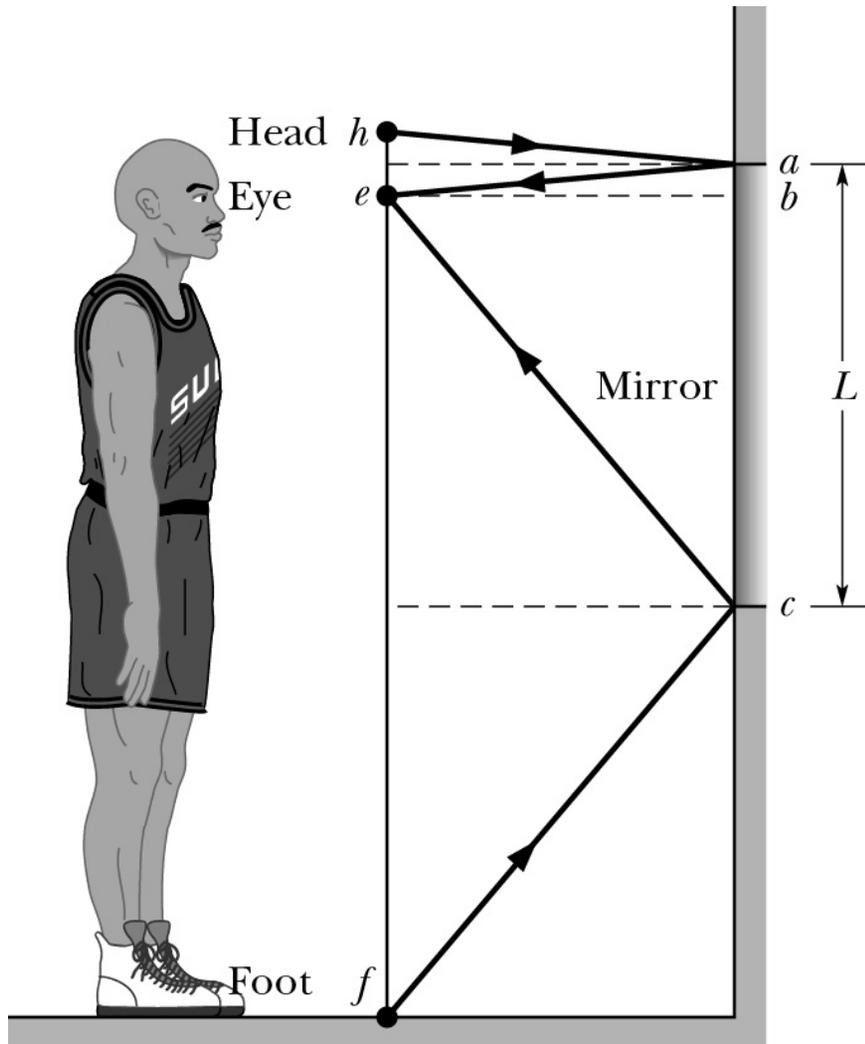


## Announcements

1. Quiz for today was tardy – it is now available; quiz for Monday will be available this weekend
2. Topics for today:
  - Geometric optics – mirrors and lenses; optical instruments
  - The mirror and lens equation
  - Ray diagrams
  - The physics of cameras, microscopes, telescopes

## Comment about HW question:

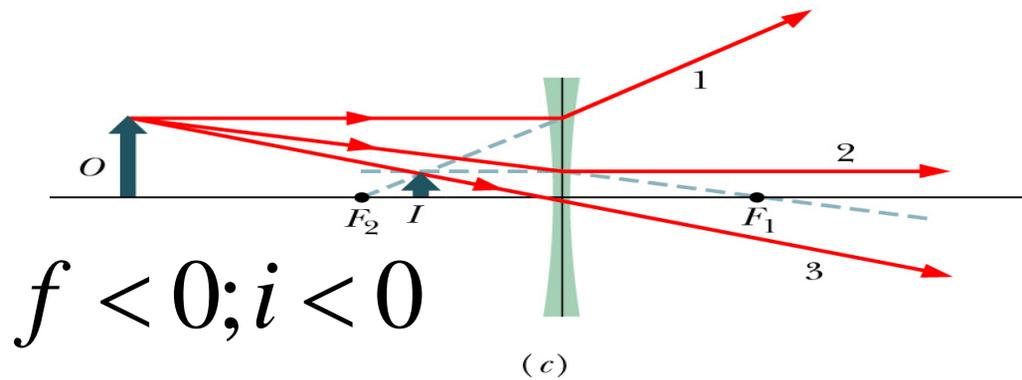
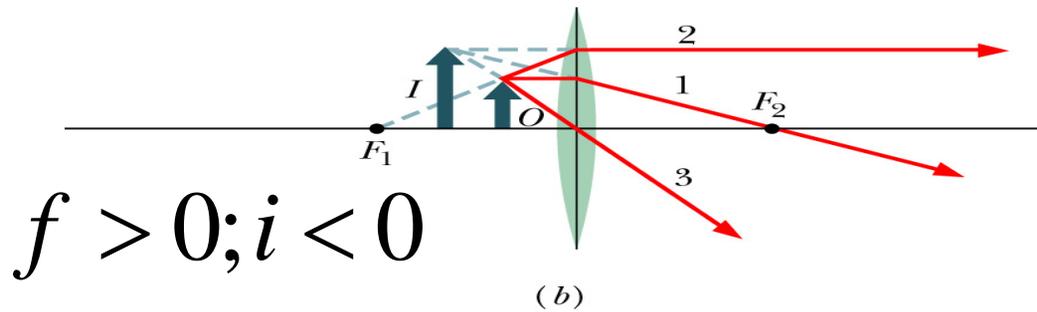
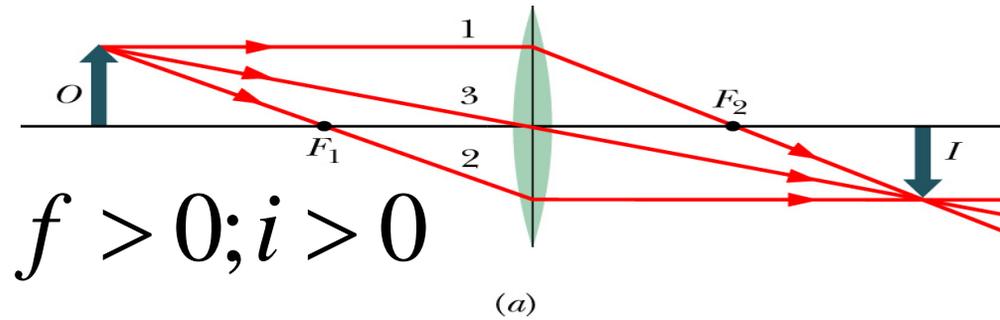


A person of height  $h$  wishes to see a full length image of him/herself in a plane mirror. What is the minimum length mirror required?

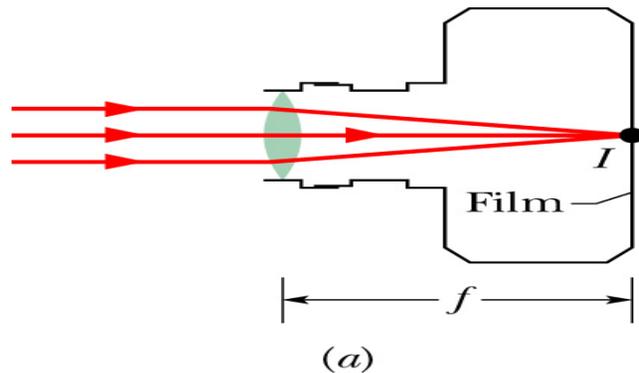
$$h = L / 2$$

# Thin lens equation:

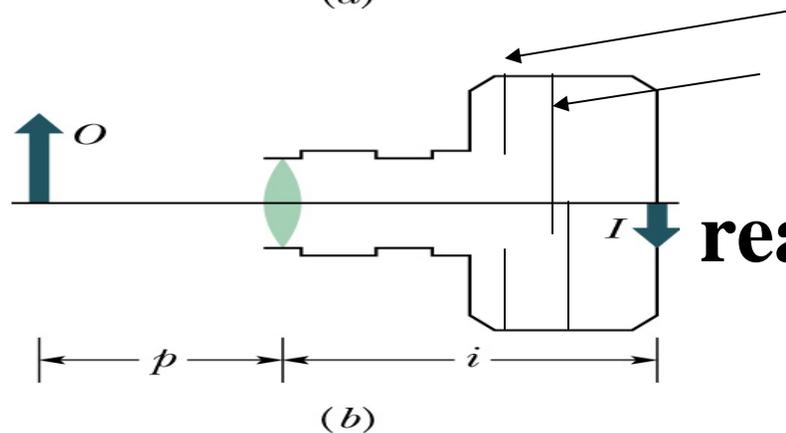
$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$$



# Physics of the camera



aperture



shutter

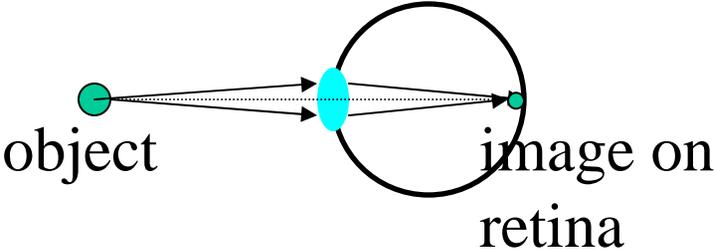
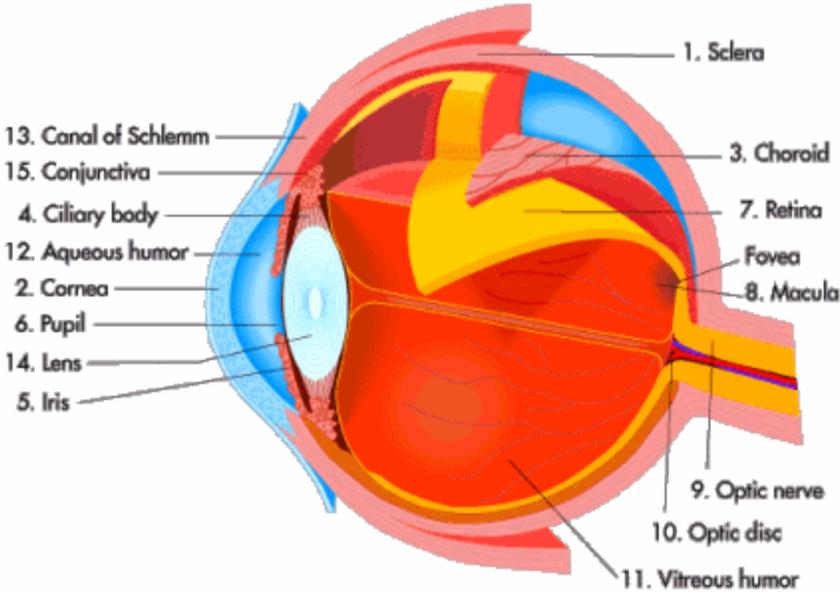
real image on detector

**Example:**  $f=50\text{mm}$   $\rightarrow i=50\text{mm}$  for  $p=\infty$

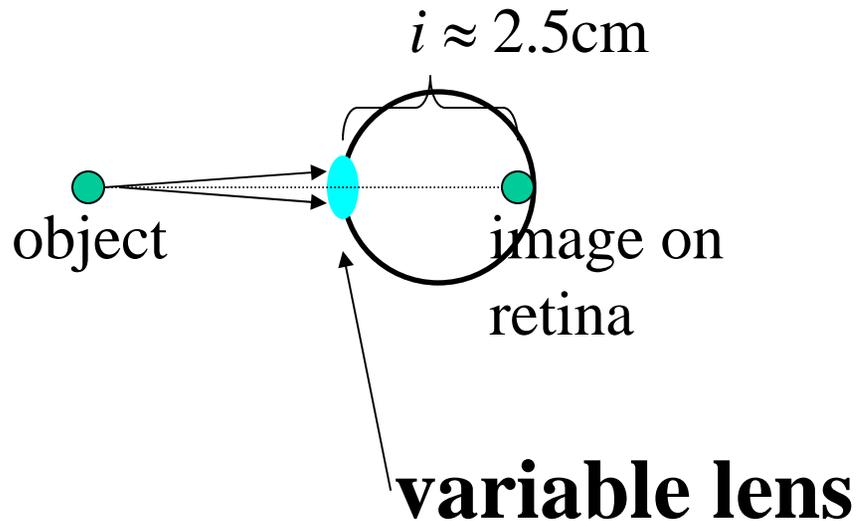
$\rightarrow i=51.3\text{mm}$  for  $p=2\text{m}$

# View of the eye from

<http://science.howstuffworks.com/eye1.htm>



## More details about eye:



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

$$\frac{1}{25} + \frac{1}{2.5} = \frac{1}{f}$$

$$f = \frac{1}{\frac{1}{25} + \frac{1}{2.5}} = 2.27\text{ cm}$$

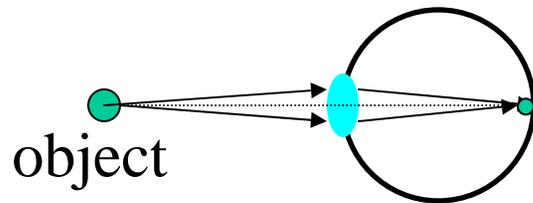
**“near point”**  $\equiv$  **closest point that the eye can focus**

**25 cm standard value**

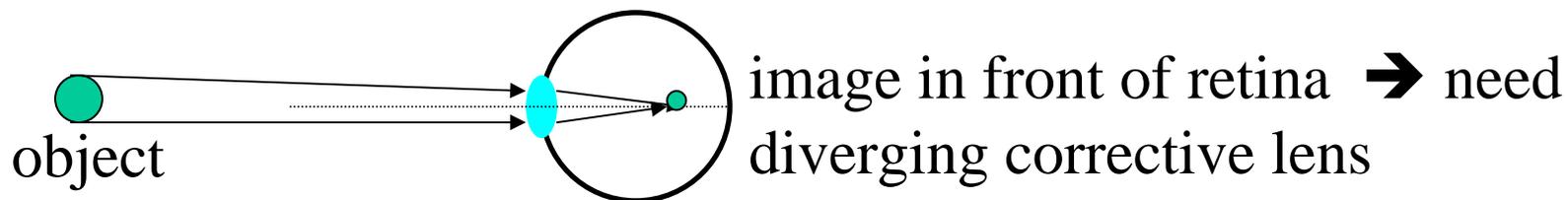
**7-200 cm depending on person**

# Vision problems and corrective lenses

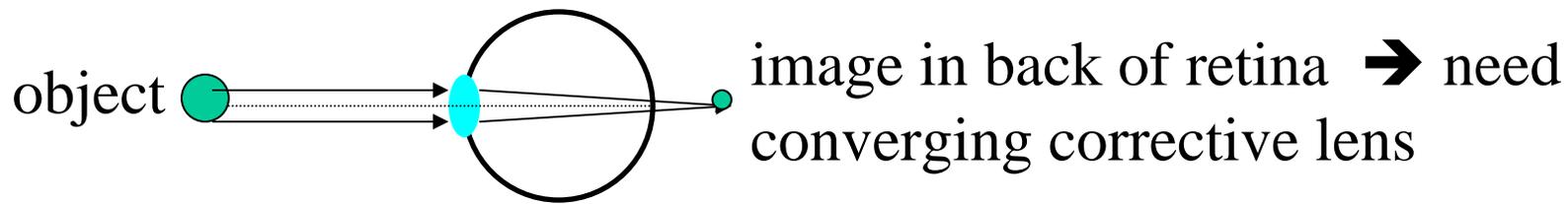
Ideal vision:



Near sighted vision – problem with “Far point”

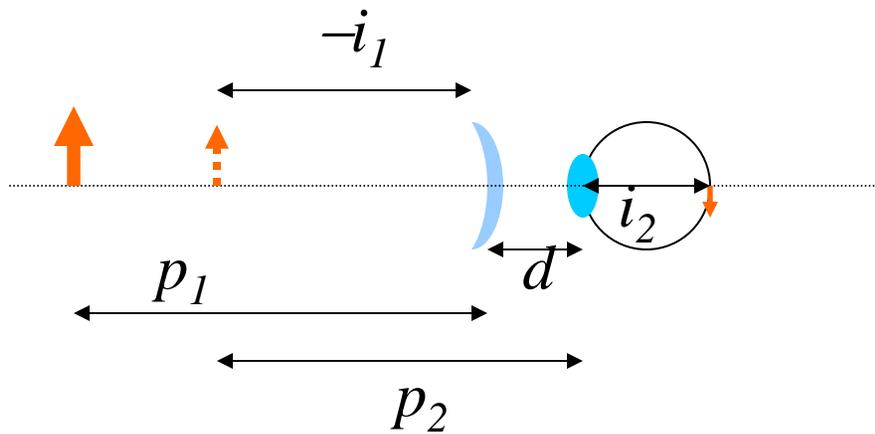


Far sighted vision – problem with “Near point”



## Refraction from two or more lenses

→ Successive use of lens equation



$$\frac{1}{p_1} + \frac{1}{i_1} = \frac{1}{f_1}$$

$$p_2 = -i_1 + d$$

$$\frac{1}{p_2} + \frac{1}{i_2} = \frac{1}{f_2}$$

Example:

$$p_1 = 50 \text{ cm}; \quad f_1 = -25 \text{ cm}; \quad f_2 = 1.4 \text{ cm}; \quad d = 1.0 \text{ cm}$$

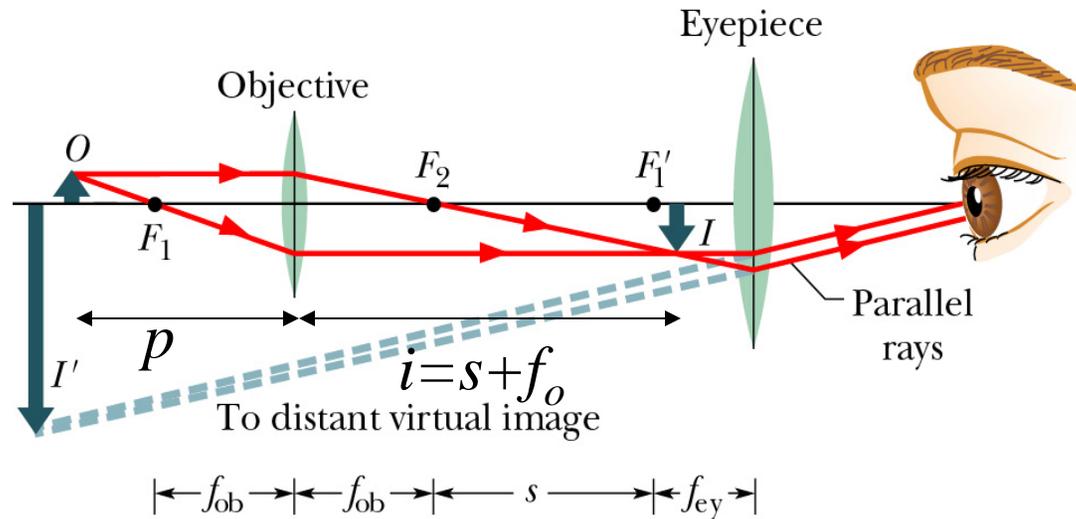
We find:

$$i_1 = -16.667 \text{ cm}; \quad i_2 = 1.52 \text{ cm}$$

Without the diverging lens:

$$i_2 = 1.44 \text{ cm (short of retina)}$$

# Physics of the microscope

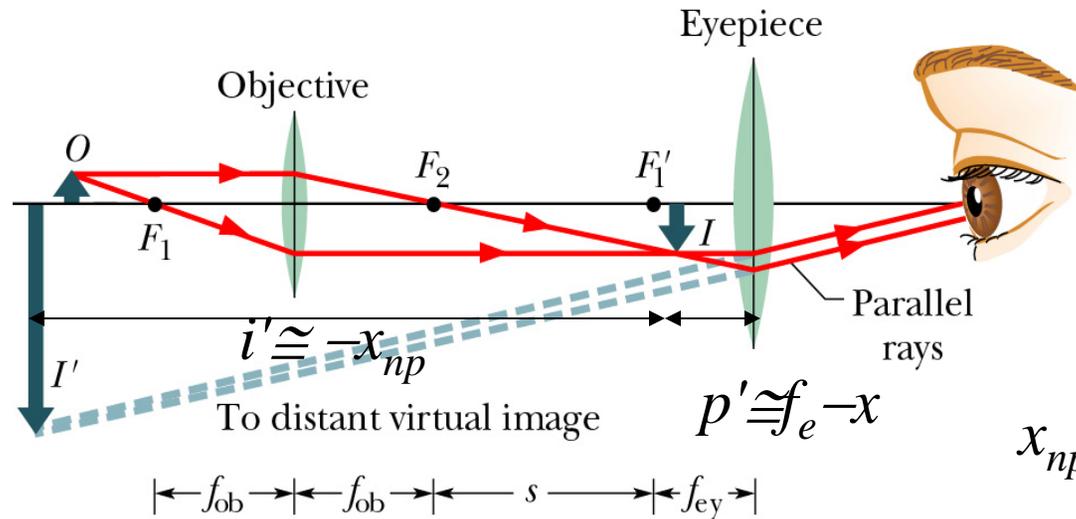


**Objective:**

$$\frac{1}{p} + \frac{1}{s + f_o} = \frac{1}{f_o} \qquad p = \frac{f_o(s + f_o)}{s}$$

$$m = \frac{-i}{p} = -\frac{s + f_o}{\frac{f_o(s + f_o)}{s}} = -\frac{s}{f_o}$$

# Physics of the microscope



$x_{np} \equiv$  “near point” distance

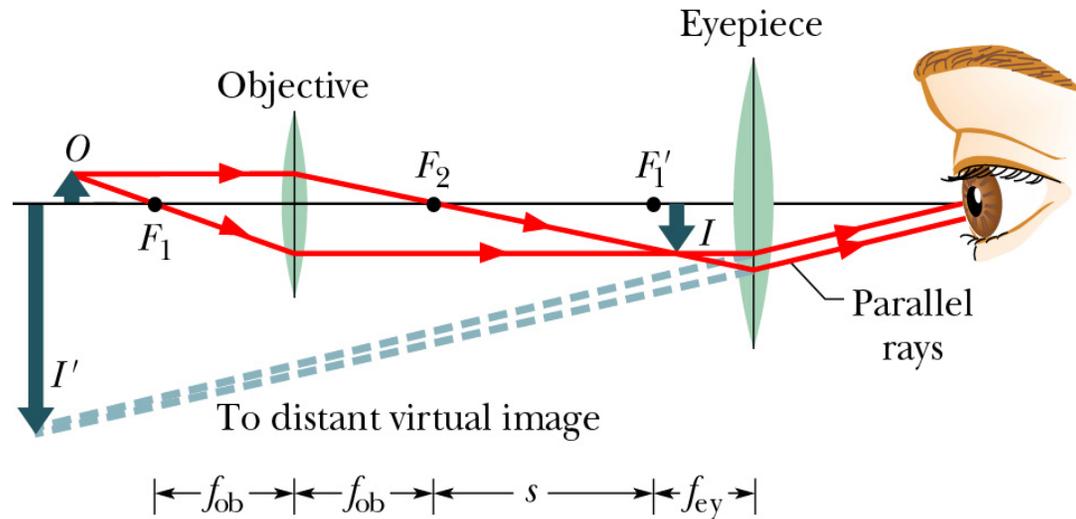
**Eyepiece:**

$$\frac{1}{f_e - x} + \frac{1}{-x_{np}} = \frac{1}{f_e}$$

$$x = \frac{f_e^2}{x_{np} + f_e} \quad (f_e \ll x_{np})$$

$$m' = \frac{-i'}{p'} = \frac{x_{np}}{f_e - x} \approx \frac{x_{np}}{f_e}$$

# Physics of the microscope



Net magnification :

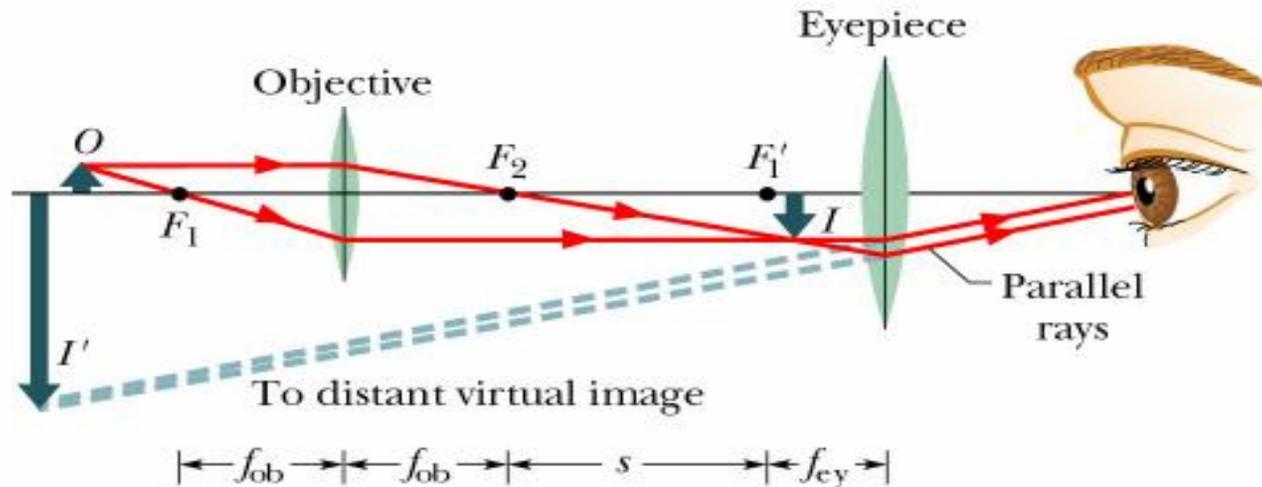
$$M = mm' = \frac{-s}{f_o} \frac{x_{np}}{f_e}$$

Example:  $f_o = 6\text{mm}; f_e = 20\text{mm};$

$$s = 150\text{mm}$$

$$M = -\frac{150}{6} \frac{250}{20} = -312.5$$

Online Quiz for Lecture 23  
Geometrical optics -- Mar. 30, 2005



The above diagram shows the geometrical optics of a microscope. Suppose instead of viewing the image with your eye, you wanted to photograph the image. Where would you put the camera?

- A. Put the camera at the same location as the eye in the diagram.
- B. Put the camera at the location of the image formed by the objective.
- C. Put the camera at the location of the eyepiece.
- D. Put the camera so that objective image is to the right of camera lens focal point.
- E. Put the camera so that objective image is to the left of camera lens focal point.