Refraction through a Lens – Summary Notes

- **Lens:** It is a transparent refracting medium, usually glass, bounded by two curved surfaces which are generally spherical. The primary function of a lens is to form images of real objects.
- **Types of Lenses:** Lenses are of two types: convex lenses and concave lenses.
  - A convex lens is thicker in the middle and thinner at the edges. It is also called a converging lens because it converges a parallel beam of light rays.
  - A concave lens is thinner in the middle and thicker at the edges. It is also called a diverging lens because it diverges a parallel beam of light rays.
- An imaginary line joining the centres of curvature of two spherical surfaces of a lens is called principal axis.
- A point within a lens, situated on the principal axis, such that any ray of light passing through it does not suffer any deviation, is called optical centre of the lens. It is abbreviated by the letter O.
- **First principal focus for a convex lens:** It is a point on the principal axis of the lens such that the rays of light starting from it after refraction become parallel to the principal axis of the lens.
- **First principal focus for a concave lens:** It is a point on the principal axis of the lens such that the incident rays of light appearing to meet at it after refraction from the lens become parallel to the principal axis of the lens.
- **Second principal focus for a convex lens:** It is a point on the principal axis of the lens such that the rays of light incident parallel to principal axis after refraction from the lens pass through it.
- **Second principal focus for a concave lens:** It is a point on the principal axis such that the rays of light incident parallel to the principal axis after refraction from the lens appear to meet at this point.
- The distance between optical centre and first focus of a lens is called its first focal length.
- The distance between optical centre and second focus of a lens is called its second focal length.
- The focal length of a lens depends on the following factors:
  - Radii of curvature of the lens surfaces
  - Refractive index of the material of the lens
  - Colour or wavelength of light
- If the medium on both sides of a lens is the same, the first and second focal lengths are equal.
- A convex lens always produces real and inverted images, except when it forms a virtual and erect image when an object is between optical centre and focus.
- **Real and Virtual Images**
  - A real image is one from which all the rays of light actually emanate.
  - A virtual image is one from which all the rays of light do not actually come but only appear to do so.
- A concave lens always produces virtual, erect and diminished images.

- In a concave lens, if the objects is at a distance equal to the focal length of the lens, the image is exactly at the midpoint between the optical centre and the second focus of the lens.
- **Rules for Formation of Images by a Spherical Lens**
  - Rays of light parallel and near to the principal axis converge to the principal focus on the other side of the lens by a convex lens, or appear to diverge from the principal focus on the same side of the lens by a concave lens.
  - Rays of light directed towards the optical centre pass through the lens without deviation.
  - Rays of light diverging from the principal focus on the incident side of a convex lens or directed towards the principal focus on the other side of a concave lens become parallel to the principal axis after passing through the lens.

Table: Position, size and nature of images formed by convex and concave lenses for different positions of object

Lens	Position of object	Details of the image			Uses
		Position	Size	Nature	
Convex lens	At infinity	At the focus	Highly diminished	Real and inverted	As a burning glass and in telescopes
	Beyond 2F	Between F and 2F	Diminished	Real and inverted	In photographic cameras
	At 2F	At 2F on the other side of lens	Same size as the object	Real and inverted	In terrestrial telescopes
	Between F and 2F	Beyond 2F	Magnified	Real and inverted	Film and slide projectors
	At F	At infinity	Highly magnified	Real and inverted	In search-lights
	Between F and O	On the same side as the object	Magnified	Virtual and erect	In simple microscopes and spectacles
Concave lens	At infinity	On the same side as the object	Diminished	Virtual and erect	In Galileo telescope as an eyelens
	Between infinity and optical centre	Between F and O on the same side as the object	Diminished	Virtual and erect	In spectacles for correcting short-sightedness

- The measure of convergence and divergence of a lens is called the power of lens. It is measured in dioptre (D). One dioptre is the power of a lens of focal length one metre.

  The power of a convex lens is positive and that of a concave lens is negative.

$$\text{Power of a lens} = \frac{1}{\text{Focal length (in metre)}}$$

- The ratio of the size of the image (I) to the size of the object (O) is called magnification, abbreviated by the letter $m, m = I / O$
  - If $m > 1,$ the image is magnified.
  - If $m < 1,$ the image is diminished.
  - The magnifying power of a microscope = 1 + D/f, where *f* is the focal length of the lens and D is the distance between virtual image and optical centre.