Human Eye

Human Eye

LEAST DISTANCE OF DISTINCT VISION

- The least distance at which a normal average human eye can view an object clearly.
- For human eye, (Normal) $D = 25cm$
- Also called Near Point of Normal eye.

NEAR POINT

The least distance at which a person can see an object clearly.

FAR POINT

The farthest point at which an object is visible distinctly.

ACCOMODATION

Range of distance for which a person can see clearly.

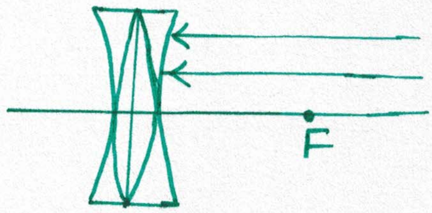
NEAR SIGHTEDNESS (MYOPIA)

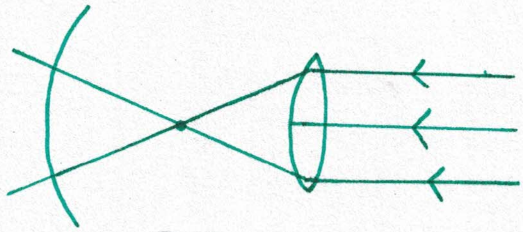
- If a person can see near objects clearly but far point is not normal.
- For correction of this defect, spectacles should form the image of ∞ at his far point (F).

$u = -\infty$, $v = -F$

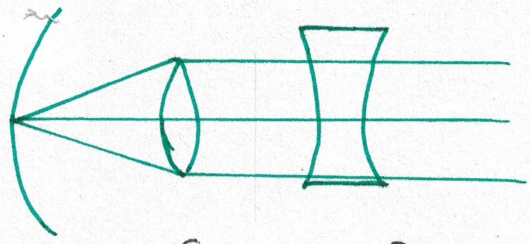
$f = -F$

∴ Concave lens
(Diverging lens)





Defecting Eye



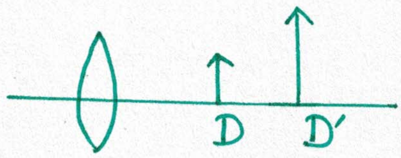
Corrected Eye

FAR - SIGHTEDNESS (HYPERMETROPIA)

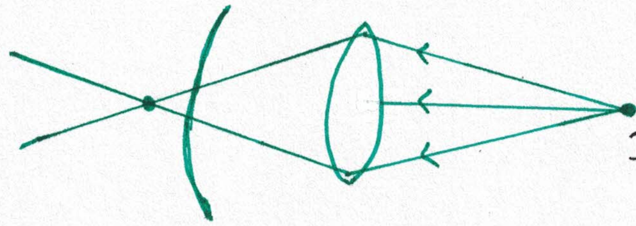
- Far point is normal but near point > D
- To correct this defect, the image of an ~~eye~~ object at D is formed at the person's near point.

$V = -D'$, $u = -D$

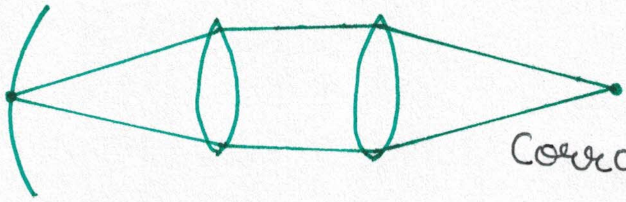
$$f = \frac{DD'}{D'-D}$$



∴ convex lens
(Converging lens)



Defecting eye



Corrcted eye

PRESBYOPIA

Simultaneous presence of myopia and hypermetropia.
It is cured by using bifocal lenses.

ASTIGMATISM

Happens when a person cannot simultaneously focus on horizontal and vertical lines due to different focal lengths along different planes.
It is cured using cylindrical lenses.

SIMPLE MICROSCOPE (HAND LENS)

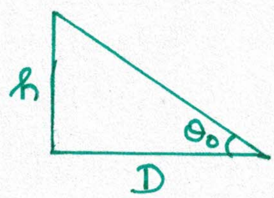
For any magnifying instrument, magnification is a measure of ↑ in the angle subtended on the eye.
It can be used in two models:

(1) Normal Adjustment

→ Here, final image is formed at ∞.
→ To be seen with a fully relaxed eye.

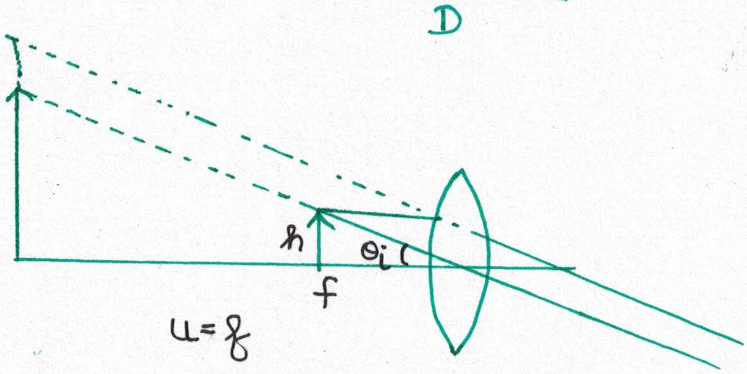
(2) Near Point Adjustment

→ to be seen with max. strained eye.
→ at near point.



$\theta_0 = \frac{h}{D}$

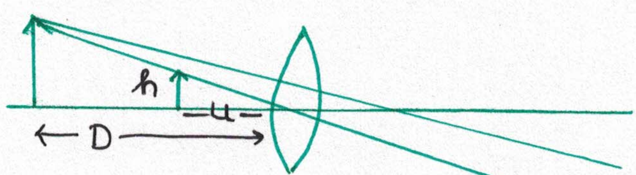
(1)



$\theta_i = \frac{h}{f}$

$$m = \frac{\theta_i}{\theta_0} = \frac{D}{f}$$

(2)



$\theta_i = \frac{h}{-u} = h\left(\frac{1}{f}+\frac{1}{D}\right)$

$m = \frac{\theta_i}{\theta_0}$

$m = \frac{\frac{1}{f}+\frac{1}{D}}{1/D}$

$$m = 1 + \frac{D}{f}$$

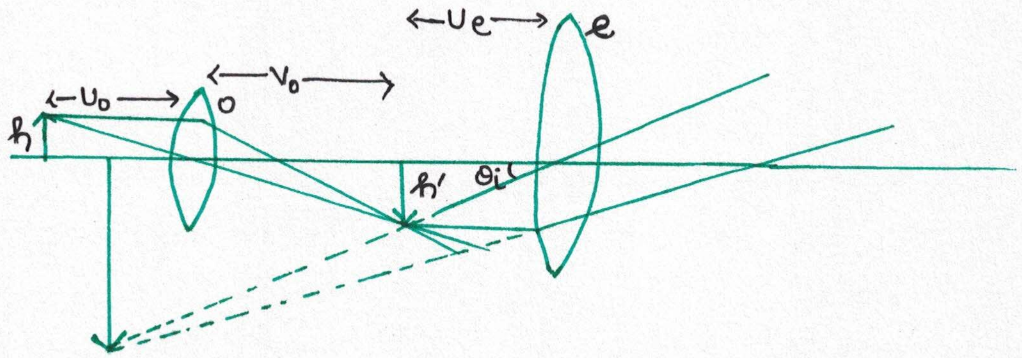
Near Point

$V = -D_i$

$V = \frac{1}{-D} - \frac{1}{u}$

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

Near Point adjustment:



$\theta_o = \frac{h}{D'}$, $\theta_i = \frac{h'}{-u_e} = \frac{hV_o}{+u_o u_e}$

$m = \frac{\theta_i}{\theta_o}$ —① $\quad (\because h' = \frac{V_o}{-U_o})$

① is valid in general

(a) In case of near point adjustment

$V_e = -D$

$\frac{1}{V_e} - \frac{1}{U_e} = \frac{1}{f_e}$

$\frac{1}{-D} - \frac{1}{u_e} = \frac{1}{f_e}$

$\frac{1}{u_e} = -\left(\frac{1}{D} + \frac{1}{f_e}\right)$

$-\frac{1}{u_e} = \frac{D+f_e}{Df_e}$

$m = -\frac{V_o}{u_o} \frac{\cancel{D}(D+f_e)}{\cancel{D}f_e}$

$m = \frac{-V_o}{u_o}\left(1 + \frac{D}{f_e}\right)$

In practical setting

$u_o \approx -f_o \qquad l = V_o - u_e$

$\& \quad f_e << f_o \qquad -u_e << V_o$

$\therefore V_o \approx l$

(approx.) $m = \frac{l}{f_o}\left(1 + \frac{D}{f_e}\right)$

(b) In case of Normal Adjustment:

$$v_e = -\infty$$

$$u_e = -f_e$$

$$m = -\frac{v_o}{u_o}\left(\frac{D}{f_e}\right)$$

In practical setting,

$$\text{(Approx.)} \quad m = \frac{l}{f_o}\left(\frac{D}{f_e}\right)$$

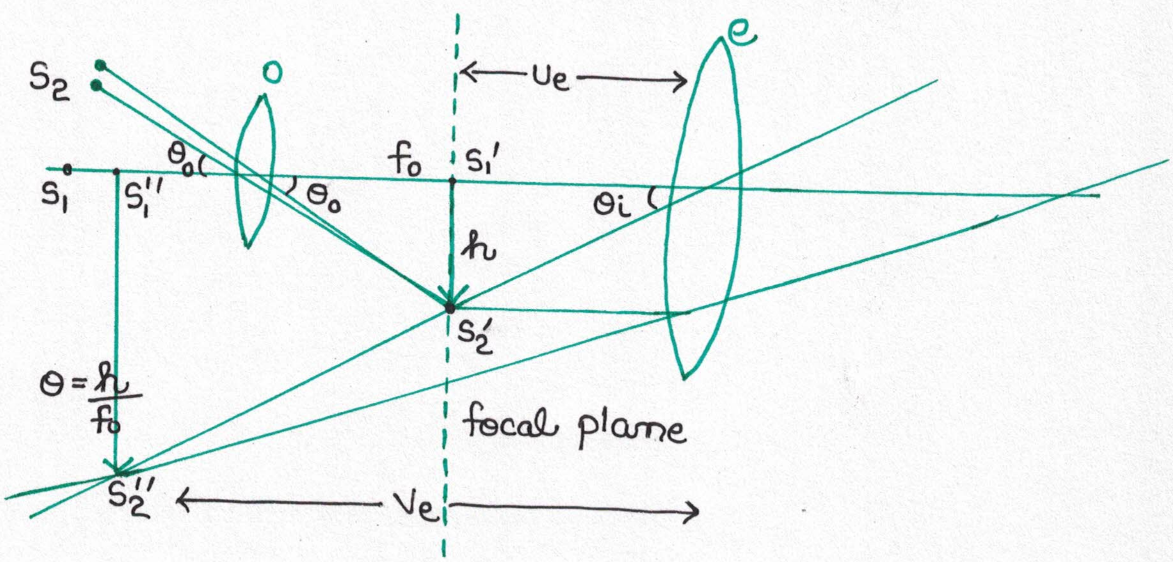
★ Sometimes in microscope, we fill the tube with a refracting liquid to improve resolution.

$$\because \theta \simeq 1.22\frac{\lambda}{d}$$

& λ changes to $\frac{\lambda}{\mu}$

thereby reducing the scattering.

ASTRONOMICAL TELESCOPE



$$\theta_o = \frac{h}{f_o}, \quad \theta_i = -\frac{h}{u_e}$$

$$m = \frac{\theta_i}{\theta_o} = -\frac{f_o}{u_e} \quad \rightarrow \text{valid in general}$$

(A) For normal adjustment

$$u_e = -f_e$$

$$m = f_o/f_e$$

$l = f_o - u_e$

$l = f_o + f_e$

(B) for near point adjustment

$v_e = -D$

$-\frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$

$-\frac{1}{u_e} = \frac{D+f_e}{Df_e}$

$m = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

$l = f_o + \frac{1}{f_e} + \frac{1}{D}$

Que.) Far point of a person is 1.5m. Find the power of the spectacles required.

$\frac{1}{f} = \frac{1}{\infty} - \frac{1}{+(1.5)m}$

$P = -\frac{2}{3} D$

Que.) $f_o = 200cm$, $f_e = 4cm$, $u_o = 10Km$ (Telescope)
Normal adjustment.
Find length of tube & angular magnification.

$l = 204cm$

$m = -50$

Que.) $P_{lens} = 10D$, $u = ?$, $m = \text{maximum}$

m_{max} for near point adjustment

$\frac{1}{100} = \frac{1}{-25} - \frac{1}{u}$

$u = -10$

$\frac{1}{u} = -\left(\frac{1}{25} + \frac{1}{100}\right) = \frac{35}{250} = \frac{7}{50}$

$$\frac{1}{u} = \frac{-1025}{2500} = \frac{41}{100}$$

$$u = \frac{-100}{41} \text{ cm} \simeq -2.44$$

$$u = 7.1\text{cm}$$

Que) Compound Microscope

$f_o = 1\text{cm}$, $f_e = 25\text{cm}$. Normal adjustment

$u_e = -1.2\text{cm}$, Find m & l.

$$\frac{1}{V_e} - \frac{1}{U_e} = \frac{1}{f_e}$$

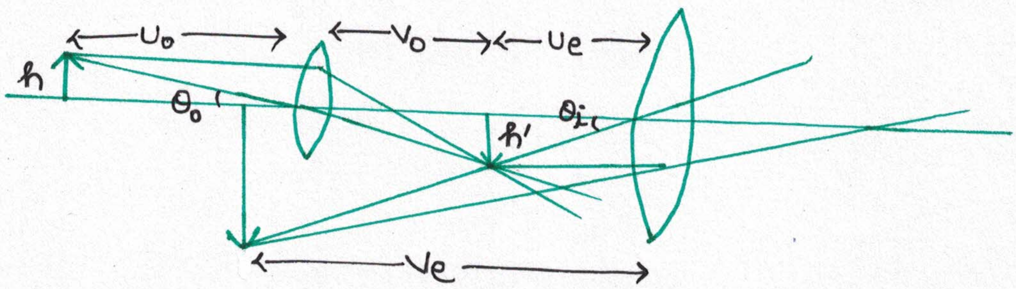
$$l = V_o - U_e$$

$$l = V_o + 1.2$$

$$\frac{1}{V_e} = \frac{1}{2.5} - \frac{1}{1.2}$$

$$\frac{1}{V_e} = \frac{1.2 - 2.5}{(2.5)(1.2)} = \frac{-1.3}{(2.5)(1.2)}$$

$$V_e = -2.3\text{cm}$$



$$\theta_o = \frac{h}{+u_o} \quad , \quad \theta_i = \frac{h'}{-u_e} \quad , \quad -\frac{h'}{h} = \frac{V_o}{-u_o}$$

$$\theta_i = \frac{V_o h}{u_o u_e}$$

$$m = \frac{\theta_i}{\theta_o} = -\frac{V_o}{u_o V_e} \cdot \frac{u_o}{1}$$

$$m = \frac{-V_o}{u_e}$$

$$\left(m = \frac{V_o}{+f_e}\right)$$