Phys 1402 2012-11-28 Lec 24

Converging Lens: Positive focal length

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

Infinitely far object - Parallel Rays

$d_o = \infty$

$d_i = f$

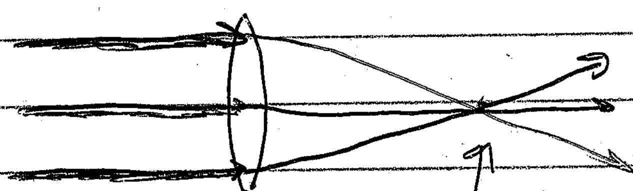


image is at focal point

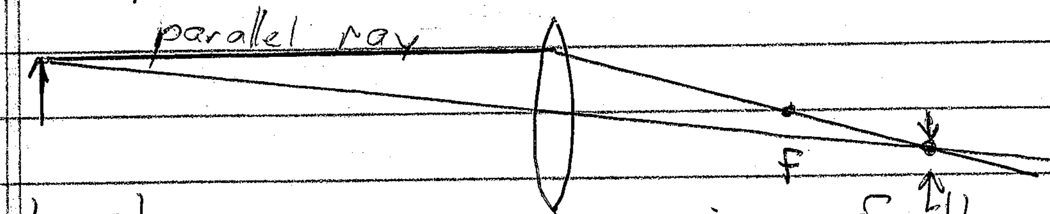
Fairly Far object

$d_o = 8$ cm

$f = 3$ cm

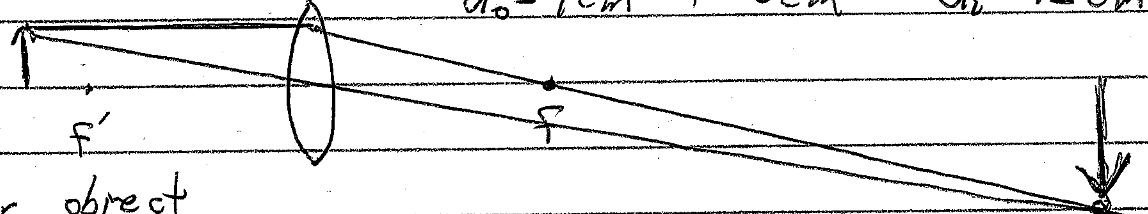
Result:

$d_i = 4.8$ cm



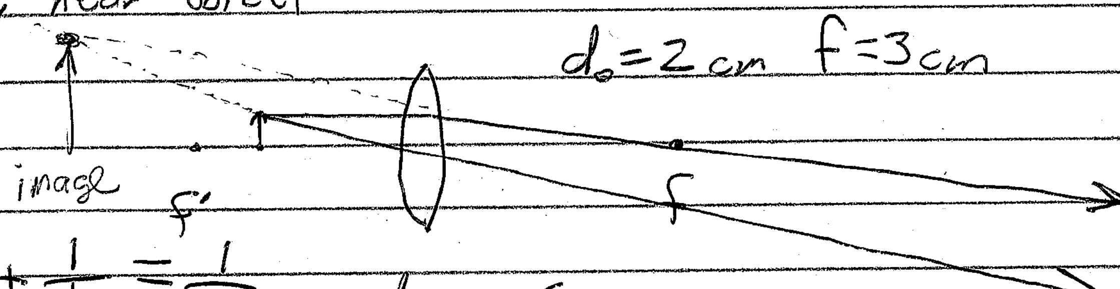
Nearer object

$d_o = 4$ cm $f = 3$ cm $d_i = 12$ cm



Very near object

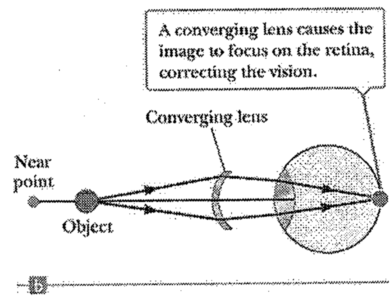
$d_o = 2$ cm $f = 3$ cm



$$\frac{1}{2} + \frac{1}{d_i} = \frac{1}{3} \qquad d_i = -6 \text{ cm}$$

Correcting Farsightedness

Correcting Farsightedness



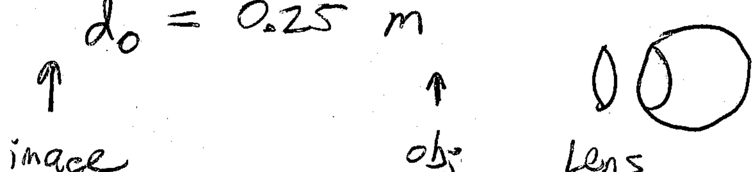
- Image Rays don't converge enough to focus, so make them converge more with a converging lens.
- The eye looks at a virtual image (not shown) at the near point.

Section 25.2

- Person can see far things.
- Rays must be weakly diverging.
- Nearby object has strongly diverging rays.
  - Correct by reducing divergance with a converging lens.
- ~~Far Poin~~ Near Point is nearest thing a person can see.

Ex: $d_{np} = 2.0$ m = hard to read phone.

$d_o = 0.25$ m

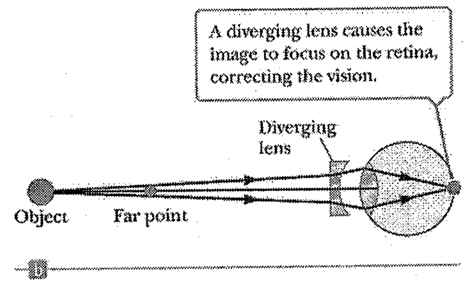


$d_o = 0.25$ m

$d_i = -2.0$ m (Virtual Image!)

$\frac{1}{0.25} + \frac{1}{-2} = 4 - 0.5 = 3.5 = 1/f$ = Power of Lens in diopters

$f = \frac{1}{3.5} = 0.286$ m



- A diverging lens can be used to correct the condition.
- The eye looks at a virtual image (not shown) at the far point.

Section 25.2

Nearsighted Example:

$d_o = \infty$

$d_i = -d_{fp}$ Virtual image at far point

$d_{fp} = 1.0\ m$ $\quad d_i = -1.0\ m$

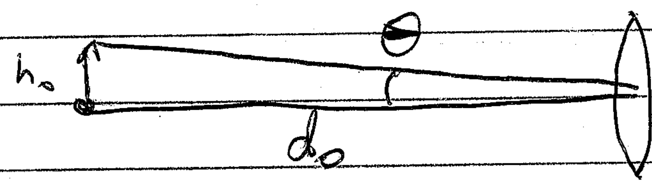
$$\frac{1}{\infty} + \frac{1}{-1.0} = \frac{1}{f}$$

$$-1 = 1/f = \text{Power}$$

$f = \frac{1}{-1} = -1.0\ m$ = Negative focal length

④ # Magnifying Glass

Angular Size



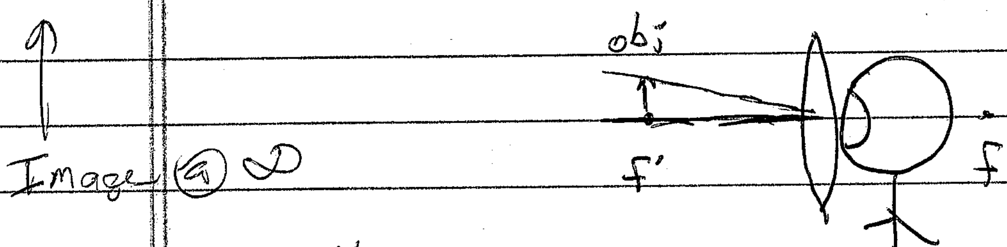
$$\tan\theta = \frac{h_o}{d_o}$$

Small Angle Approx: $\sin\theta \approx \theta$ $\cos\theta \approx 1$ $\tan\theta \approx \theta$
For small angles in radians.

Angular size of a small detail: $\theta_o = \frac{h_o}{d_o}$

A magnifying glass allows d_o to be smaller than d_{np}
near point ↗

Ex: Place object @ lens's focal point.



$f = 5$ cm
$d_o = 5$ cm
$$\frac{1}{5} + \frac{1}{d_i} = \frac{1}{5}$$

$1/d_i = 0 \rightarrow d_i = \pm\infty$

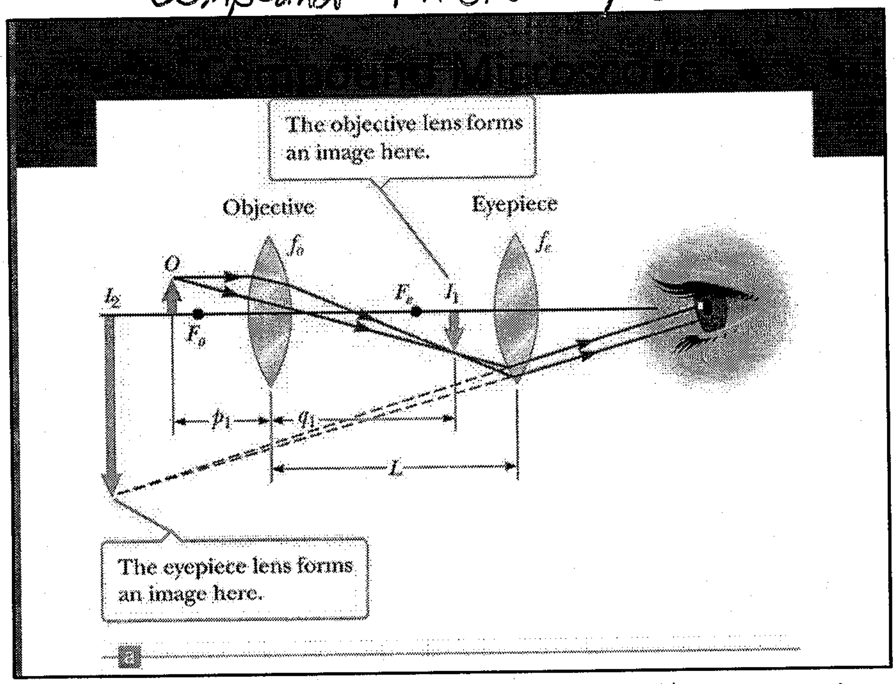
$$\theta = \frac{h_o}{f} \quad \text{(With Lens)}$$

$$\theta = \frac{h_o}{d_{np}} \quad \text{(Without Lens)}$$

$$\text{Angular Mag} = \frac{\theta_{with}}{\theta_{w/o}} = \frac{h_o/f}{h_o/d_{np}} = \frac{d_{np}}{f}$$ (Relaxed Viewing)

Max mag: Add One

Compound Microscope



First, objective lens: Projects real intermediate image,

$d_o \approx f_o$

$d_i \approx L$ = Length between lenses

$$\text{Linear mag} = \frac{-d_i}{d_o} = \frac{-L}{f_o}$$

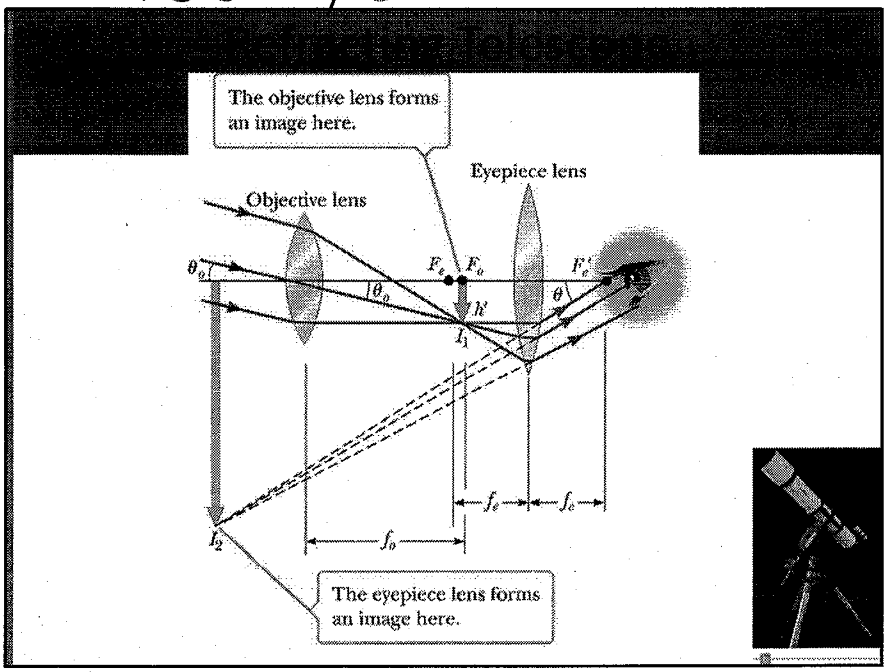
Second lens, eyepiece: Acts as magnifying glass.

$$\text{Angular mag} = \frac{d_{np}}{f_e}$$

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

Two powerful lenses ↗

Telescope



Object is stuck at infinity.

Given quantity is $\theta_o = \frac{h_o}{d_o}$ ← Both huge

First, objective lens projects a small intermediate image.

$$\frac{h_i}{d_i} = \theta_o = \frac{h_i}{f_o}$$

Second lens, eyepiece is magnifying glass.

$$\theta_{with} = \frac{h_i}{d_o} = \frac{h_i}{f_e}$$

↑ second lens

Overall Mag

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