1 + I_2$

Practice Problems :

1. Interference fringes are obtained due to the interference of waves from two coherent sources of light with amplitudes a_1 and a_2 ($a_1 = 2a_2$). The ratio of the maximum and minimum intensities of light in the interference pattern is

(a) 2 (b) 4 (c) 9 (d) ∞

2. Two coherent monochromatic light beams of intensities I and 4 I are superposed. The maximum and minimum possible intensities in the resulting beam are

(a) 4 I and I (b) 5 I and 3 I (c) 9 I and I (d) 9 I and 3 I

3. In the Young's double-slit experiment, the interference pattern is found to have intensity ratio between bright and dark fringes as 9. This implies that

(a) the intensities at the screen due to the two slits are 5 units and 4 units respectively.

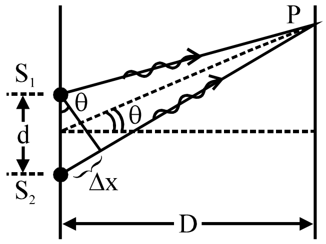
(b) the intensities at the screen due to the two slits are 4 units and 1 unit respectively

(c) the amplitude ratio is 2

(d) both (b) and (c) are correct

[Answers : (1) c (2) c (3) d]

C18 Important point for Young's Double Slit Interference Experiment



(i) Position of nth maxima from the central maxima $\mathbf{y_n = n\lambda \frac{D}{d}}$ where n = 0, 1, 2,.............

(ii) Position of nth minima from the central maxima is given by $\mathbf{y_n = \left(n - \frac{1}{2}\right)\frac{\lambda D}{d}}$

where n = 1, 2, 3,....

(iii) **Fringe Width :** It is defined as the distance between two successive maxima or minima $\boldsymbol{\beta = \frac{\lambda D}{d}}$

(iv) **Intensity Distribution :** In YDSE, usually the intensities I_1 and I_2 are equal then $I = 4I_0\cos^2(\phi/2)$

Practice Problems :

1. In the double-slit experiment, the distance of the second dark fringe from the central line is 3 mm. The distance of the fourth bright fringe from the central line is

(a) 6 mm (b) 8 mm (c) 12 mm (d) 16 cm

2. In Young's experiment, monochromatic light is used to illuminate the two slits and interference fringes are observed on a screen placed in front of the slits. Now if a thin glass plate is placed normally in the path of the beam coming from one of the slits, then

(a) the fringes will disappear

(b) the fringe-width will decrease

(c) the fringe-width will increase

(d) there will be no change in the fringe-width

3. In Young's double-slit experiment, if L is the distance between the slits and the screen upon which the interference pattern is observed, x is the average distance between the adjacent fringes and d is the slit separation, then the wavelength of light is

(a) xd/L (b) xL/d (c) Ld/x (d) 1/Ldx

4. A double-slit interference experiment is set up in a chamber that can be completely evacuated. With monochromatic light, an interference pattern is observed when the container is open to air. As the container is evacuated, a careful observer will note that the interference fringes

(a) do not change at all (b) move slightly farther apart

(c) move slightly closer together (d) disappear completely

5. If a torch is used in place of monochromatic light in Young's experiment

(a) fringes will appear as for monochromatic light

(b) fringes will appear for a moment and then they will disappear

(c) no fringes will appear

(d) only bright fringes will appear

6. For which of the following colours will the fringe-width be minimum in the double-slit experiment ?

(a) violet (b) red (c) green (d) yellow

7. **In a two-slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2}m towards the slits, the change in fringe width is 3×10^{-5}m. If the separation between the slits is 10^{-3} m, the wavelength of light used is**

(a) 6000 Å (b) 5000 Å (c) 4500 Å (d) 3000 Å

8. **The Young's double slit experiment light carried out with light of wavelength 5000 Å. The distance between the slits is 0.2 mm and the screen is at 200 cm from the slits. The central maximum is at x = 0. The third maximum will be at x equal to**

(a) 1.67 cm (b) 1.5 cm (c) 0.5 cm (d) 5.0 cm

9. **In a Young's experiment, two coherent sources are placed 0.9 mm apart and the fringes are observed 1.0 m away. If the second dark fringe is at a distance of 1 mm from the central fringe, the wavelength of light used is**

(a) 60×10^{-10} cm (b) 10×10^{-4} cm (c) 10×10^{-5} cm (d) 6×10^{-5} cm

[Answers : (1) b (2) d (3) a (4) b (5) c (6) a (7) a (8) b (9) d]

C19 Diffraction : The bending the light around corners or spreading of light into the geometrical shadow of an obstacle is called diffraction. Sound wave is easily defracted as comapre to light wave.

Single slit diffraction : If the width of the slit is d and θ is the angle made by the wave with the direction of normal to the slit then (a) the condition of minima is given by $d\sin\theta = n\lambda$ (b) the condition of maxima is given by $d\sin\theta = (n + ½)\lambda$ where n = 1, 2, 3.

Angular width of central maxima is $\frac{2\lambda}{d}$ and width of central maxima is $\frac{2\lambda D}{d}$ where D is the distance between the slit and the screen.

<u>**Practice Problems :**</u>

1. **A diffraction pattern is obtained using a beam of red light. If the red light is replaced by blue light, then**

   (a) the diffraction pattern remains unchanged

   (b) diffraction bands become nattower and crowed together

   (c) bands become broader and farther apart

   (d) bands disappear

2. **To observe diffraction, the size of the obstacle**

   (a) should be of the same order as the wavelength

   (b) should be much larger than the wavelength

   (c) has no relation to wavelength

   (d) should be exactly half the wavelength

3. **Light of wavelength 6328 Å is incident normally on a slit having a width of 0.2 mm. The distance of the screen from the slit is 0.9 m. The angular width of the central maximum is**

   (a) 0.09 degrees (b) 0.72 degrees (c) 0.18 degrees (d) 0.36 degrees

4. **The beam of light of wavelength 600 nm from a distant source falls on a single slit 1.00 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of the central bright fringe is**

   (a) 1.2 cm (b) 1.2 mm (c) 2.4 cm (d) 2.4 mm

[Answers : (1) b (2) a (3) d (4) d]

C20 Resolving power : The resolving power of an instrument is a measure of its ability to resolve two close lying points.

1. **Microscope :** The limit of resolution of a microscope, i.e., the least distance between two point objects which can be distinguished is $d = \frac{\lambda}{2n\sin\theta}$ where λ is the wavelength of light, n is the refractive index of

the medium between the point object and the objective, and θ is the half angle of the cone of light from the object. The expression n sin θ is called the numberical aperture. The resolving power is 1/d.

2. **Telescope :** The resolving power of a telescope is the reciprocal of the smallest angular separation (dθ) between two distant objects whose images are separated in the telescope. This is given by $d\theta = \frac{1.22\lambda}{a}$ where a is the aperture of the objective of telescope.

Practice Problems :

1. To get high resolving power for a telescope, one should use

(a) objective of large aperture **(b) objective of large focal length**

(c) eye piece of large focal length **(d) eye piece of small focal length**

[Answers : (1) a]

C21 Polarization : If the vibrations take place equally in all the directions in a plane perpendicular to the direction of propagation, the wave is called an unpolarized wave. On the other hand, if the vibrations are limited to just one direction in a plane perpendicular to the direction of propagation, the wave is said to be polarized.Only transverse wave can be polarized but longitudinal wave cannot be polarized because they are symmetrical about the direction of propagation.

Malus Law : If the angle between the polarizer and analyzer is θ then the intensity $I = I_0\cos^2\theta$ where I_0 is the maximum intensity and I is the intensity of the polarized light passed through the analyzer.

Polarization by reflection and Brewster's law : It is found that unpolarized light, on reflection from a transparent surface, gets polarized. At a particular angle of incidence, called the polarizing angle or Brewster's anglei_p, the reflected ray is completely polarized. It is observed that when light is incident at polarizing angle, the reflected and the refracted rays are perpendicular to each other. It is easy to show that the refractive index (n) of the medium is related to the polarizing angle as $n = \tan i_p$. This is called **Brewster's law**.

Practice Problems :

1. Plane polarised light is passed through a polaroid. On viewing through the polaroid we find that when the polaroid is given one complete rotation about the direction of light

(a) the intensity of light gradually decreases to zero and remains at zero

(b) the intensity of light gradually increases to a maximum and remains maximum

(c) there is no change in the intensity of light

(d) the intensity of light varies such that it is twice maximum and twice zero

2. A beam of unpolarized light is passed first through a tourmaline crystal A and then through another tourmaline crystal B oriented so that its principal plane is parallel to that of A. The intensity of the emergent light is I. If A is now rotated by 45^0 in a plane perpendicular to the direction of the incident ray, the intensity of the emergent light will be

(a) I/2 **(b) I/√2** **(c) I** **(d) I/4**

[Answers : (1) d (2) a]