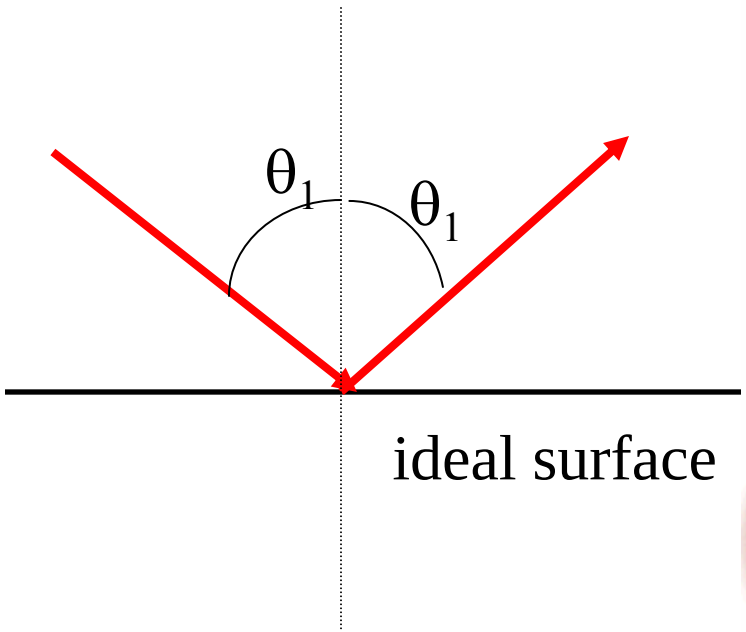
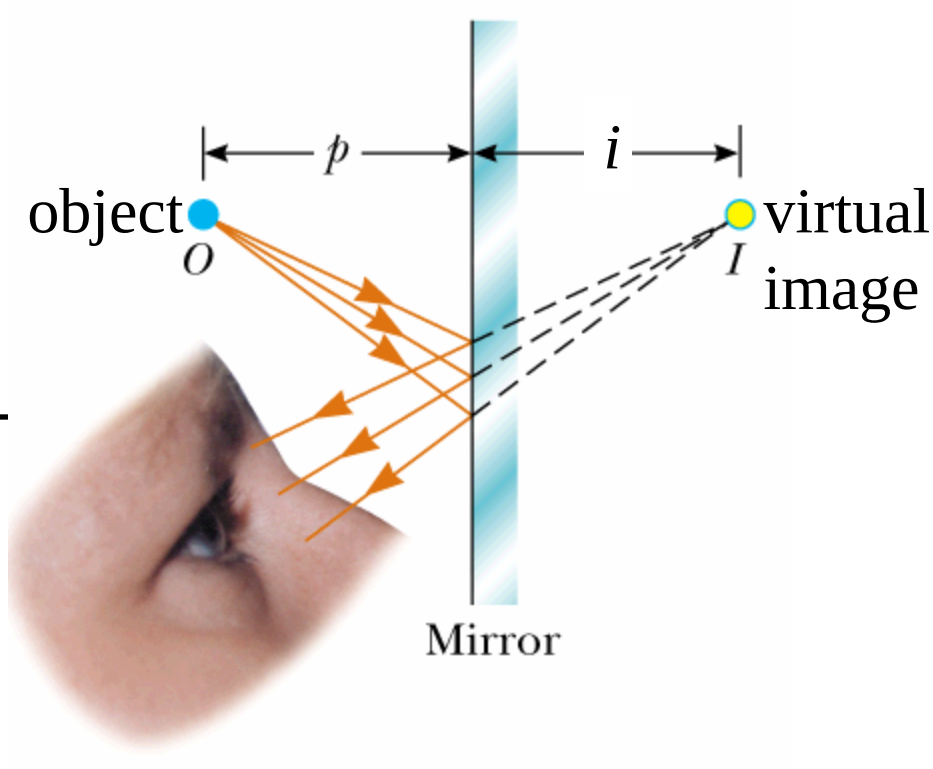
Announcements

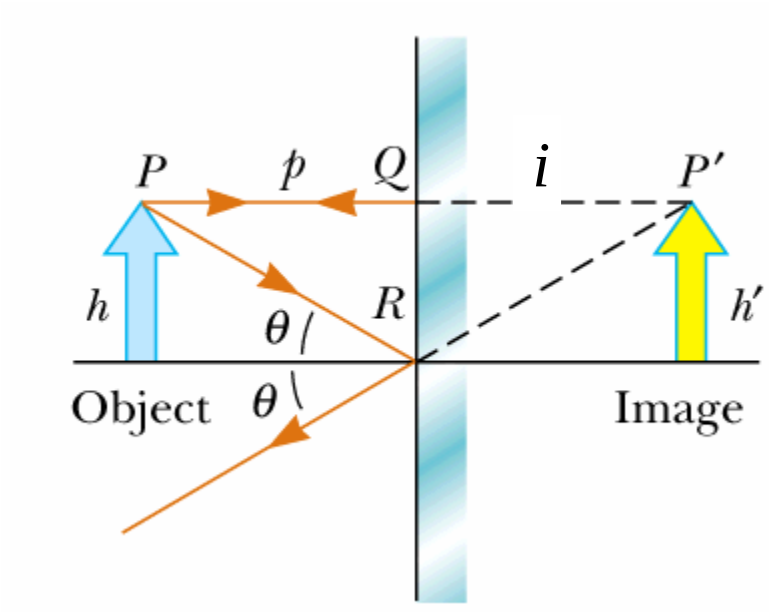
1. Exam 3 will be returned on Wednesday
2. Assignment #22 is available; due Wednesday night
3. Problem solving session Wednesdays at 6 PM??
4. General schedule for the remainder of the course:
   - Geometrical optics – images formed from mirrors and lenses, optical devices
   - Interference properties of light
   - Topics in “modern” physics
   - Exam 4 scheduled for April 15th
5. Today’s topics --
   - Mirrors
   - Real and virtual images

Images formed from reflected light:

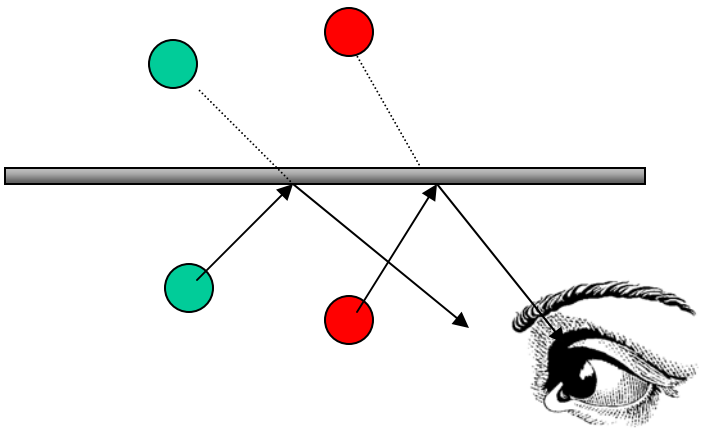




Analysis of mirror image



Mirror symmetry:



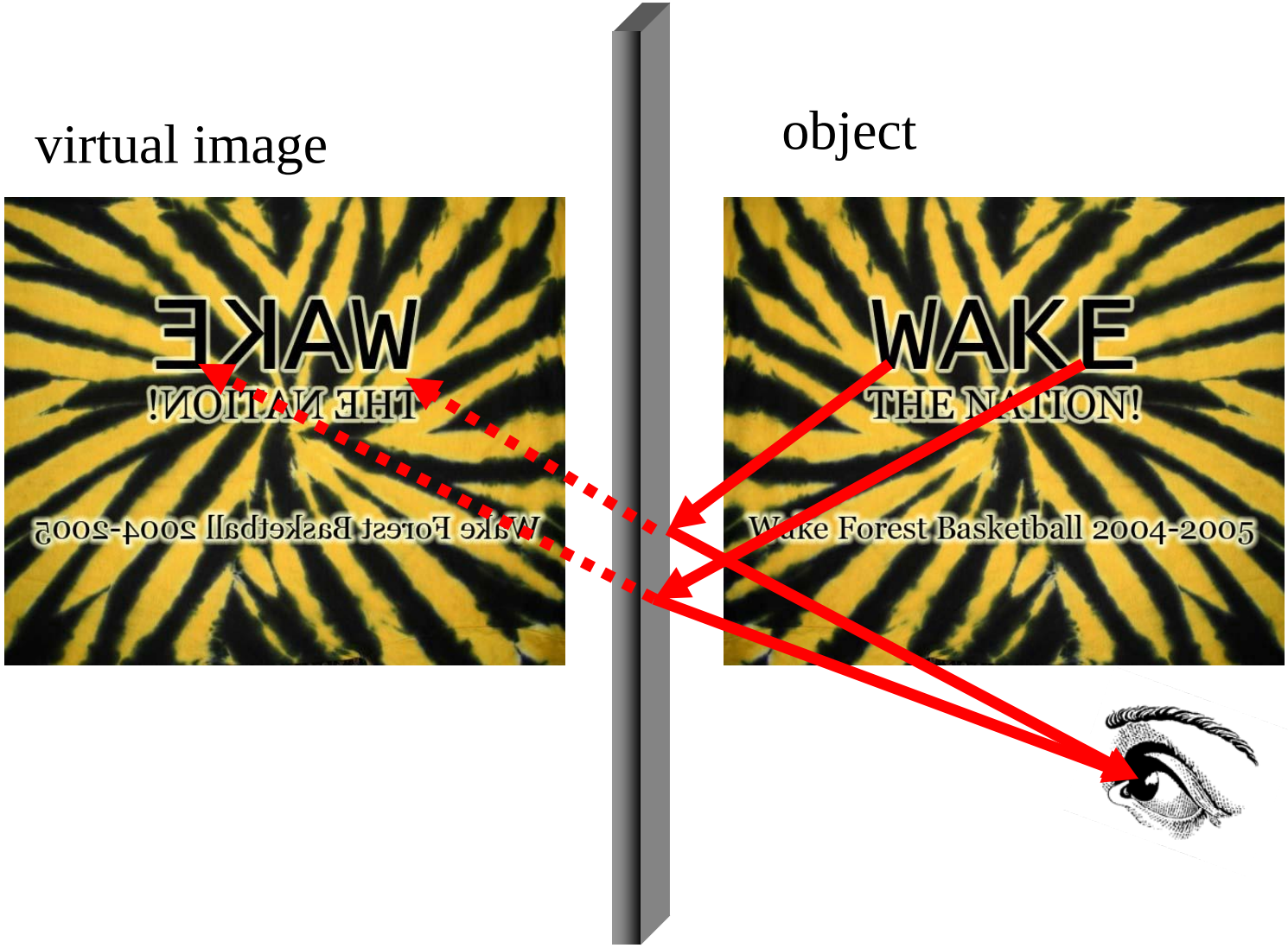
Using geometry:

$$i = p \qquad h = h'$$

Terminology:

Virtual image -- perceived image but no light can be detected at the location of the virtual image

Real image - - light can detected at the location of the real image

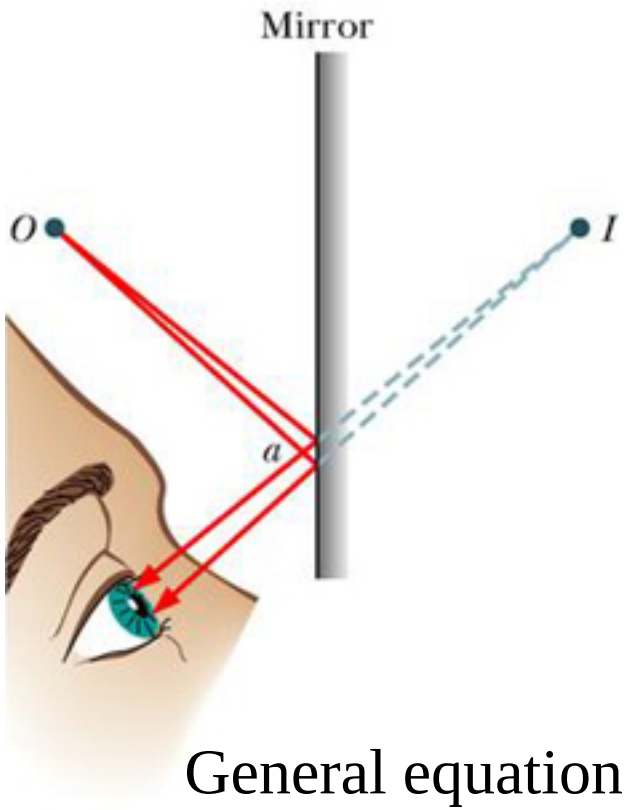

virtual image
object
WAKE
THE NATION!
Wake Forest Basketball 2004-2005
WAKE
THE NATION!
Wake Forest Basketball 2004-2005

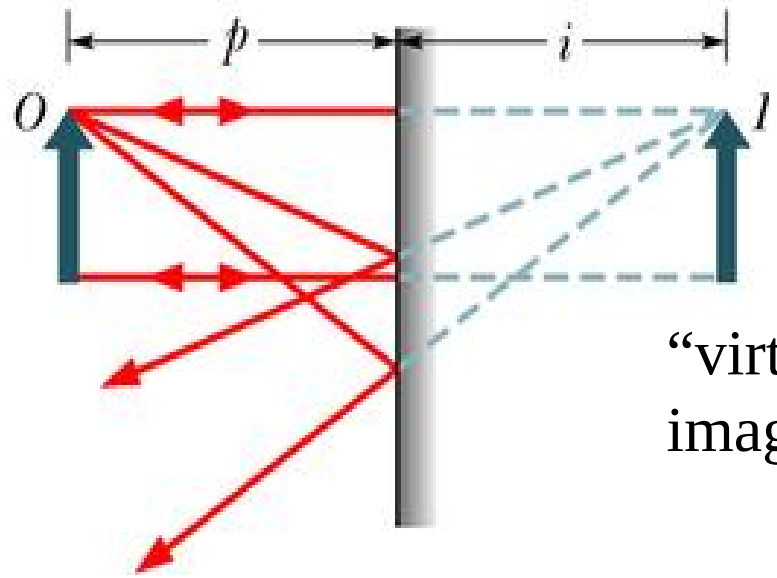
Online Quiz for Lecture 22
Geometrical optics -- Mar. 28, 2005

For each of the following sequences of letters, write the mirror image in the box.

1. OTAMOT TOMATO
2. UOY YHW WHY YOU
3. TIM MIT

Summary of geometric optics of plane mirror





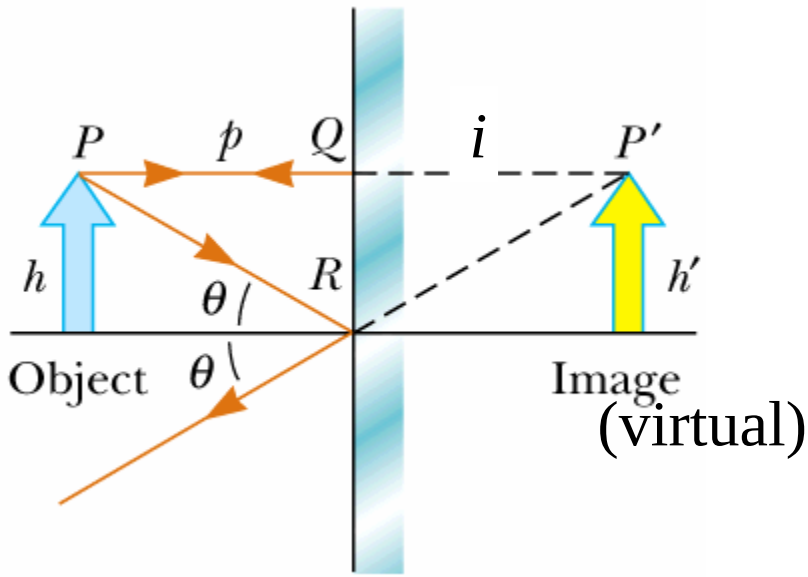
"virtual" image

In this case: $i = -p; \quad f = \infty$

General equation describing object and image positions:

Mirror equation: $\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$

Analysis of image from plane mirror



Geometrical relationships

$|i| = p \qquad h = h'$

Magnification $M \equiv \dfrac{\text{Image height}}{\text{Object height}} = \dfrac{h'}{h}$

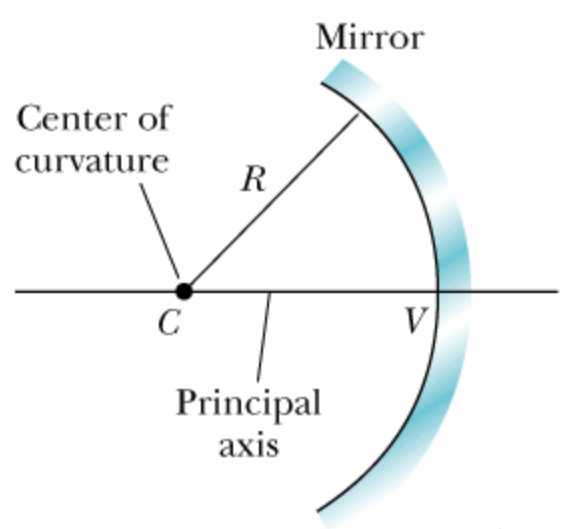
Some details:

By convention,

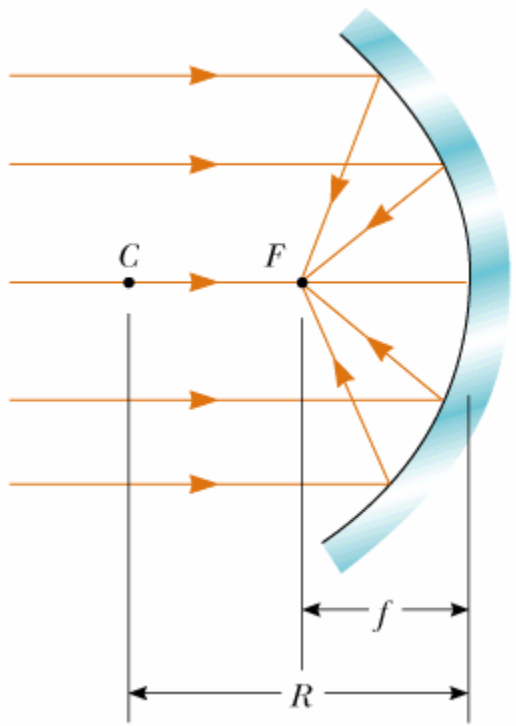
$i < 0$ for virtual image

$$\frac{1}{i} + \frac{1}{p} = 0 = \frac{1}{\infty}$$

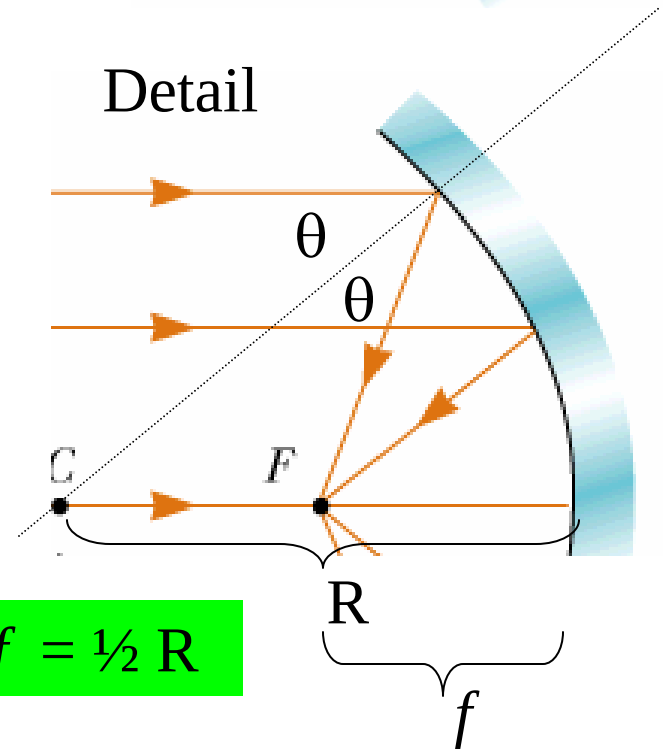
Spherical mirrors -- concave



Reflection of parallel light rays:

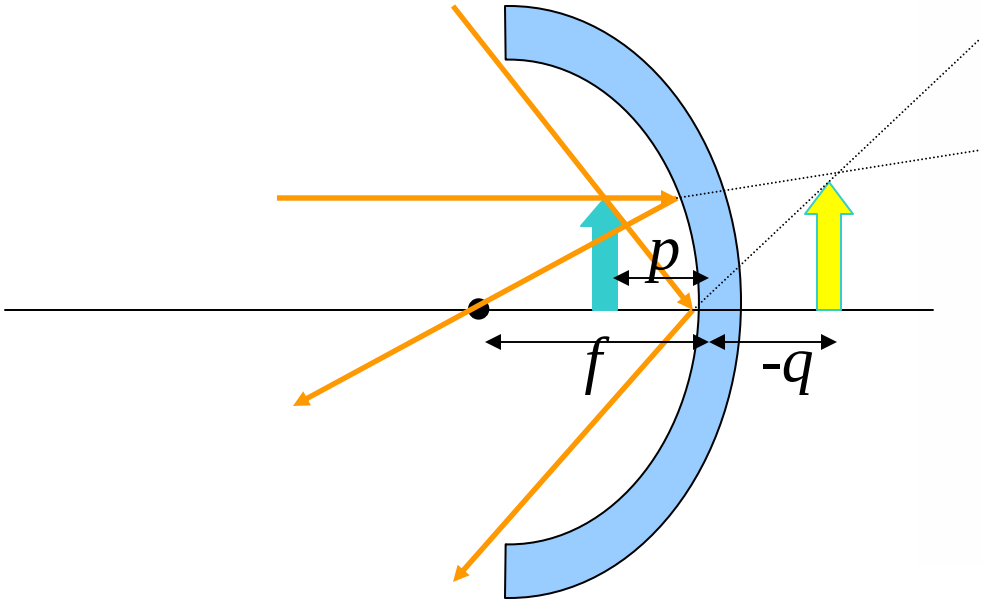


Detail

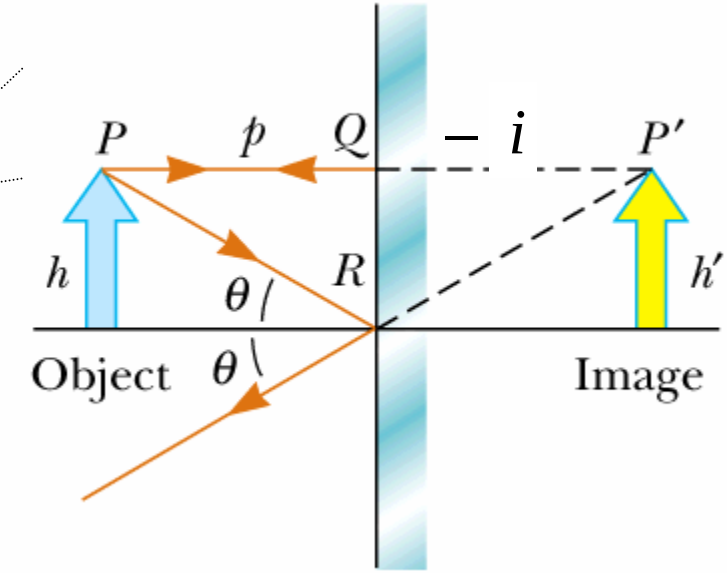


$f = \frac{1}{2} R$

Image formed in concave mirror:



Plane mirror:



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

$$M=\frac{h'}{h}=\frac{-i}{p}$$

Example: f = 4 cm

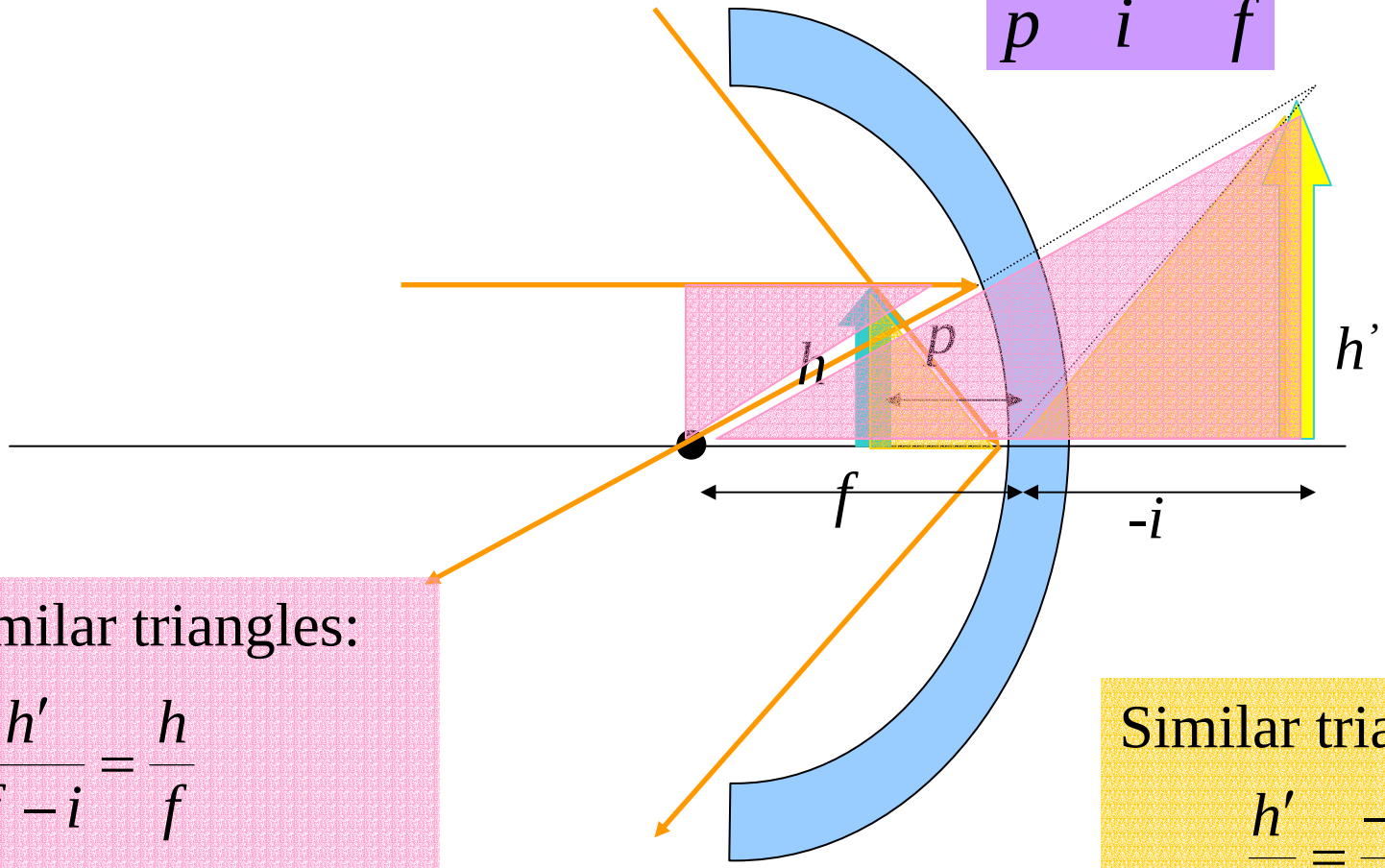
p = 1 cm

i = -1.33 cm

$$M=\frac{-i}{p}=\frac{1.33}{1}=1.33$$

"Proof" of mirror equation:

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



Similar triangles:

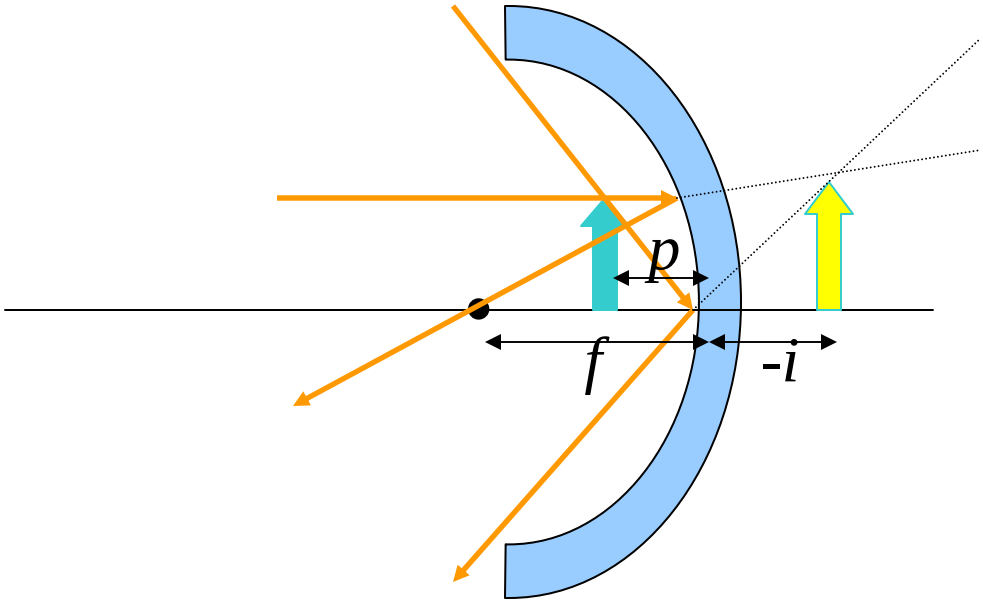
$$\frac{h'}{f-i}=\frac{h}{f}$$

$$\Rightarrow \frac{h'}{h}=\frac{f-i}{f}=\frac{-i}{p}$$

Similar triangles:

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

Image formed by concave mirror:

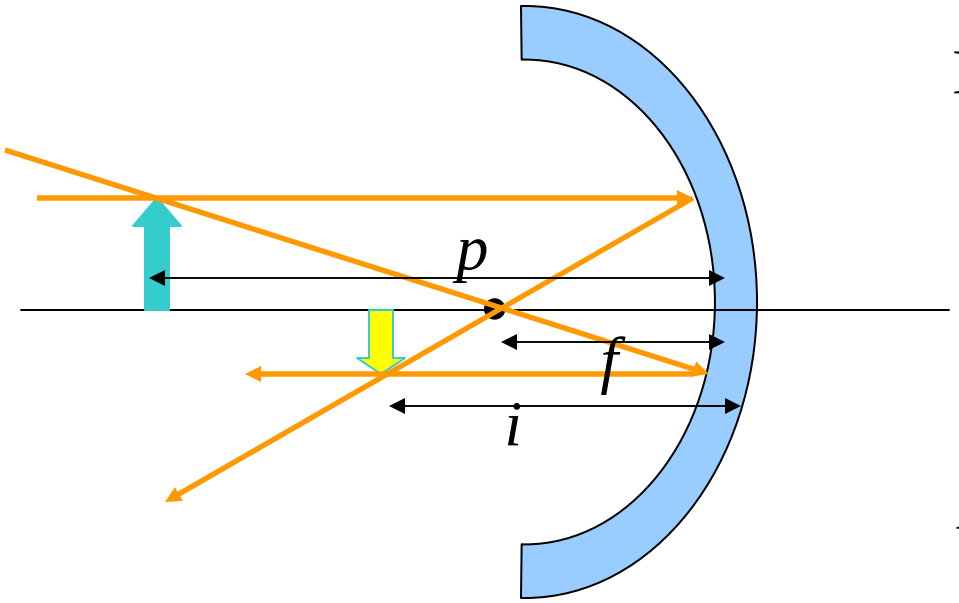


General result for virtual image formed by concave mirror

$p < f$

image is upright and increased in size

Image formed by concave mirror:



Example: $f = 4$ cm

$p = 10$ cm

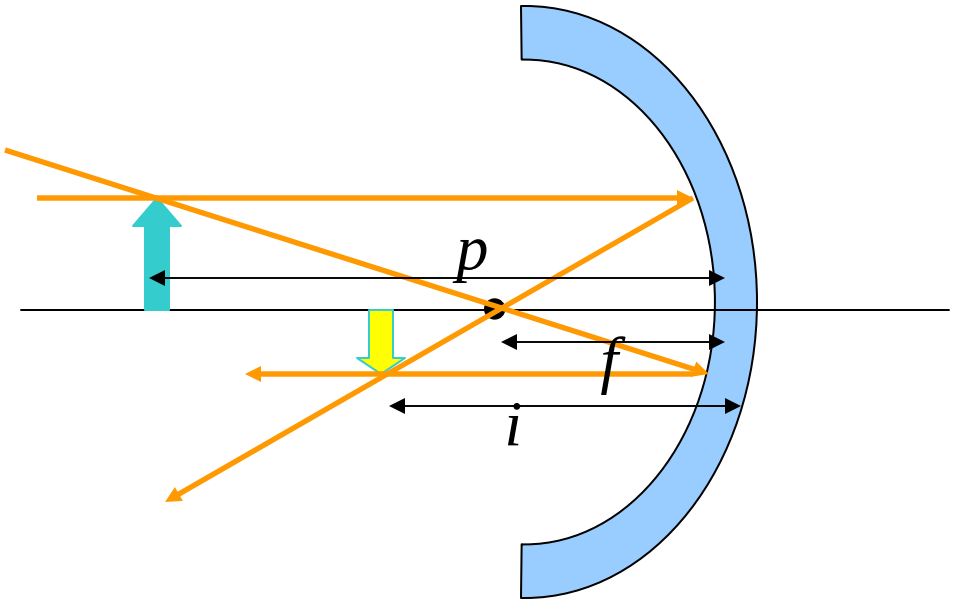
$i = 6.67$ cm

$$M = \frac{-i}{p} = \frac{-6.67}{10} = -0.667$$

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

$$M = \frac{-h'}{h} = \frac{-i}{p}$$

Image formed by concave mirror:



General result for real image formed by concave mirror

$p > f$

image is upside down

Peer instruction question: Is image always reduced in size?

(A) yes (B) no

Convex mirror

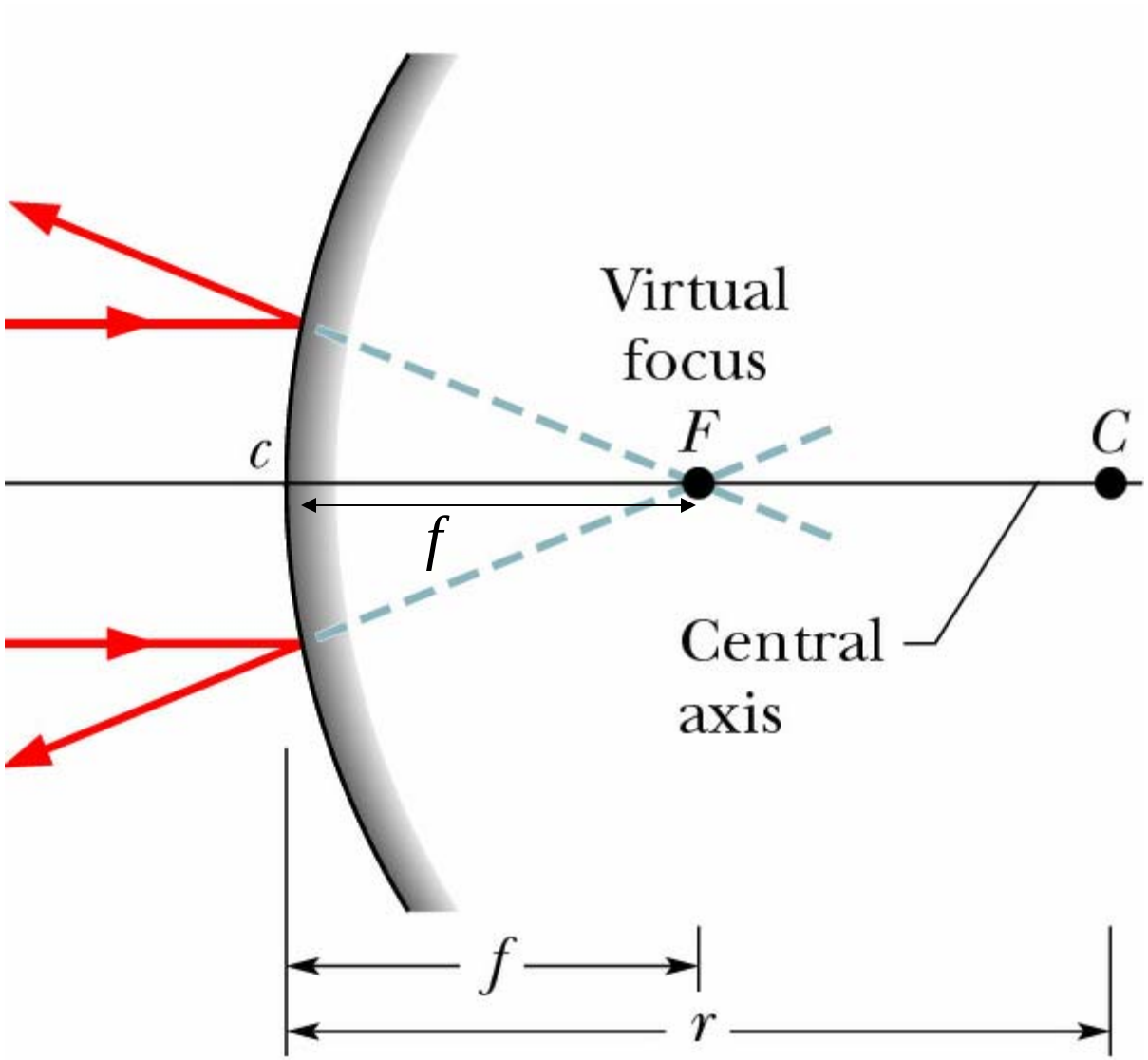
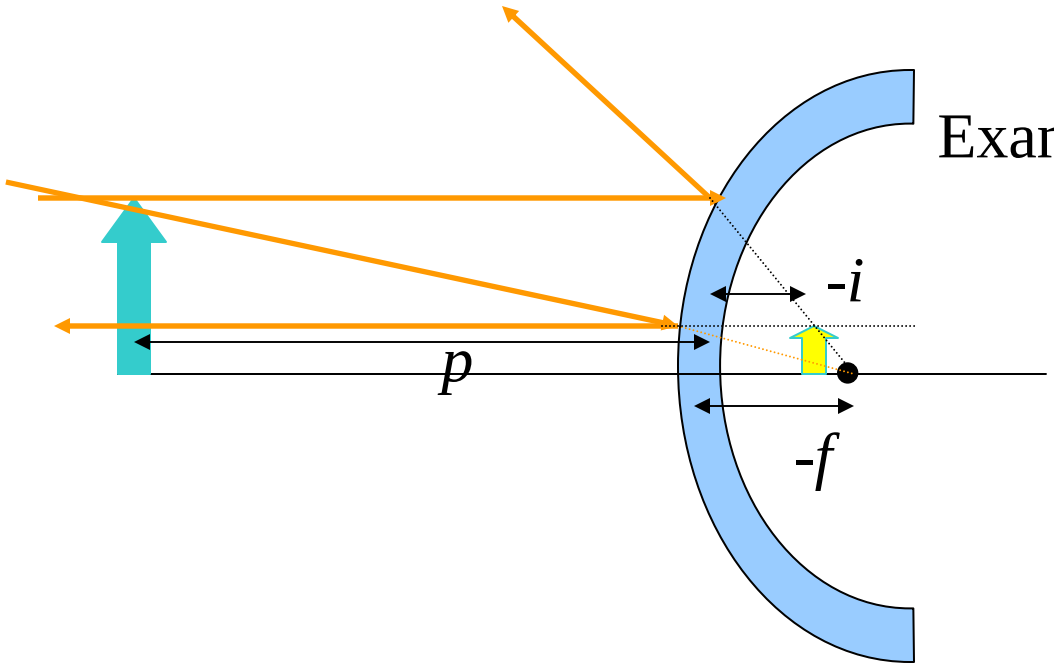


Image formed by convex mirror:



Example: f = -4 cm

p = 16 cm

i = -3.2 cm

$$M = \frac{-i}{p} = \frac{3.2}{16} = 0.2$$

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

$$M = \frac{h'}{h} = \frac{-i}{p}$$

General result for virtual image formed by convex mirror:

image is upright and decreased in size

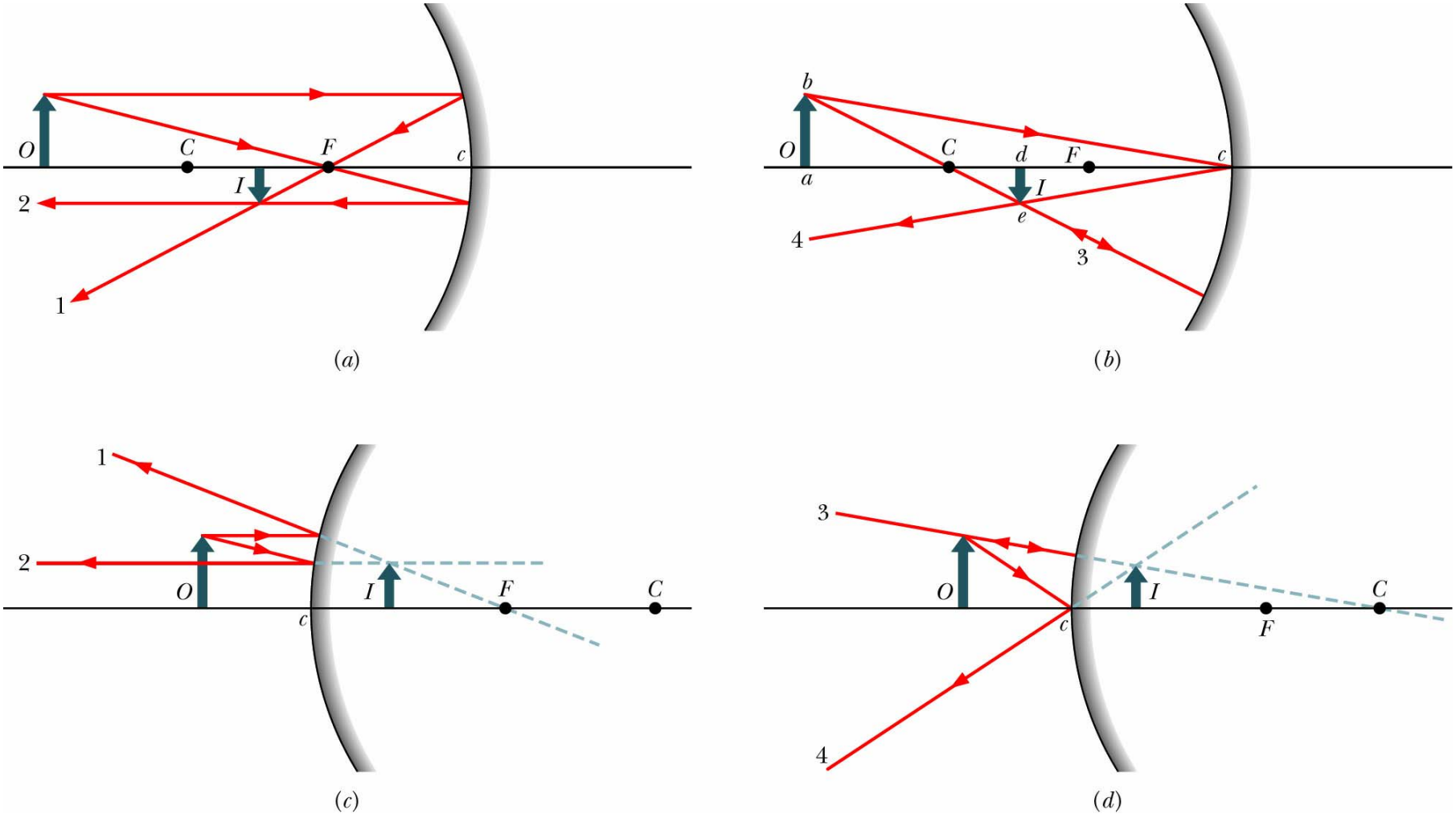
Peer instruction question:

Can the image formed by a convex mirror ever be *increase* in size? (A) yes (B) no

Is it possible to form a real image with a convex mirror?

(A) yes (B) no

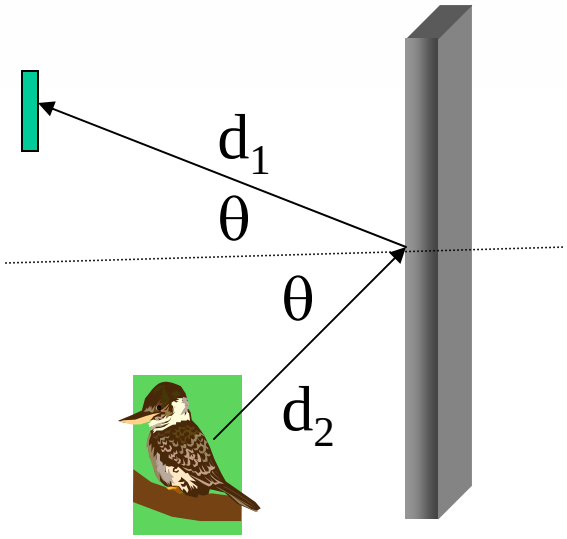
Alternative ray diagrams for spherical mirrors:



Homework problem:

1. [HRW6 35.P.002.] You look through a camera toward an image of a hummingbird in a plane mirror. The camera is 4.38 m in front of the mirror. The bird is at camera level, 5.06 m to your right and 3.35 m from the mirror. For what distance must you focus your camera lens to get a clear photo of the image; that is, what is the distance between the lens and the apparent position of the image?

_____ m



Need to find $d_1 + d_2$