Viewing Objects

* Objects are viewed (or seen) through **the Eye**
* Eye is one of the finest organs which functions like an "**Optical Imaging Device**"
* An image of the object is formed on the **Retina**, which is then **perceived appropriately by the Brain**.
* **Limitations**, when the object is → **Very far** / → **Very small**
* **Needs Optical Instruments to assist !**

Optical Instruments

Microscopes and Telescopes are optical instruments that assist the Human Eye in viewing very small ("micro") and faraway ("tele") objects, respectively.

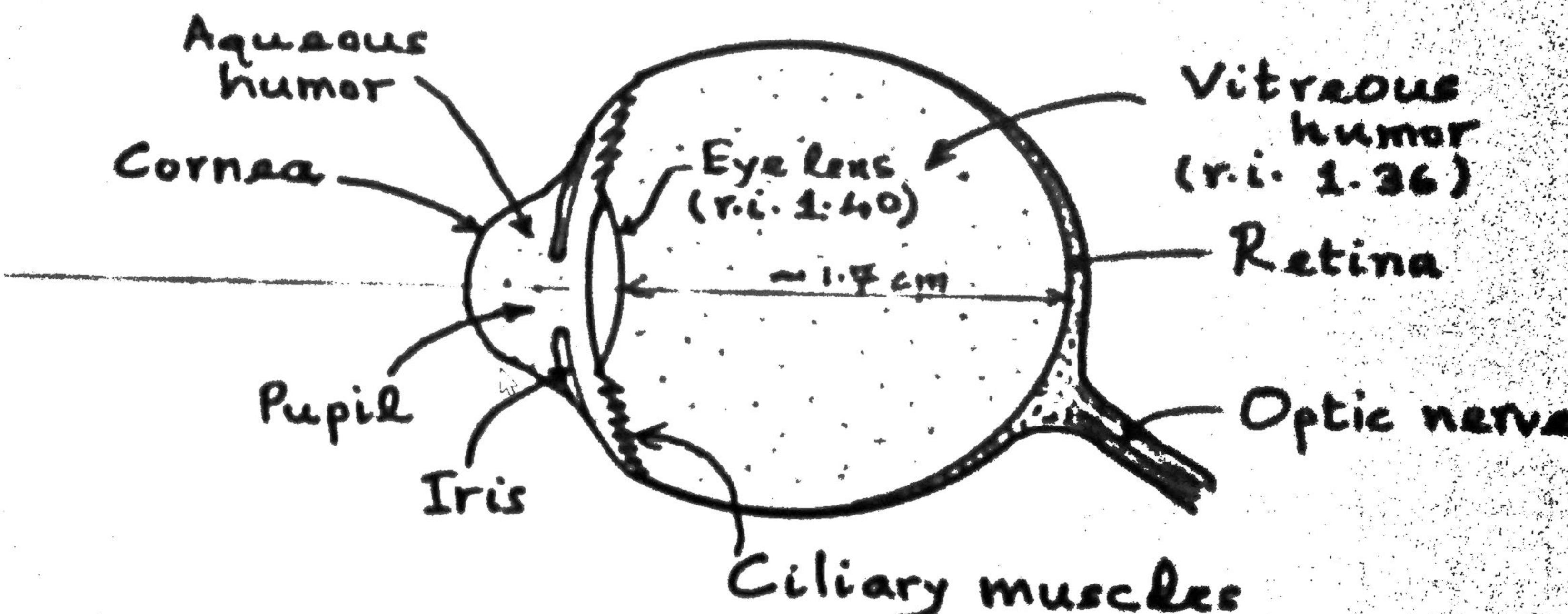
Eye also needs 'assisting devices' to correct "defective vision" such as —

(i) farsightedness (Hypermetropia)

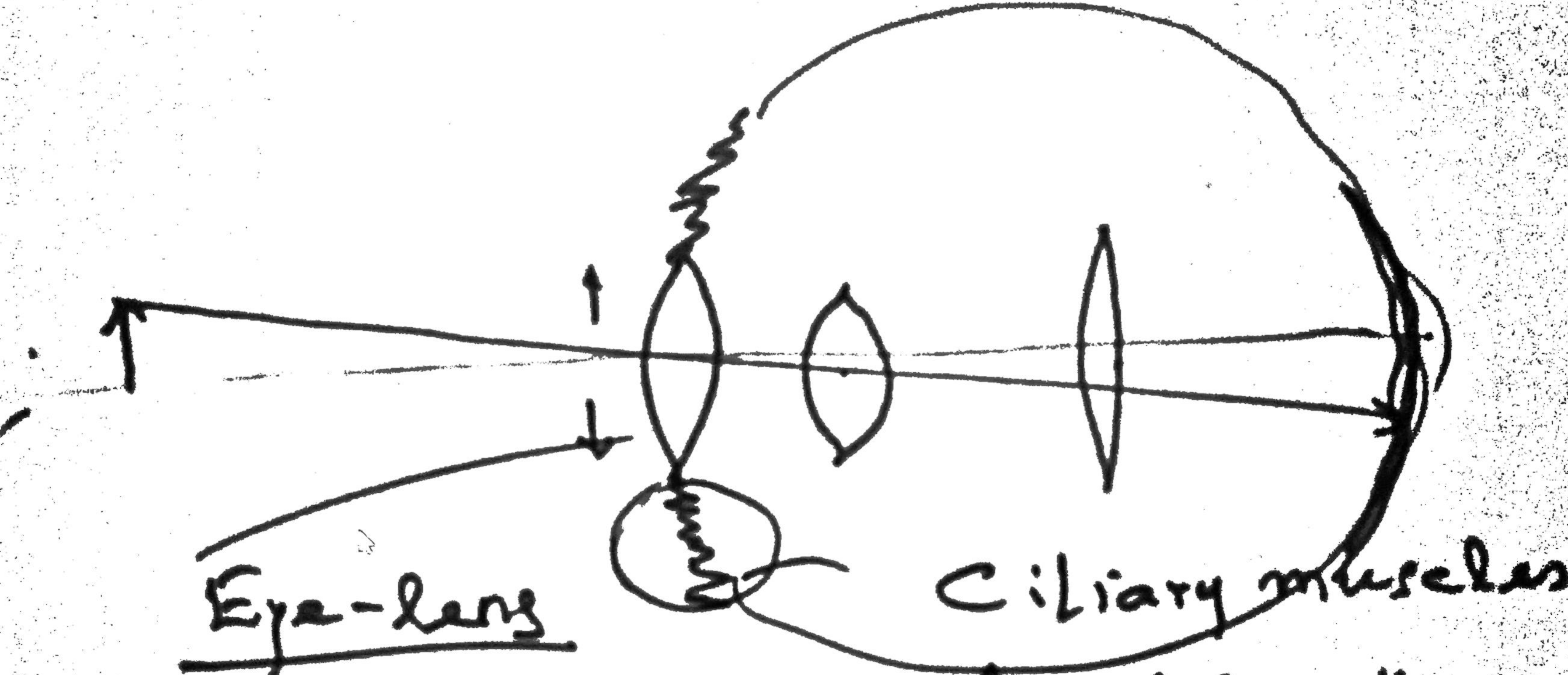
(ii) nearsightedness (Myopia)

To understand the above, it is necessary to know the constitution and functioning of the Eye.

The Human Eye



Retina is the optical receptor where the image is formed; it comprises of large number of optical guides called "rods" and "cones"

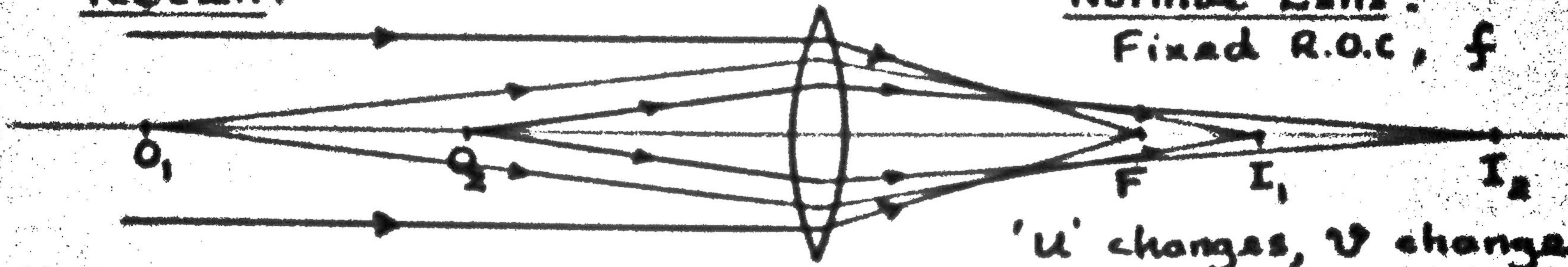


Eye-lens has a variable focal length.

"Accommodation"

Recall:

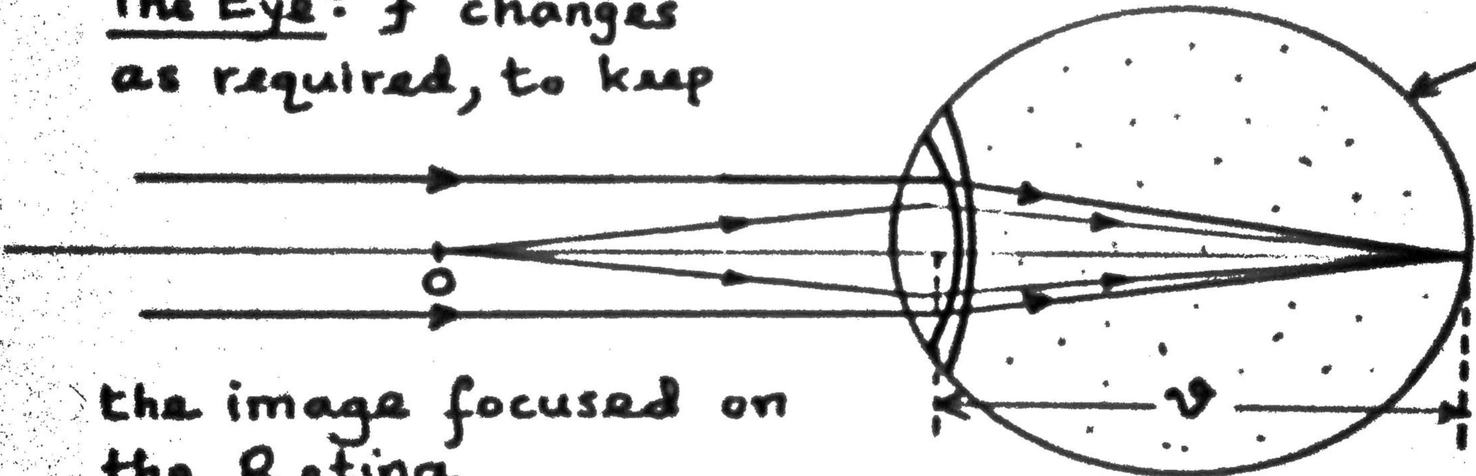
Normal Lens: Fixed R.O.C, f



'u' changes, v changes

The Eye: f changes as required, to keep the image focused on the Retina.

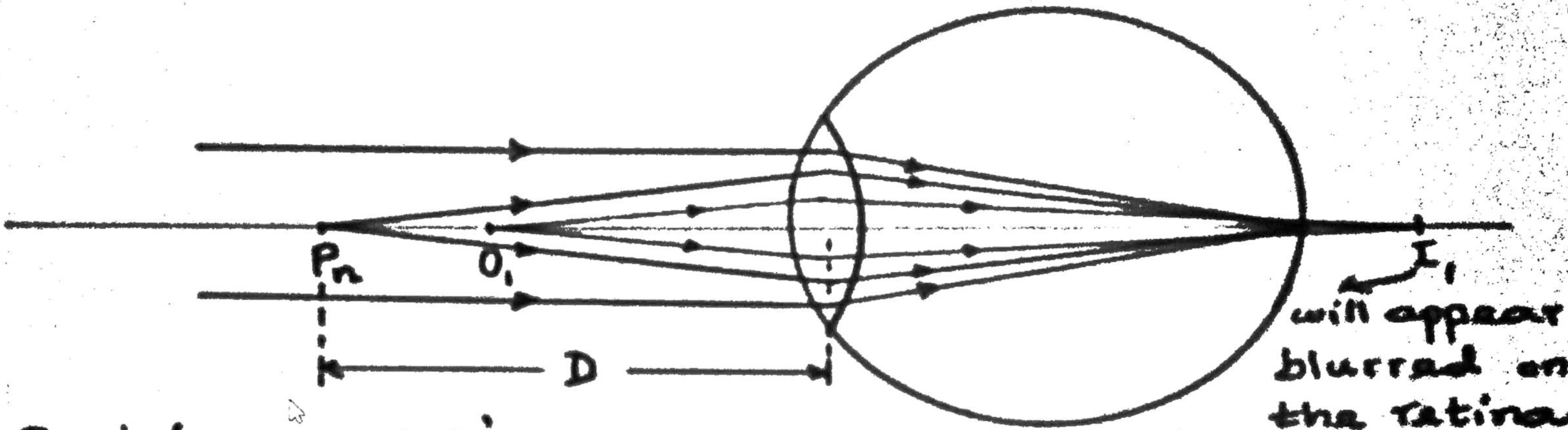
"Reduced Eye"



v is fixed!

Of course, there is a limit!

'Near Point' and 'Far Point' for the Eye



* P_n is 'near point' meaning
  D is the "least distance for clear vision"
* The eyelens can "accommodate" upto an object distance corresponding to P_n.
* Similarly, 'far point' refers to the farthest distance - - -

For Normal Vision,

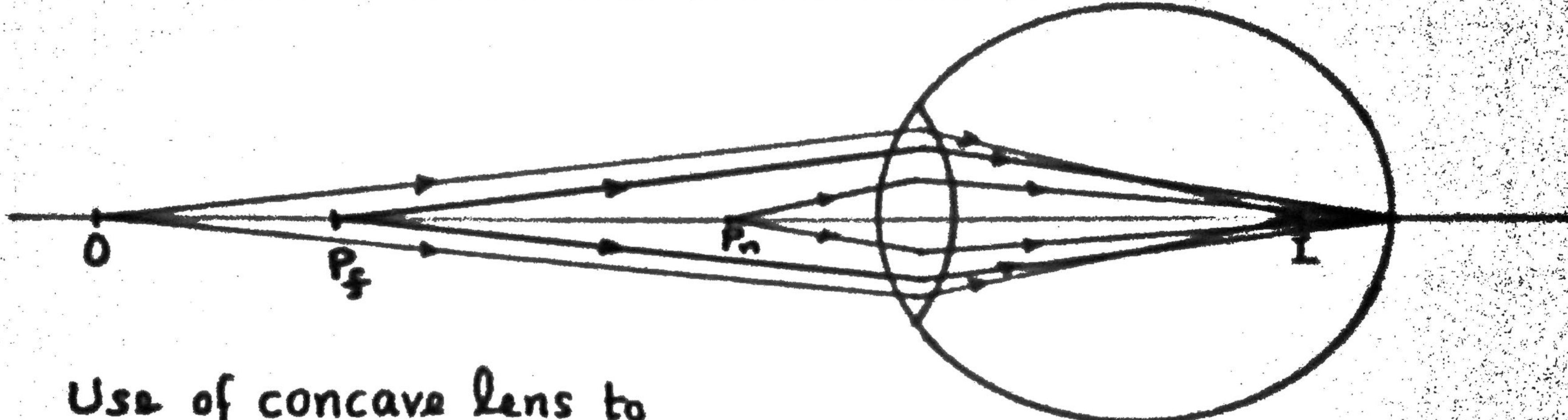
$D \simeq 25$ cm

Yr	D
~ 10 yrs	~ 10 cm
~ 20 - 25	~ 25 cm
~ 60 yrs	~ 100 cm - 500 cm

$P_f \rightarrow$ far point is ∞

→ "Eye can be focussed to infinity"

Nearsightedness (Myopia)



Use of concave lens to correct nearsightedness

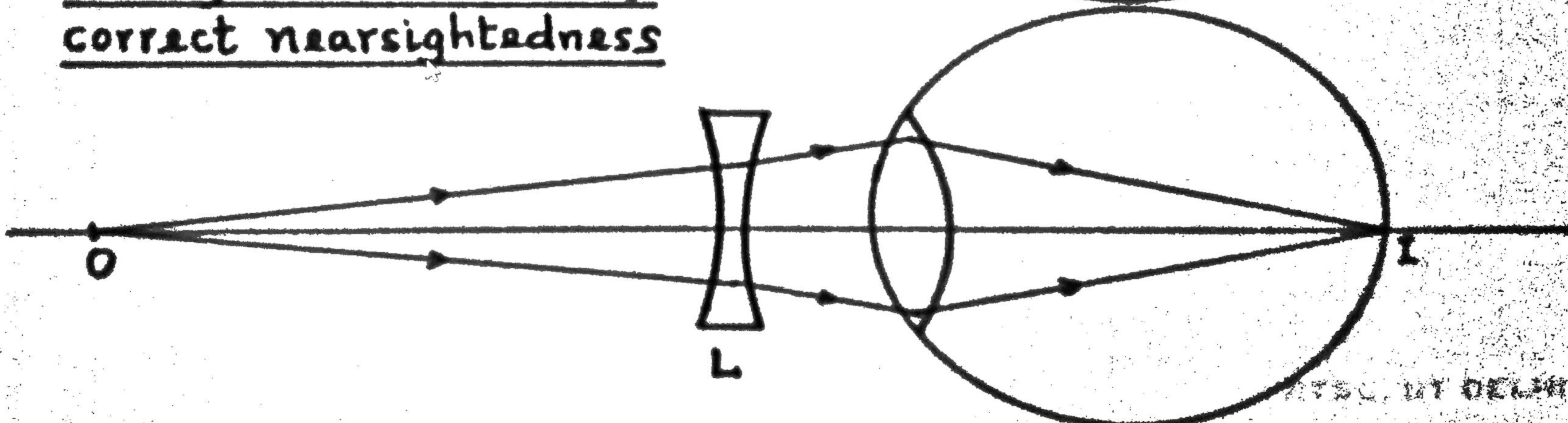
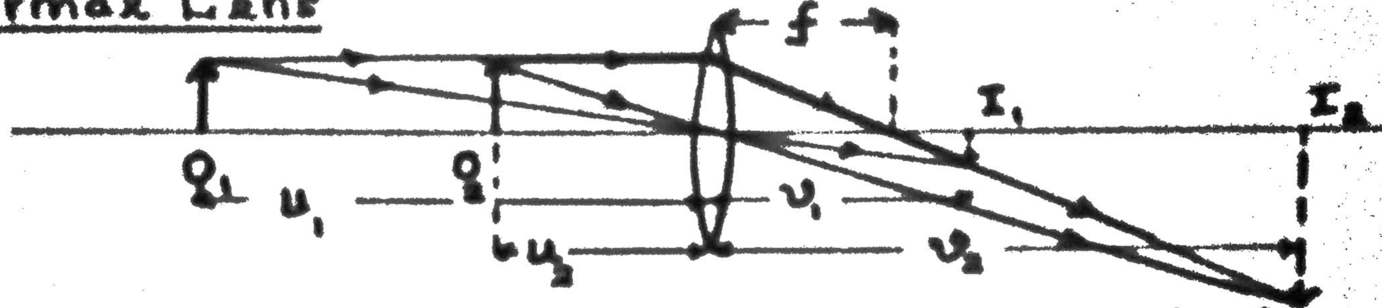


Image formation on the Retina — Extended Objects

Normal Lens



- f constant ; use Lens Formula to get v
- Two rays are necessary to determine image distance and size.

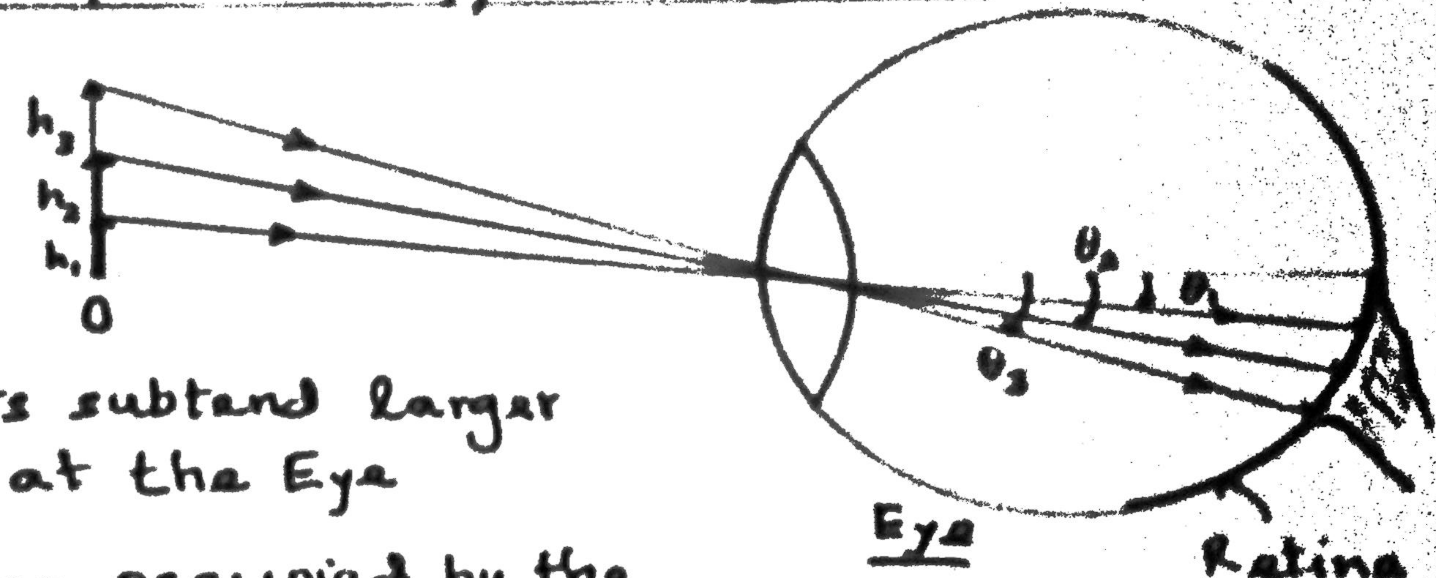
Eye Lens

Retina is like a fixed 'image plane'

- Adjustable f ; fixed v
- One ray is sufficient to determine the 'image size'

Object size vs. Angular extent on the Retina

A. Same 'Object position', different 'object size'



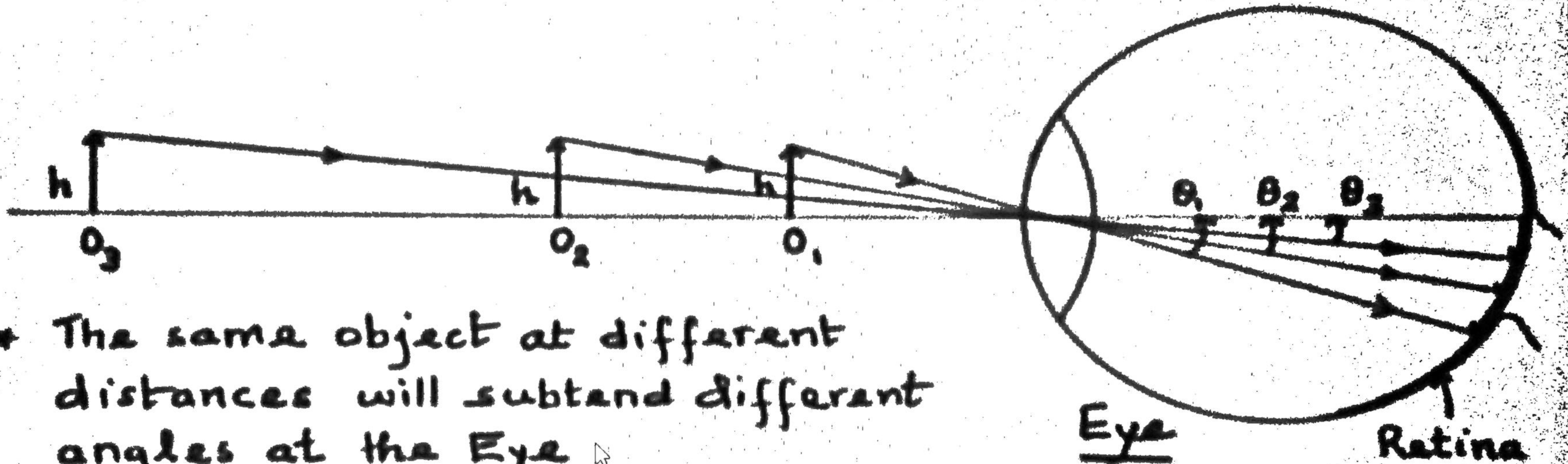
Larger objects subtend larger angles at the Eye

→ Larger area occupied by the image on the retina

→ Better resolution and clarity of the image

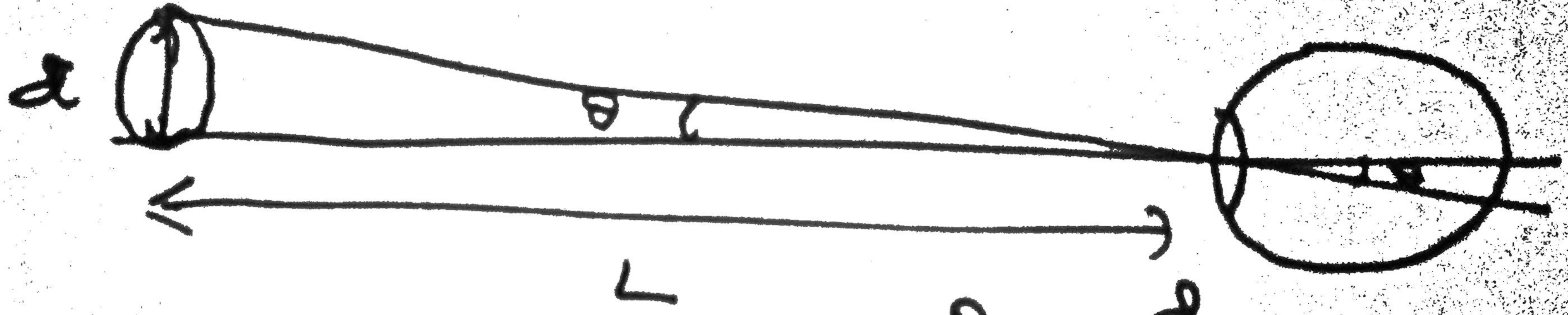
∵ Larger number of rods and cones would be involved in the perception of the image.

B. Same Object (size), Different Object Positions



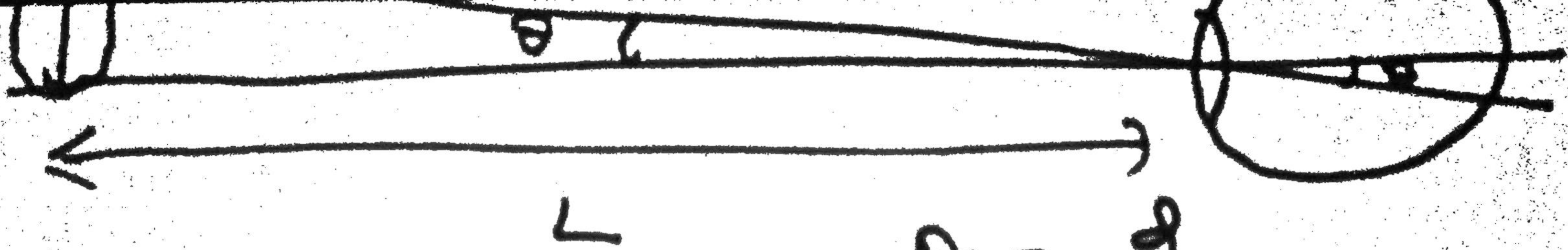
* The same object at different distances will subtend different angles at the Eye
* Angle subtended will determine the size of the image on the Retina, and hence size of the object — as perceived by the Brain.

- Angular resolution of the Eye ~ 1 arc minute



$$\theta = \frac{d}{L}$$

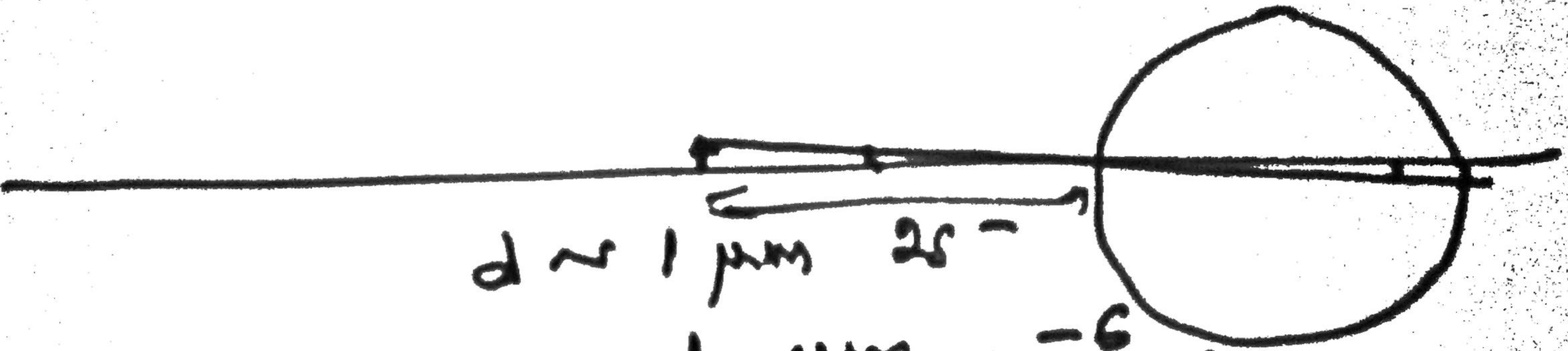
$\theta \sim 10^{-2}$ rad. $\longrightarrow$ Moon



$$\theta = \frac{d}{L}$$

$\theta \sim 10^{-2}$ rad. $\longrightarrow$ Moon

$$1 \text{ arcminute} = \frac{1}{60} \times \frac{\pi}{180} \approx 3 \times 10^{-4} \text{ rad}.$$



$d \sim 1\ \mu m$

$$\theta = \frac{1 \times 10^{-6}\ m}{0.25\ m}$$

$$= \underline{4 \times 10^{-6}\ rad}$$

Both very small nearby objects and faraway objects subtend a small angle at the Eye.

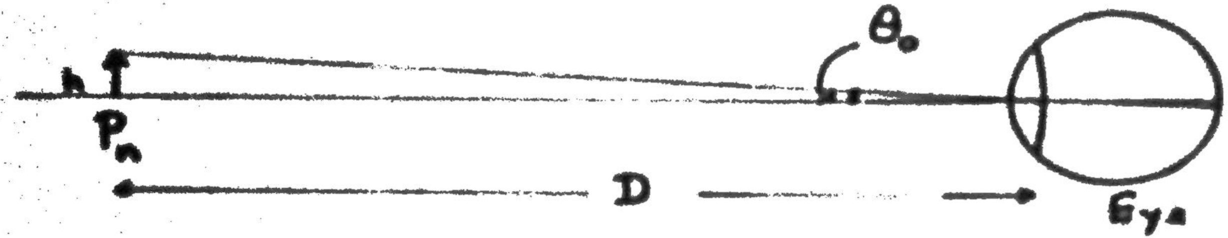
⇒ Angular resolution of the image will be poor.

Q: Can we somehow increase the angle subtended at the Eye (by the small objects and faraway objects), so that we can see them clearly?

The search for solution (of the above question) led to the development of "microscopes" and "telescopes".

Use of Convex Lens as a Magnifying Glass

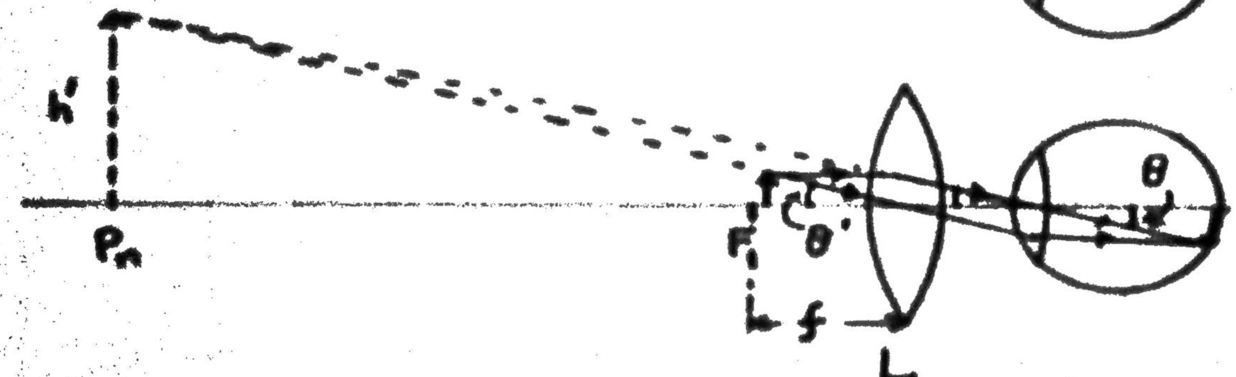
— The Simple Microscope



– Object at the near point:

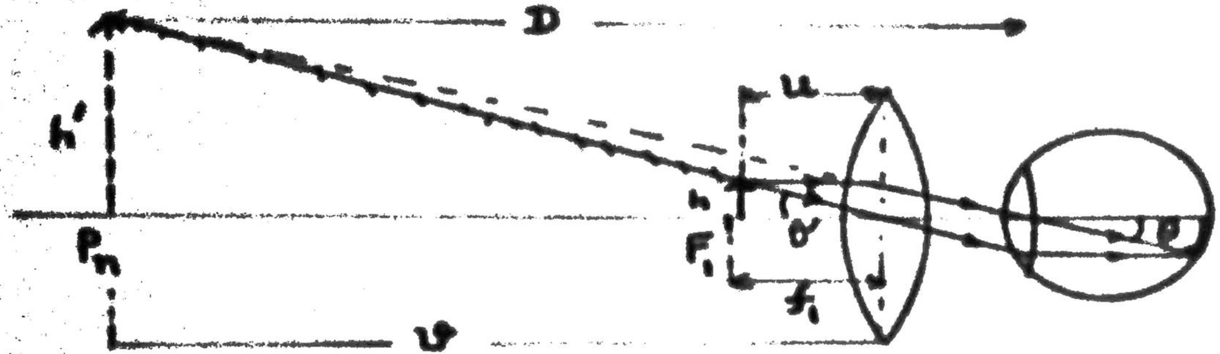
$$\theta_o = \frac{h}{D}$$

– Bringing the object closer; angle increases, but image is not clear.



– Inserting the Magnifying Glass

Angular Magnification, m_θ



$$\theta \approx \theta' \propto \frac{h}{f}$$

$$\therefore m_\theta = \frac{\theta}{\theta_0} = \frac{h/f}{h/D}$$

$$m_\theta = D/f$$

ANGULAR MAGNIFICATION

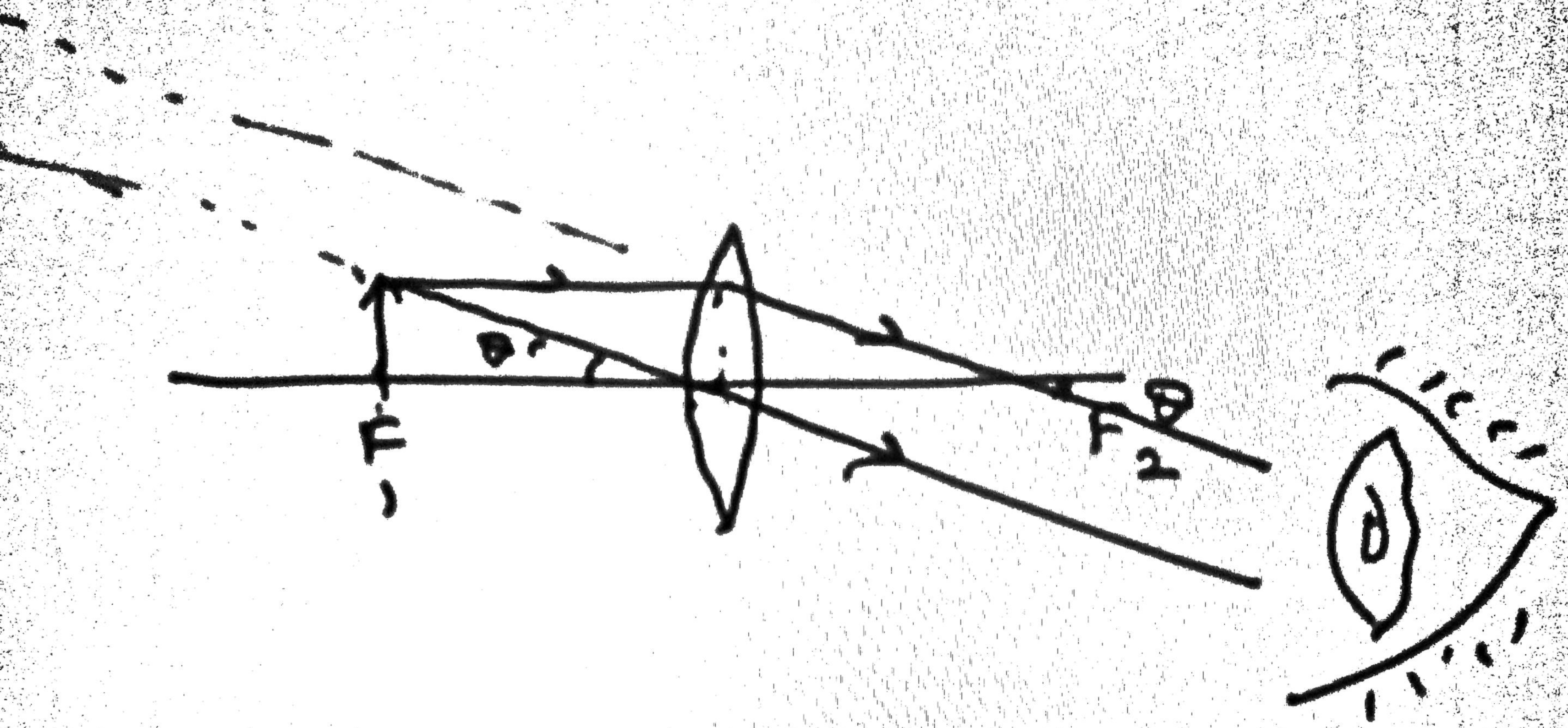
Linear magnification $m = \frac{h'}{h} = \frac{v}{u}$

$$m = v\left(\frac{1}{v} - \frac{1}{f}\right) = \left(1 + \frac{v}{f}\right) \simeq \left(1 + \frac{D}{f}\right)$$

$$\hookrightarrow \left(1 - \frac{(-v)}{f}\right)$$

NOTE: When the Eye is focussed to infinity, (i.e $u = f$)

$$\theta = \theta' = \frac{h}{f} \quad (\text{for small } \theta).$$



θ
θ
F_1
F_2

$$m_o = \frac{D}{f} \rightarrow \frac{25\,cm}{3\,cm} \simeq 8.3$$

$m_o = 6.25$
for $f = 4\,cm$

$$m_o \sim 5-10$$