# Optics

## (Lec-1)

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# OUTLINES

- Definitions and classifications of Lens
- Combination of lenses
- Power of a lens.

# Optics

Optics is the branch of physics which involves the behavior and properties of light, including its interactions with matter and the construction of instruments that use or detect it.

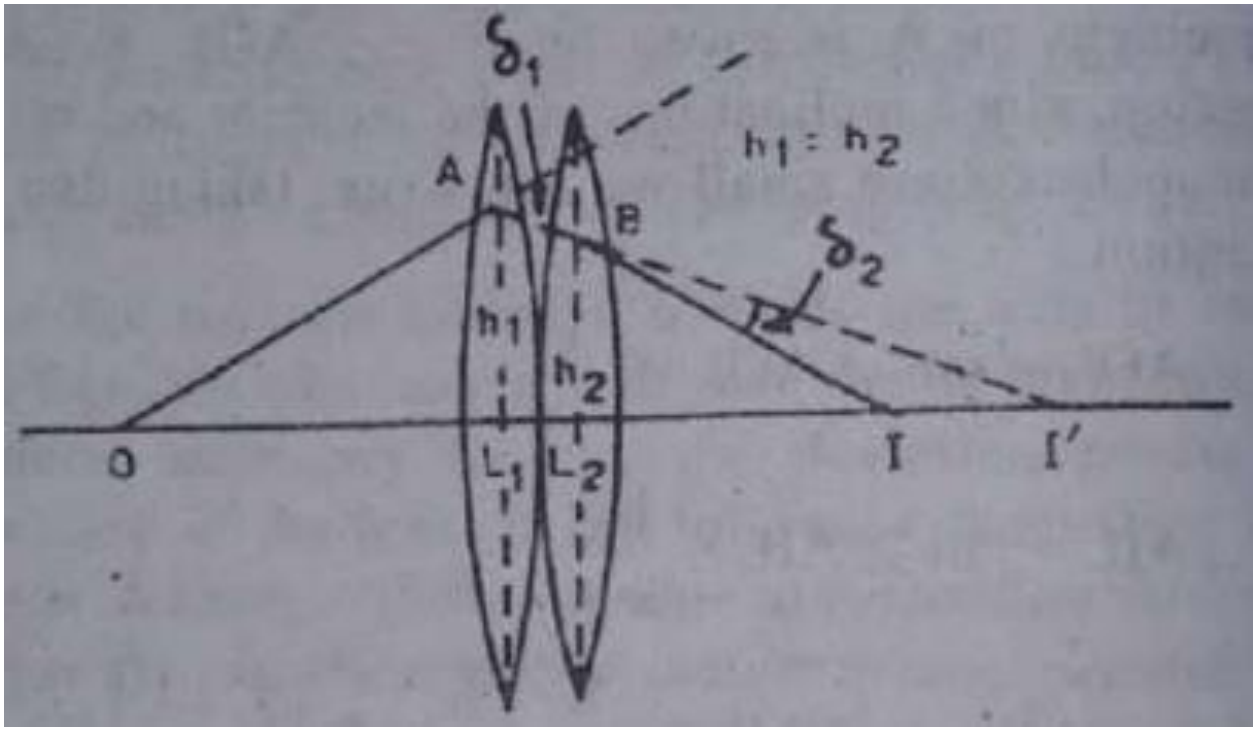
**Lenses:** Lens is an optical device, that works on the principle of refraction of light and consists of a thin, transparent piece of glass or plastic that allows light rays to refract when passed through it. These light rays may converge or diverge after refraction.

**Equivalent Lens:** A single lens is said to be equivalent to a number of lenses when this single lens produces an image of a given object at the same place and of same size as that formed by the number of lenses together. The focal length of such a single lens is known as the equivalent focal length.

# Equivalent focal length of two lenses in contact (by the method of deviation)

$L_1$ and $L_2$ are two thin convex lenses focal lengths $f_1$ and $f_2$. Let a parallel ray strike the first lens at a height $h_1$ above the principal axis.

Let the deviations produced by the first and the second lens be $\delta_1$ and $\delta_2$. Since the deviations produced are in the same direction, the total deviation $\delta = \delta_1 + \delta_2$.



# Cont…

$$\delta_1 = \frac{h_1}{f_1}$$

And

$$\delta_2 = \frac{h_2}{f_2}$$

$$\delta = \delta_1 + \delta_2 = \frac{h_1}{f_1} + \frac{h_2}{f_2}$$

If the combination is replaced by their equivalent lens of focal length f then the deviation

$$\delta = \frac{h_1}{f}$$

Comparing two values of δ, we obtain,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

# CONTINUE…

Under this condition rays parallel to the principal axis, after refraction through this *hypothetical lens*, would also come to focus at F. Accordingly, this lens is termed as the *equivalent lens* for parallel rays' incident on the first lens. $H_2F$ is called the *equivalent focal length* of the combination and the plane $E_2H_2$ along which the equivalent lens must be placed is called the *(second) principal plane* of the optical system. The deviation δ, produced as a result of refraction through the equivalent lens, is given by

$$\delta = \frac{h_1}{f}$$

Now,

$$\delta = \delta_1 + \delta_2$$

Substituting the values of δ, $\delta_1$ and $\delta_2$, we get,

$$\frac{h1}{f} = \frac{h1}{f1} + \frac{h2}{f2} \quad \text{.....(1)}$$

From similar triangles $AL_1F_1$ and $BL_2F_1$, we get

$$\frac{AL_1}{F_1L_1} = \frac{BL_2}{L_2F_1}$$

or,

$$\frac{h_1}{f_1} = \frac{h_2}{f_1 - d}$$

# Cont….

$$h_2 = \frac{h_1(f_1 - d)}{f_1}$$

Substituting this value of $h_2$ in equ. (1)

$$\frac{h_1}{f} = \frac{h_1}{f_1} + \frac{h_1(f_1 - d)}{f_1 f_2}$$

Or,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{f_1 - d}{f_1 f_2}$$

$$= \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Or,

$$f = \frac{f_1 f_2}{f_1 + f_2 - d}$$

## Restriction in equivalent

It should be clearly noted that a single lens will be truly equivalent to two lenses only for objects situated at infinity. If the object is situated at a finite distance, then the equivalence will hold good for one pair of object and image distances only. The equivalence will hold good neither with regard to size not with regard to the position of the image for any other pair of points. Strictly speaking, a single lens is equivalent to two lenses only in a restricted sense. There cannot be any single lens which is equivalent to two lenses as regards the position and magnification of the image for all distances of the object.