1 Phys 2426 2014-11-24

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

$$M = \frac{h_i}{h_o} = \frac{-q}{p}$$

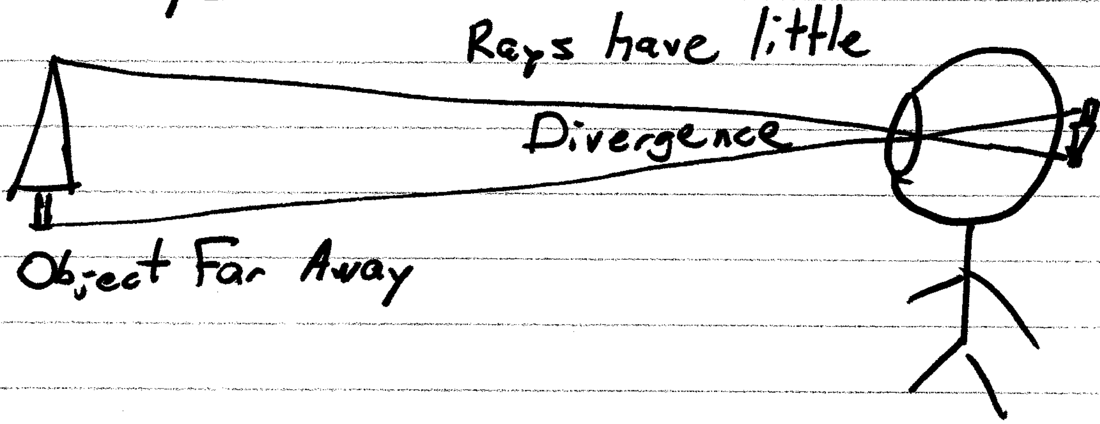
What do the results tell us?

q positive - real image
negative - virtual image

M positive - upright
negative - inverted

|M| larger than 1 - enlarged
< 1 - reduced

The Eye

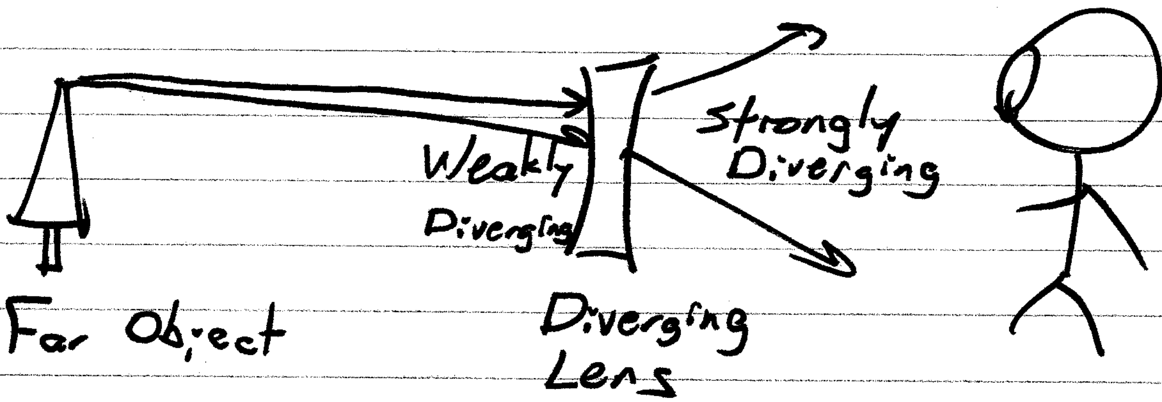


Divergence - How much does Θ change as you move to the side $\frac{d\Theta}{dy} = \frac{1}{x}$

(2)

Nearsightedness - person needs the "object" to be near - person needs strongly diverging rays.

A diverging Lens makes the rays diverge more.



f is negative for Diverging Lens
$p = \infty$ for far object

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \qquad q = f = \text{negative value}$$

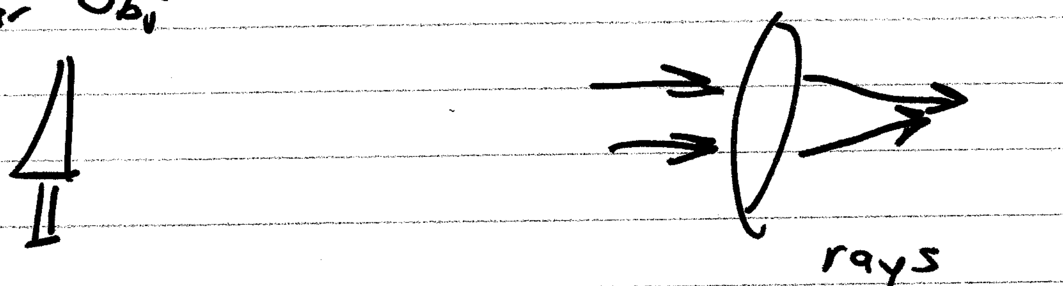
Whenever you look "thru" a lens, q is negative. The image is virtual. See Figure 36.38.

(3)

Farsighted - need far "object"
- need weakly diverging rays.

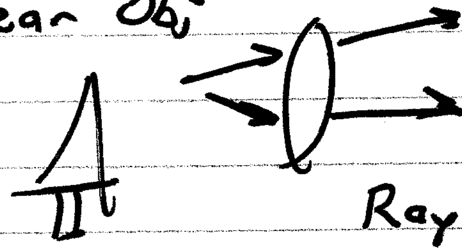
A converging lens makes rays converge more, or diverge less.

Far Obj



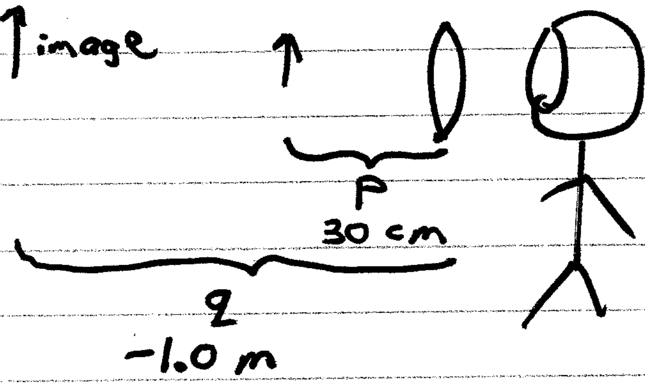
"Projector Configuration"

Near Obj



Rays Diverge
Less
Obj seems further.

Ex: Near Point 1.0 m
Want to read book @ 30 cm



$$\frac{1}{30} + \frac{1}{-100} = \frac{1}{f}$$

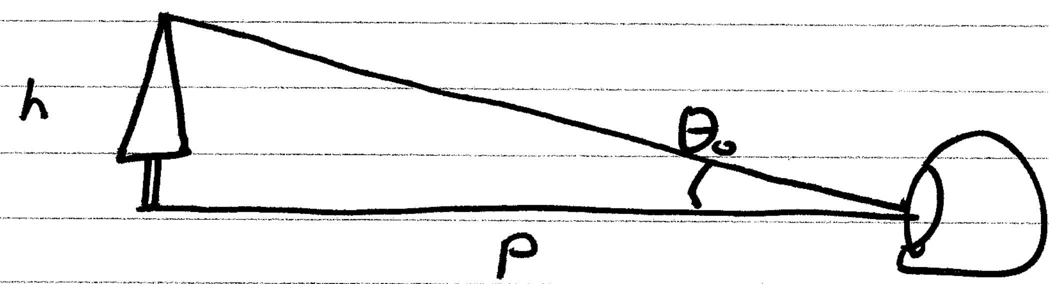
$$0.0233 = 1/f$$

$$f = 42.9 \text{ cm}$$

Applications

- Magnifying Glass   Fig 36.40
- Microscope   .41
- Telescope   .42

Angular Size



$\tan\theta_o = \frac{h}{p}$ $\theta_o \approx \frac{h}{p}$ small angles in rad

How can we maximize θ_o? Reduce p.

Minimum $p = d_{np}$

Maximum $\theta_o = h/d_{np}$

Magnifying Glass - converging w/ small f.

Can place object at the focal point.

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \rightarrow \frac{1}{f} + \frac{1}{q} = \frac{1}{f} \rightarrow \frac{1}{q} = 0$$

$q = \infty$ image @ infinity

Now the object is closer without messing w/ our focus. How big?

For the Lens: $\theta = h/p = h/f$ = angle w/ Lens

Magnification $m = \frac{\theta}{\theta_o} = \frac{h/f}{h/d_{np}} = \frac{d_{np}}{f}$

Can move image closer by moving the object closer. An extra magnification increment is introduced.

$$m_{strained} = m_{relaxed} + 1$$

Ex: A 6X magnifier

$$m_{relaxed} = 5 = \frac{d_{np}}{f} = \frac{25\,cm}{f}$$

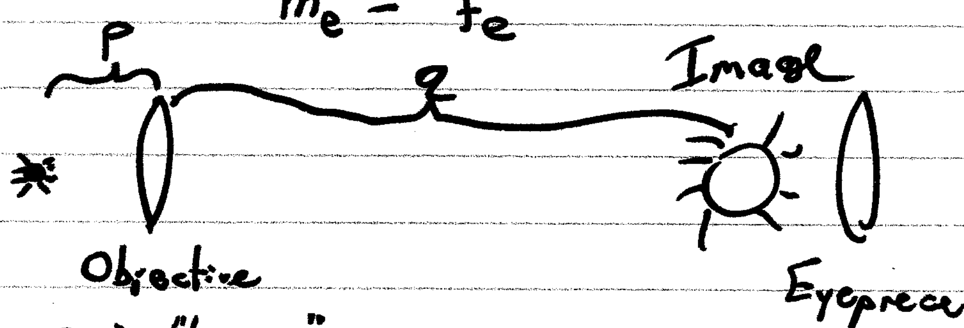
$$f = 5\ cm$$

<u>Microscope</u>

Two Lenses

- Objective - projects an intermediate image.
  - Obj is further than f_o.
  - $M_o = h_i/h_o = -q/p$
- Eyepiece - used as a magnifier.

$$m_e = \frac{d_{np}}{f_e}$$



q is "Large"

$p \approx f_o$

$$M = \frac{-q}{p} = \frac{-L}{f_o}$$

Total Mag:

$$m = M_o m_e = \frac{-L\,d_{np}}{f_o f_e}$$