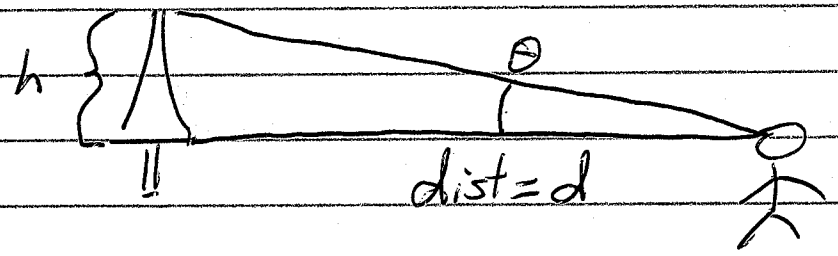
Phys 2426 · 2015-11-19 Lec 25

Geometric Optics

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

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

Angular Size



$\tan\theta = \frac{h}{d}$ for small angles $\theta = \frac{h}{d}$

From the lens's perspective.

$d = p$

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

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② Magnifying Glass

Without the lens - object is near but small

$$\theta_{w/o} = \frac{h}{d_{np}} = \frac{h}{25\,cm}$$

With the lens

- Single converging lens $f > 0$
- Virtual image $q < 0$
  - we look into the lens
  - we can get right up against the lens
  - image is upright

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

$\underbrace{\oplus - \ominus}_{\text{Bigger}}$

p is less than f.

Strategy 1: Set $p = f$ (just under)

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = 0 \quad \text{(just barely } \ominus\text{)}$$

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

$$\theta_{with} = \frac{h'}{d} = \frac{h'}{-q} = \frac{h}{p} = \frac{h}{f}$$

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

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

③ Microscope

- Two converging lenses
- Objective - close to object
  - Acts as a projector
  - Intermediate image is real.
  - Intermediate is magnified.
- Eyepiece
  - Acts as mag. glass
  - Gives more magnification

Strategy: For objective, p is small, but not too small.

Let $p = f_o + \delta$

$$\frac{1}{q} = \frac{1}{F} - \frac{1}{p} = \frac{1}{f_o} - \frac{1}{f_o + \delta} = +\varepsilon$$

$$q = \frac{1}{\varepsilon} = \text{large distance}$$

If q is large, $p \approx f_o$

$q = L$ is a choice.

$$\text{Linear mag} = \frac{-q}{p} = \frac{-L}{f_o}$$

$$\text{Eyepiece Angular mag} = \frac{25\text{ cm}}{f_e}$$

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

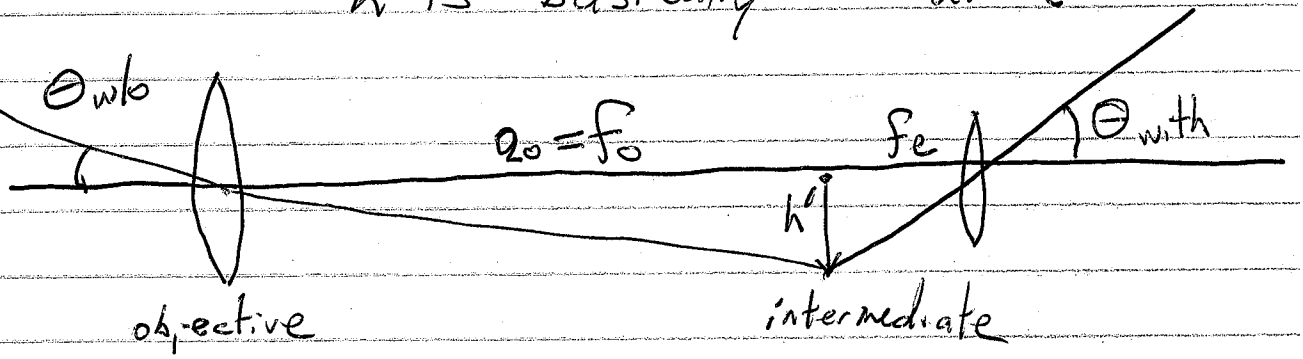
④ Telescope

- Two Converging Lenses
- Objective
  - Acts as a projector
  - Image is real
  - Image is reduced.
- Eyepiece
  - Acts as a mag. glass
  - Gives magnification (angular)

Without: $\theta_{w/o} = \frac{h}{d} = \text{const}$

But, $d = p$ is basically ∞.
h is basically ∞ also.

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



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

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

Converging Lens

p	result
$p < f$	virtual image, mag glass
$f < p < 2f$	real image, magnified proj.
$2f < p$	real image, reduced proj.