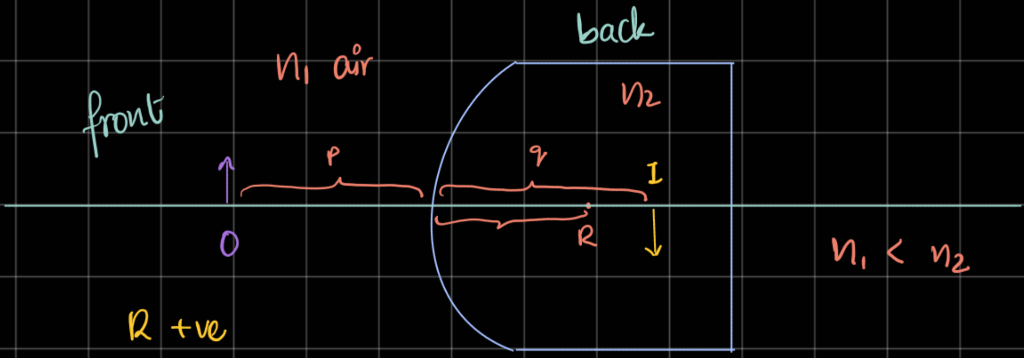
Images by Refraction



$n_1 < n_2$

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

R +ve

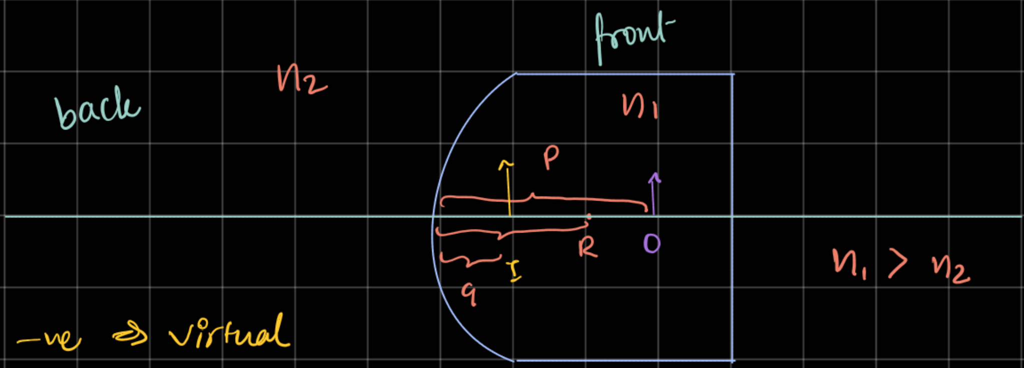
q +ve ⇒ real

M −ve ⇒ inverted

Image is real if it's in back

Image is virtual if it's in front

Refraction is opposite to reflection



$n_1 > n_2$

q −ve ⇒ virtual (front)

M +ve upright

R − ve

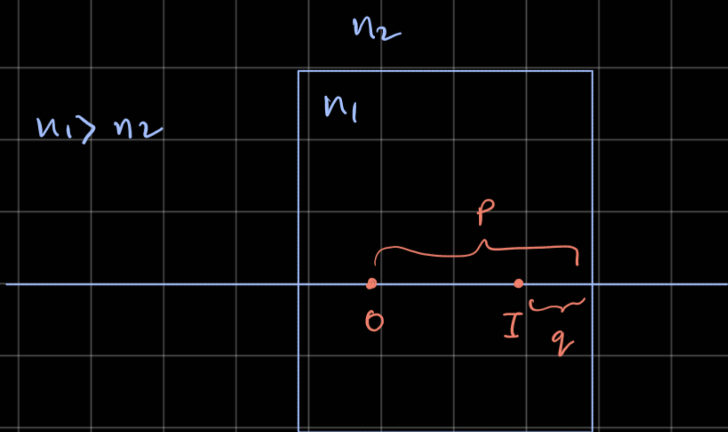
$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

$R = \infty$

$$\frac{n_1}{p} + \frac{n_2}{q} = 0$$

$$q = -\frac{n_2}{n_1} p$$

$n_1 > n_2$



$q \Rightarrow$ Always $-ve$

$q \Rightarrow$ Always virtual

If $n_2 > n_1$

$q \Rightarrow -ve$, virtual, in front

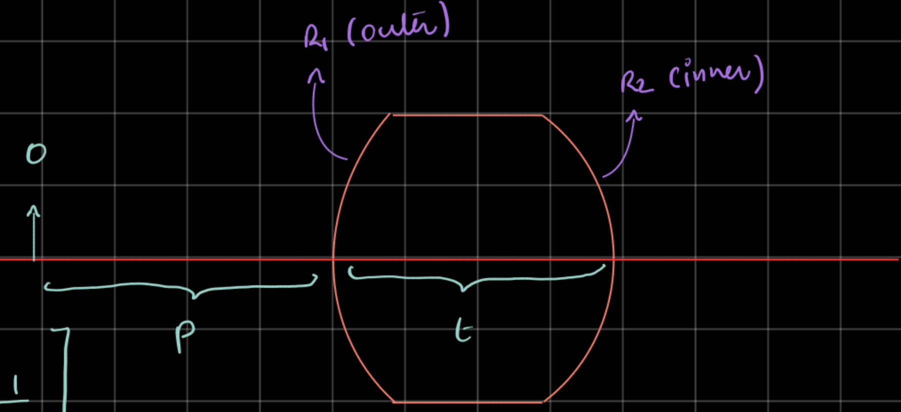
$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

$$\frac{1.5}{2} + \frac{1}{q} = \frac{-0.5}{3}$$

$$\frac{1}{q} = \frac{-0.5}{3} - \frac{1.5}{2}$$

$$q = \underline{-12/11} \text{ cm}$$

Thin Lenses



$$\frac{1}{p} + \frac{1}{q} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$= \frac{1}{f}$$

Example

$$\frac{1}{p} + \frac{1}{q} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = \frac{1}{f}$$

$$(1.5-1)\left[\frac{1}{2} - \frac{1}{2.5}\right] = \frac{1}{f}$$

$f = \underline{20 \text{ cm}}$

Converging & Diverging Lenses

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Converging Lenses

Image real $\Rightarrow$ q +ve

virtual $\Rightarrow$ q -ve

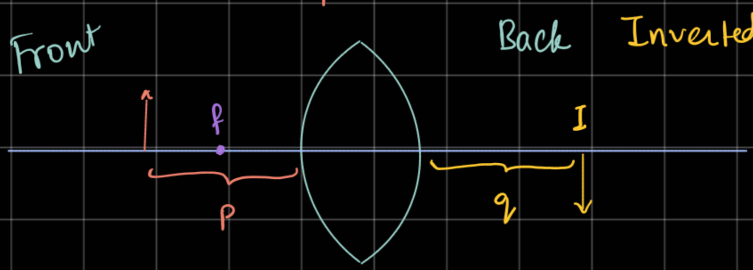
f +ve

Smaller / Larger

Real

Inverted

$p > f$



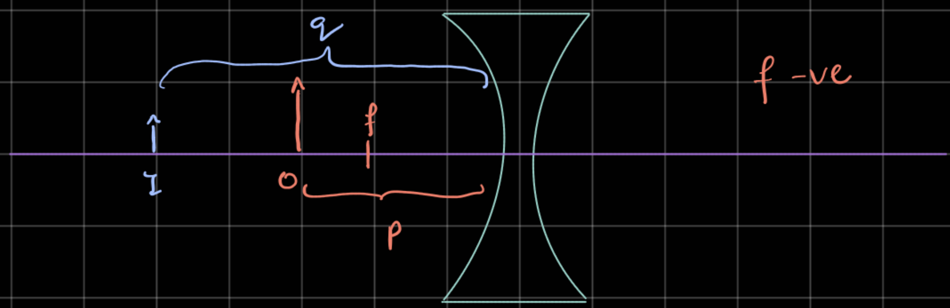
$p < f$

Larger

Virtual

Upright

Diverging Lens



f -ve

$f = 10$ cm

$p = ?$

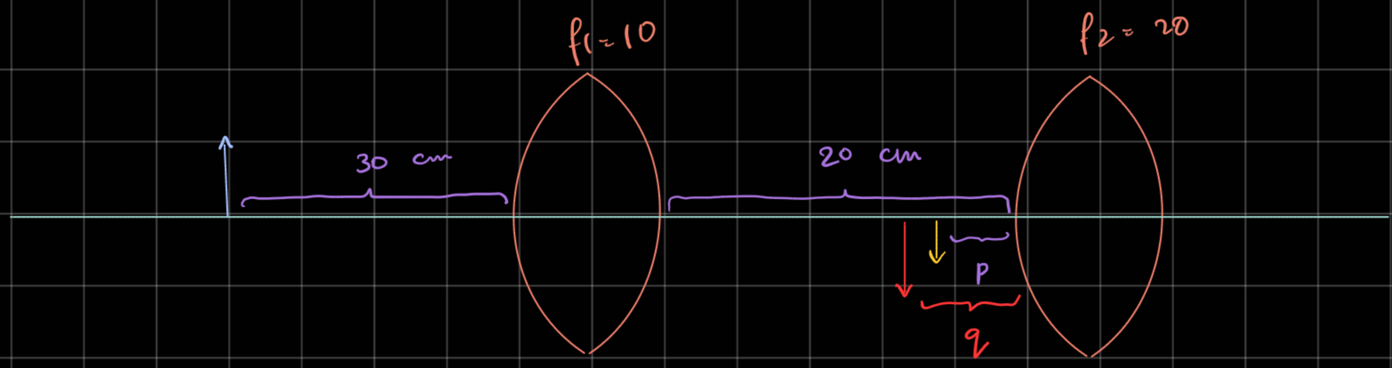
$q = 20$ cm

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{p} = \frac{1}{f} - \frac{1}{q}$$

$$= \frac{1}{10} - \frac{1}{20}$$

$$p = 20 \text{ cm}$$



$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{30} + \frac{1}{q} = \frac{1}{10}$$

$$q = 15 \text{ cm}$$

$$M = -\frac{q}{p} = \frac{-15}{30} = -0.5$$

$$\frac{1}{5} + \frac{1}{q} = \frac{1}{20}$$

$$\frac{1}{q} = \frac{1}{20} - \frac{1}{5}$$

$$q = -6.67$$

$$M = -\frac{q}{p} = \frac{20/3}{5}$$

$$= 1.33$$

$$M_{final} = M_1 M_2$$

$$= -0.5 \times 1.33$$

$$= -0.665$$

∴ Image is virtual

smaller

inverted

Spherical Aberration

Due to imperfections in sphere, focal point will not be the same. This causes a blurry image.

Chromatic Aberration

Different wavelengths intersect at different points.

Camera

f - number : $\frac{f}{d} = \frac{f}{D}$ ⇒ focal length
⇒ Diameter

$I \propto \frac{1}{(f\text{-number})^2}$

↓

Intensity of light

The Human Eye

near point = 25 cm

far point = ∞

> 25 cm
far sighted
converging

$< \infty$
near sighted
diverging

Power of the lens

$P = \frac{1}{f}$ Diopters

Magnifier

Max magnification $= 1 + \frac{25 \text{ cm}}{f}$

Min magnification $= \frac{25 \text{ cm}}{f}$

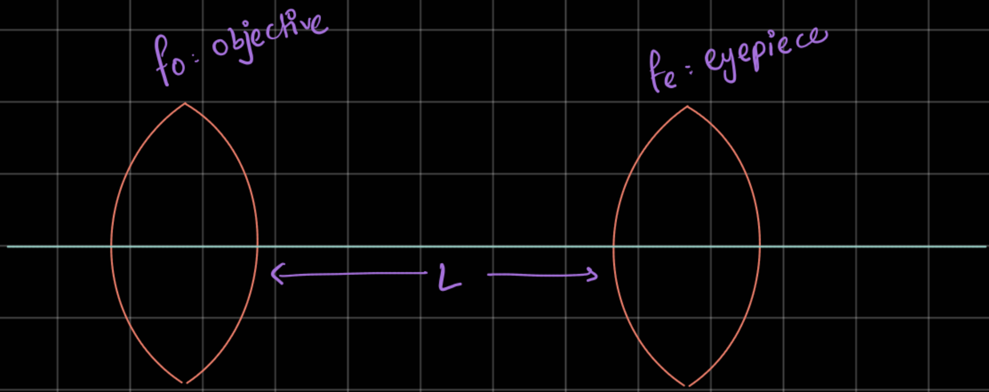
converging lens

Power $= \frac{25 f}{25 + f}$

Microscope

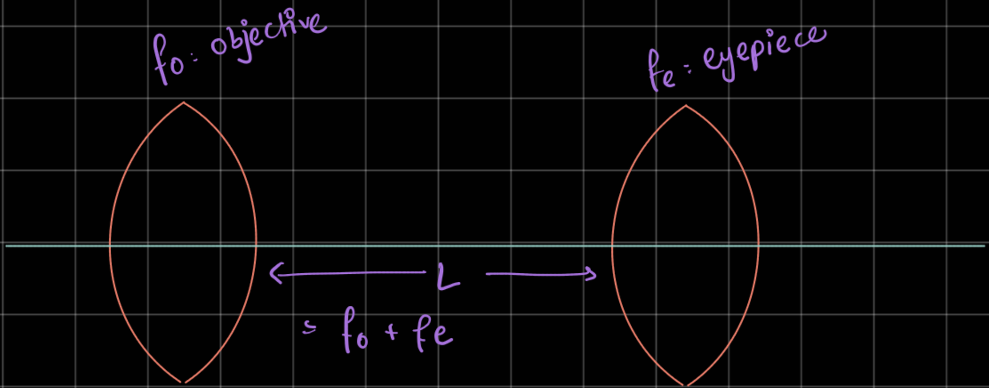
$M = M_o M_e$

$= \left(\frac{-L}{f_o}\right)\left(\frac{25}{f_e}\right)$



Telescope

- By Reflection
- By Refraction



$M = \frac{-f_o}{f_e}$

Reflection