9. Ray Optics

Spherical Mirror

- Concave spherical mirror − A spherical mirror whose reflecting surface is towards the centre of the sphere is called concave spherical mirror.
- Convex spherical mirror − A spherical mirror whose reflecting surface is away from the centre of the sphere is called convex spherical mirror.
- Focal length − The distance between the pole and the principal focus of the mirror is called the focal length (*f*) of the mirror.
- For both the spherical mirrors the f = R/2
- Mirror formula for both the mirrors is
- 1f=1u+1v=2R
- For convex mirror:
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Position of object	**Position of object**
At infinity	At the Focus behind the mirror
Between infinity and the pole	Between the pole and the focus behind the mirror

- For concave mirror:
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Position of object	**Position of object**
At infinity	C
Beyond C	Between F and C
At C	At C
Between C and F	Beyond C
Beyond C	At infinity
Between P and F	Behind the mirror

- **Difference between a real image and a virtual image**

S. No.	**Real Image**	**Virtual Image**
1.	Can be obtained on a screen or wall	Cannot be obtained on a screen or wall
2.	Can be touched	Cannot be touched
3.	Formed in front of the mirror	Formed behind the mirror
4.	Formed by concave mirrors only	Formed by all types of mirrors i.e., plane, convex, and concave
5.	These images are always inverted	These images are always erect

Spherical refracting surface

- It is a surface which forms a part of sphere of transparent refracting material.It can be convex or concave.

- The formula that governs the refraction at a spherical surface of radius of curvature R when light teravels from a medium of refractive index n_1 to medium of refractive index n_2 is -n1u+n2v=n2-n1R.

- Lensmaker's formula for both convex and concave lens.

  - 1f=(μ-1)1R1-1R2 where R_1 and R_2 are the radii of curvature of the two surfaces of the lens and μ is the refractive index of of material of lens with respect to the medium in which it is placed

- The relation between the object distance, image distance and focal length is known as lens formula and given as 1f=1v-1u

Power of Lens

- It is defined as the ability of a lens to converge or diverge a beam of light falling on the lens.
- Conjugate foci are the two points on the axis of a lens, corresponding to positions of the object and image, such that their positions are interchangeable.
- Mathematically, power of a lens is expressed as P equals 1 over f. Using the lens maker's formula, P equals space left parenthesis mu minus 1 right parenthesis open parentheses 1 over R subscript 1 minus 1 over R subscript 2 close parentheses
  .
- SI unit of lens power is dioptre.
- *f* should be taken in metres.
- For the combination of n thin lenses of focal length f_1, f_2, f_3,......fn, power,
  P equals 1 over f subscript 1 plus 1 over f subscript 2 plus.................1 over f subscript n

The eye

- It has a convex lens of focal length about 2.5 cm.

- The focal length of can be varied somewhat so that the image is always formed on the retina.

- The ability of the eye to vary its focal length is called accommodation.

- The minimum distance upto which the eye can see the object distinctly and clearly is known as near point, it is at 25 cm from the eye for human eye.

Defects of Vision

- Myopia or (near sightedness) - if the image is focussed before the retina , then a diverging corrective lens is needed.

- Hypermetropia (far sightedness) - if the image is focussed beyond the retina (hypermetropia), then a converging corrective lens is needed.

- Presbyopia - The defect that happens in old age that the person becomes fardsighted; to correct this defect the convex lebns is used.

- Astigmatism - The defect due to which a person is not able to see the vertical and horizontal lines distinctly ; it is corrected by using cylindrical lenses.

Simple microscope

- It consists of a convex lens of small focal length.
- Magnifying power of simple nicroscope is given by m=1+Df

Where, D= 25 cm, is the least distance of distinct vision or near point of the normal eye , f = Focal length of the convex lens

- If the image is formed at infinity then magnifying power m=Df

Compound microscope:

- It consists of two convex lenses objective and eyepiece.
- Image formed by the objective serves as the object for eyepiece.
- The magnifying power is given by m = $m_e \cdot m_0$

Where, m_e is the magnification due to the eyepiece and is $m_o$the magnification due to the objective lens.

Telescope

- It consists of two convex lens—objective and eyepiece—with the eyepiece having less wavelength than the objective.
- The magnifying power m of a telescope is the ratio of angle beta subtended at the eye by the image to angle alpha subtended at the eyepiece by the object.
- When image is at infinity:
  - Magnifying power, M equals negative f subscript o over f subscript e
- When the image is at the near point of the eye:
  - Magnifying power,
    M equals negative open parentheses f subscript o over f subscript e close parentheses open parentheses 1 plus f subscript e over D close parentheses
    Here, f_0 and f_e are the focal lengths of the objective and the eyepiece, respectively.

The Cassegrainian Telescope

- It is a reflecting telescope whose objective lens is replaced by a concave parabolic mirror.
- Parabolic mirrors are free from chromatic and spherical aberrations.
- The use of parabolic mirror makes the resolving power of a telescope high.
- Magnifying power,
  M equals fraction numerator R divided by 2 over denominator f subscript e end fraction

Here, R is the radius of the curvature of the concave mirror and f_e is the focal length of the eyepiece.