① Phys 2426 2017-08-02 Lec 18

As object gets closer, object rays get more diverging.

Principle Rays

- Horizontal Ray - Bends thru f
- Central Ray - goes straight
- Focal Ray - Object ray hits "other f"
  - Image ray is horizontal

For real Image

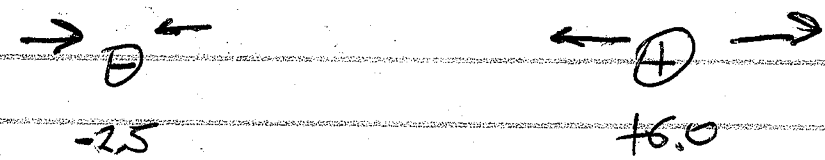
- closer object → further image
- closer object ⟹ bigger image

But, ... when $d_o = f$, math breaks

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

$$\frac{1}{d_i} = 0 \; ?$$

How can field be zero w/ multiple sources?
- Contributions must cancel.



Contributions are as described in Coulomb's Law. Field is vector sum.

In middle:
- Toward ⊖ is $-\hat{x}$
- Away from ⊕ is $-\hat{x}$
- Contributions add, no node

On Left:
- Toward ⊖ is $+\hat{x}$
- Away from ⊕ is $-\hat{x}$
- Contributions could cancel
  - Near: ⊖ is stronger
  - Far: ⊕ is stronger

$E = \frac{kq}{r^2}$

Also check Lec 7 Recording.

$$E_1 = \frac{kq_1}{r_1^2} = \frac{kq_2}{r_2^2}$$

$r_1 = x \quad r_2 = x + d$

RC Discharge

$$V = V_0 e^{-t/\tau} \rightarrow \frac{V}{V_0} = e^{-t/\tau}$$

V= 10% of initial

$$V = 0.1\, V_0$$

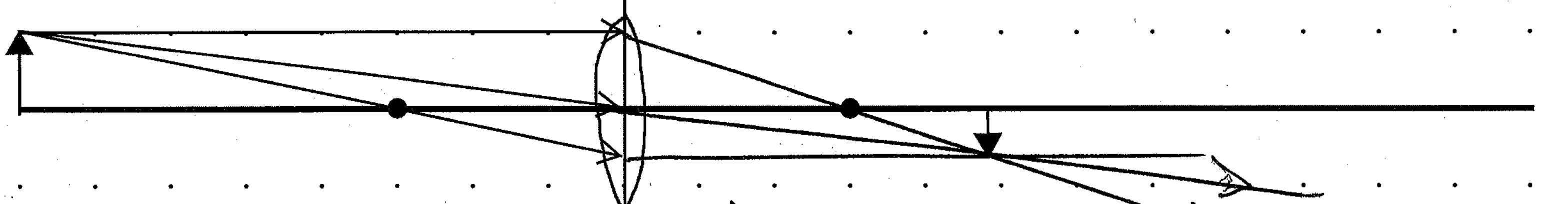
$$\frac{V}{V_0} = 0.1$$

$$0.1 = e^{-t/\tau}$$

$$\ln(0.1) = -t/\tau$$

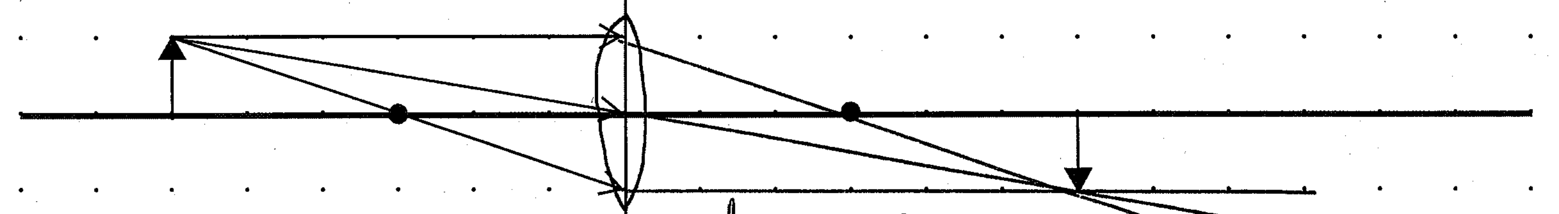
$$-\ln(0.1)\,\tau = t$$

$-\ln(0.1)$ = "How many time constants"



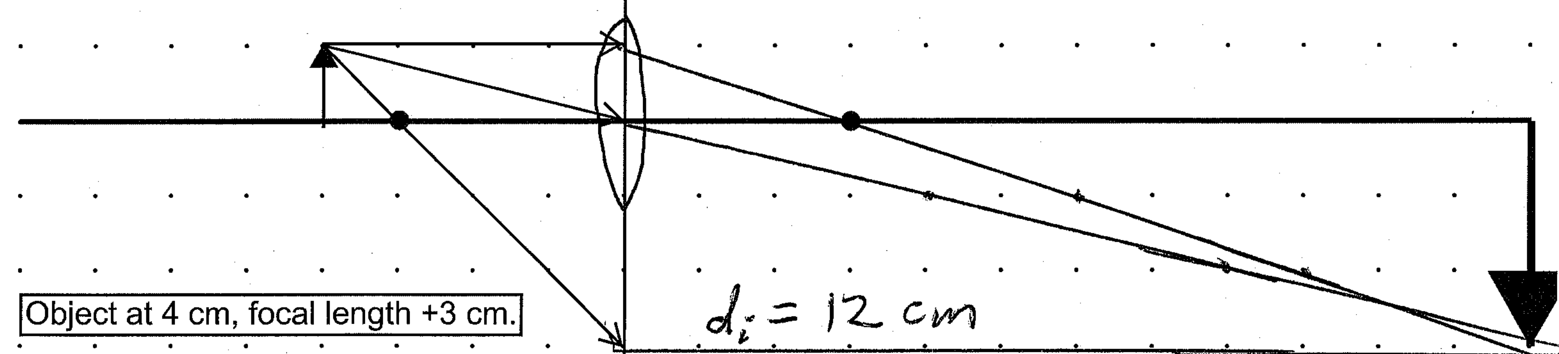
Object at 8 cm, focal length +3 cm.

$d_i = +4.8$ cm



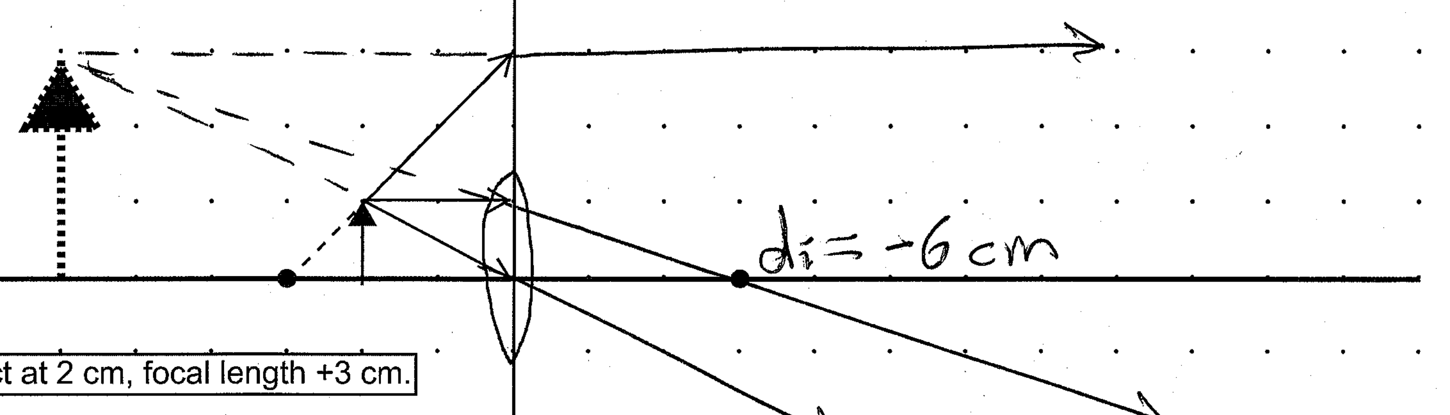
Object at 6 cm, focal length +3 cm.

$d_i = +6$ cm



Object at 4 cm, focal length +3 cm.

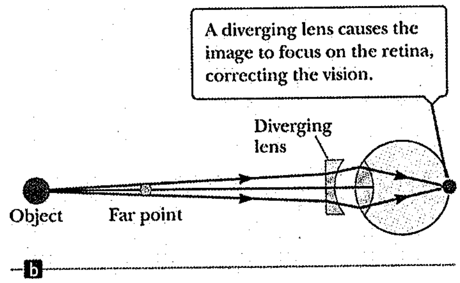
$d_i = 12$ cm



$d_i = -6$ cm

Object at 2 cm, focal length +3 cm.

Correcting Nearsightedness



- 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

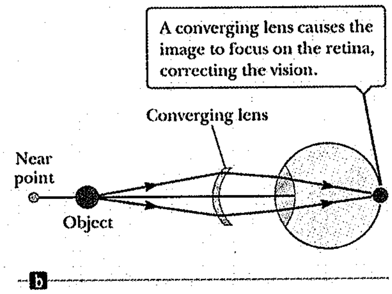
Ex: $d_o = \infty$

$d_i = -(\text{far point}) = -0.5\ m$

$\left(\frac{1}{\infty}^{0} + \frac{1}{-0.5}\right)^{-1} = -0.5\ m = f$

Power $= \frac{1}{f} = -2$

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

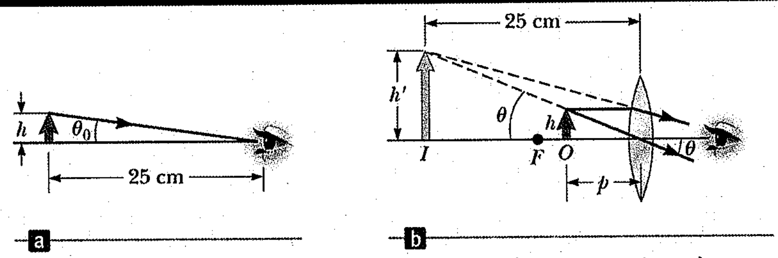
$d_o = 25 \text{ cm}$

$d_i = -(\text{near point}) = -8 \text{ m}$

$$\left(\frac{1}{0.25} + \frac{1}{-8}\right)^{-1} = f = 0.258 \text{ m}$$

$$\text{Power} = \frac{1}{f} = +3.9$$

The Size of a Magnified Image



- Without the lens, an object is placed at the near point, the angle subtended is a maximum.
  - The near point is about 25 cm
- With the lens, the object is placed near the focal point of a converging lens, the lens forms a virtual, upright, and enlarged image.

Section 25.3

w/o $\tan\theta_0 = \frac{h}{25\text{cm}} \approx \theta_0$ in rad

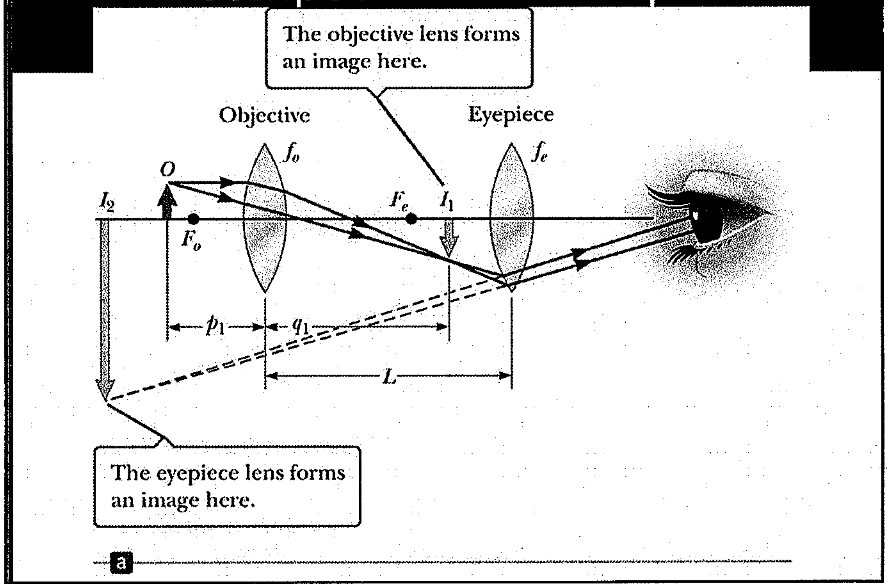
w/ $\tan\theta = \frac{h}{f} \approx \theta$

$$\text{mag} = \frac{\theta}{\theta_0} = \frac{h/f}{h/25\text{cm}} = \frac{25\text{cm}}{f}$$

Can get obj a little closer for more mag.

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

Compound Microscope



- Object at approx focal point of objective
- Projects real image inside microscope
- EyepiecE acts as magnifying glass
- Creates virtual image to look at.

Objective: $M = \frac{-d_i}{d_o} = \frac{-L}{F_o}$

Eyepiece: $m = \frac{25\,cm}{f_e}$

Overall: $m = \frac{-L\,(25\,cm)}{f_o f_e}$