Phys 1402 2015-11-19 Lec 25

Optics - Geometric Optics

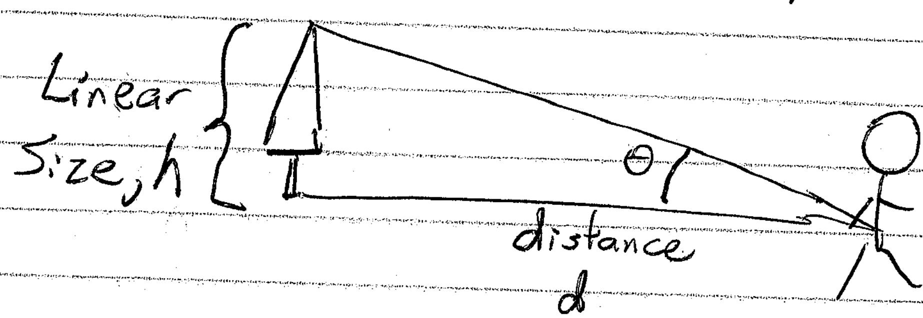
Lens/Mirror $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

$$(\text{mag}) = \frac{h'}{h} = \frac{-q}{p}$$

Angular Size vs. Linear Size

Linear Size is an agreed value.

Angular size depends on your perspective



$$\tan\theta = \frac{h}{d}$$

For small ~~objects~~ angles, in radians

$$\tan\theta \approx \theta \approx \frac{h}{d}$$

To get a bigger θ:

- increase h
- reduce d

Angular Size w/o instrument

Nearby: $\Theta = \frac{h}{d_{np}} = \frac{h}{25\text{ cm}}$

Far Away: $\Theta = \frac{h}{d} = \text{fixed}$

"subtended angle"

Magnifying Glass
- Single Converging Lens
- f is positive
- Virtual Image is produced
  - we can put our eye right up to the lens
  - we look into the lens
  - image is upright

$$\overset{o}{\frac{1}{p}} + \overset{i}{\frac{1}{q}} = \overset{l}{\frac{1}{f}} \Rightarrow \frac{1}{p} = \frac{1}{F} - \frac{1}{q}$$

Since p is ⊕, $\frac{1}{F} > \frac{1}{q}$ ~~so $f < q$~~

Def true because q is ⊖

$$\Rightarrow \quad \frac{1}{q} = \frac{1}{f} - \frac{1}{p} \rightarrow \frac{1}{p} > \frac{1}{F} \rightarrow p < f$$

($\frac{1}{q}$ is ⊖)

Place obj. close to lens

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(3)

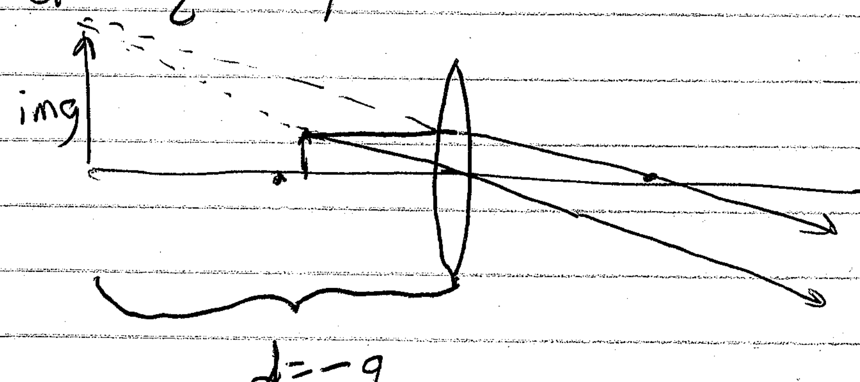
Strategy: place the object at the focal distance $p = f$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \rightarrow q = \left(\frac{1}{f} - \frac{1}{p}\right)^{-1} = 0^{-1} = -\infty$$

$$\text{Linear mag} = \frac{h'}{h} = \frac{-q}{p} = \infty$$

$$\text{Angular Size} \quad \theta = \frac{h'}{d} = \frac{\infty}{\infty}$$

$$\frac{h'}{d} = \frac{h'}{-q} = \frac{h}{p} \qquad \theta = \frac{h}{f}$$



$$\text{Without}: \quad \theta = \frac{h}{25\ \text{cm}}$$

$$\text{With}: \quad \theta = \frac{h}{f}$$

$$\text{Mag} \quad \frac{\theta_{with}}{\theta_{w/o}} = \frac{h/f}{h/25} = \frac{25\ \text{cm}}{f}$$

Can get a little more

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

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(4) Microscope

- Two converging Lenses
- Objective — close to object
    - Acts as a projector
    - Produces a real image - intermediate
    - Intermediate is magnified
- Eyepiece - close to eye
    - Acts as magnifying glass

For a projector, there is lots of freedom in positioning the object.

Strategy: place obj. close to focal length.

$$p \approx f$$

Image is "far away"

$$q \approx L = \text{length of tube}$$

Intermediate is magnified

$$\text{mag} = \frac{-q}{p} = \frac{-L}{f_o} \quad \text{initial linear mag}$$

Use another lens as a mag glass.

$$\text{angular mag} = \frac{25\text{cm}}{f_e}$$

Combined: $$\text{mag} = \frac{-L(25\text{cm})}{f_o f_e}$$

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(5) Telescope

- Two Converging Lenses
- Objective
  - Acts as a projector
  - Intermediate image is real
  - Intermediate is reduced!
- Eyepiece
  - Acts as mag. glass

The object distance $p \approx \infty$

Intermediate image at $q \approx f_o$

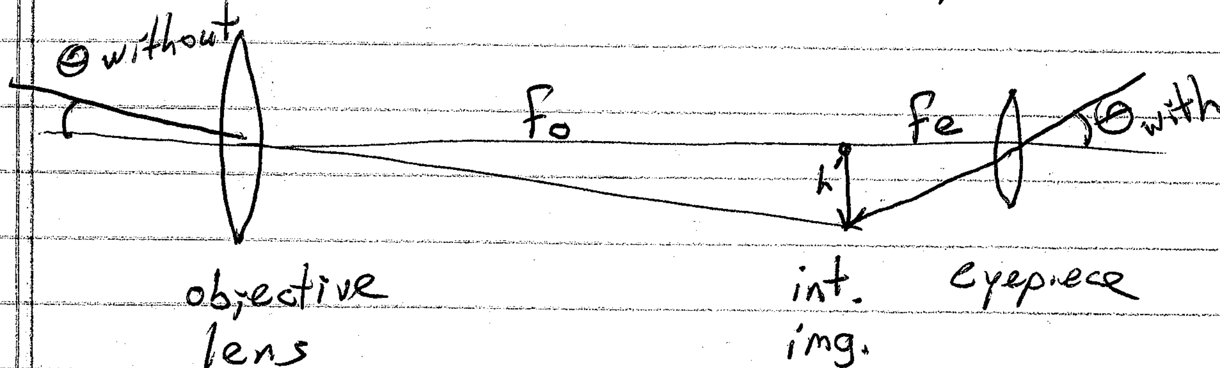
Which is bigger, (p) or q?

$$mag = \frac{-q}{p} = \frac{h'}{h} \approx 0$$

$$\frac{h'}{q} = \frac{-h}{p}$$

Both ∞, but fraction is $\theta_{w/o}$

Look at the intermediate w/ eyepiece



$$\frac{\theta_{with}}{\theta_{w/o}} = \frac{-f_o}{f_e}$$