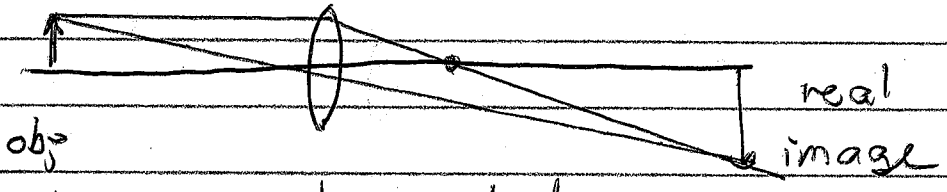
Phys2426 2017-11-28 Lec 24

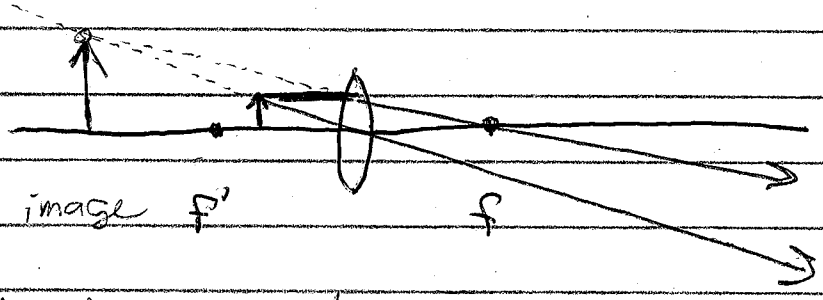
Thin Lenses $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$

Converging Lens - Projector



far object → real inverted image
could be enlarged or reduced

Converging Lens - Magnifying Glass



near object → virtual image, upright
always enlarged for converging lens

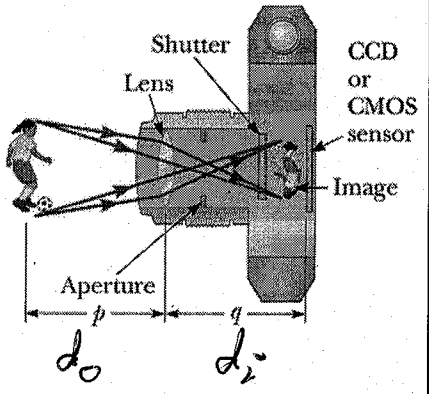
$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

d_o: big; d_i: negative; f: small

Camera / Eye

Camera

- Lens projects real image onto sensor or film
- Aperture controls amount of light and depth of field
- Shutter controls when and for how long the image is allowed to reach the sensor or film



Section 25.1

Real Image is inverted.
Limited Depth of Field.

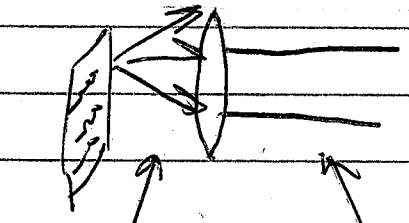
Near Point (d_{np}) - Closest allowed obj.
Far Point (d_{fp}) - Furthest obj.

Typical person 25 cm - ∞

Corrective Lenses

Farsighted - can see far things
- needs weakly diverging rays.

Want to observe nearby object.
- Rays diverge too strongly.
- Use converging lens



Place object a desired dist: $d_o = 25\text{ cm}$
Place virtual image at near point: $d_i = -d_{np}$

Ex: Person can't see closer than 3 m.

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{0.25} + \frac{1}{-3} = 3.67\ m^{-1}$$

Lens power in diopters

$$\text{Focal Length} = f = \frac{1}{3.67} = 0.273\ m$$

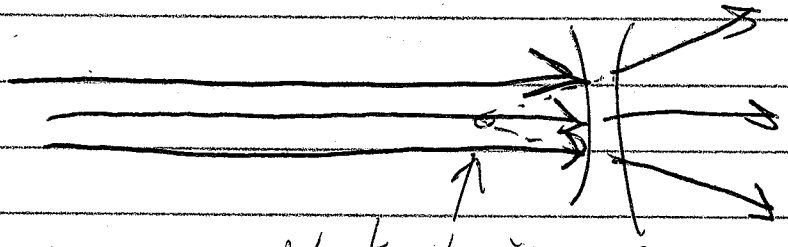
(4)

Nearsighted ex: $d_{f.p} = 3\ m$

Actual object @ infinity.

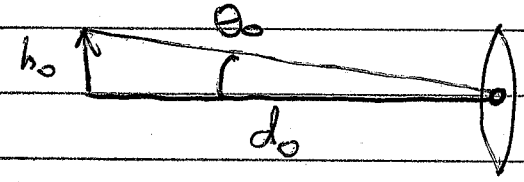
$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{\infty} + \frac{1}{-3} = -0.333\ m^{-1}$$

$$\text{Focal Length} = f = \frac{1}{-0.333} = -3\ m$$



Virtual image at focal point.

Angular Size



$$\tan\theta_o = \frac{h_o}{d_o}$$

Typically consider small angles.

$\sin\theta \approx \theta$ $\quad \tan\theta \approx \theta$ $\quad \theta_o = \frac{h_o}{d_o}$

Magnifying Glass

Easy, relaxed viewing, image @ ∞.

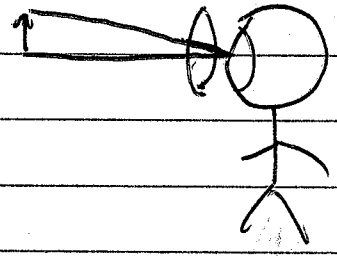
Place object @ focal point.

$f = 5$ cm

$d_o = 5$ cm

finding h_i is not useful.

$$\frac{1}{5} + \frac{1}{d_i} = \frac{1}{5} \qquad m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$



With: $\theta = h_o / f$

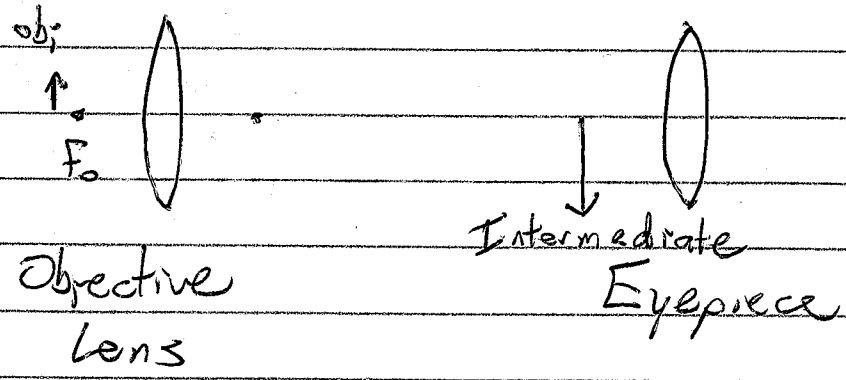
Without: $\theta_o = h_o / d_{np}$

Compare: $\text{Angular Mag} = \frac{h_o/f}{h_o/d_{np}} = \frac{d_{np}}{f}$

Can get one more "notch" of magnification by straining eyes.

$$\text{Max mag} = \frac{d_{np}}{f} + 1$$

Compound Microscope



Objective: Projector - object just outside f_o
Image is inside microscope @ $d_i = L$
Place image @ distance L.

Gain Linear mag: $m = \frac{-d_i}{d_o} = \frac{-L}{f_o}$

Eyepiece: Magnifying Glass

Gain Angular mag: $M = \frac{d_{np}}{f_e}$

Overall Mag $M = \frac{-L\, d_{np}}{f_o f_e}$

Short $f_o, f_e \Rightarrow$ big mag

Telescope or Binoculars

Object is <u>huge</u> but stuck at infinity.

Without instrument: $\theta_o = h_o / d_o$

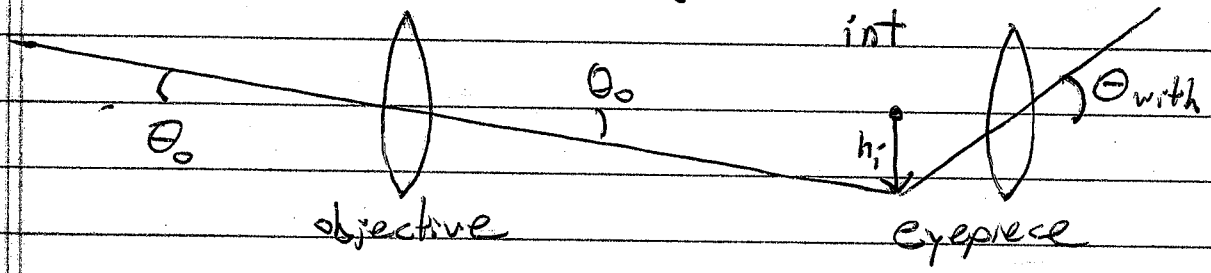
Given → θ_o ; h_o and d_o ← Both ∞

Objective - projects real intermediate image.

$d_o \approx \infty$ $\quad d_i = f_o$

The intermediate is relatively small.

Eyepece - magnifying glass.



$$\theta_o = \frac{h_i}{f_o} \qquad \theta_{with} = \frac{h_i}{f_e}$$

$$h_i = \theta_o f_o \qquad h_i = \theta_{with} f_e$$

$$\theta_o f_o = \theta_{with} f_e$$

$$\frac{f_o}{f_e} = \frac{\theta_{with}}{\theta_o} = \text{magnification}$$