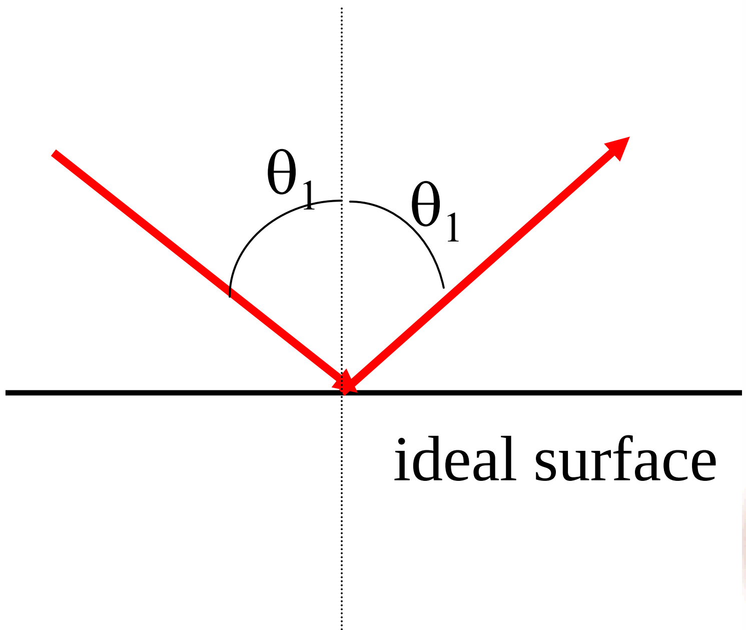
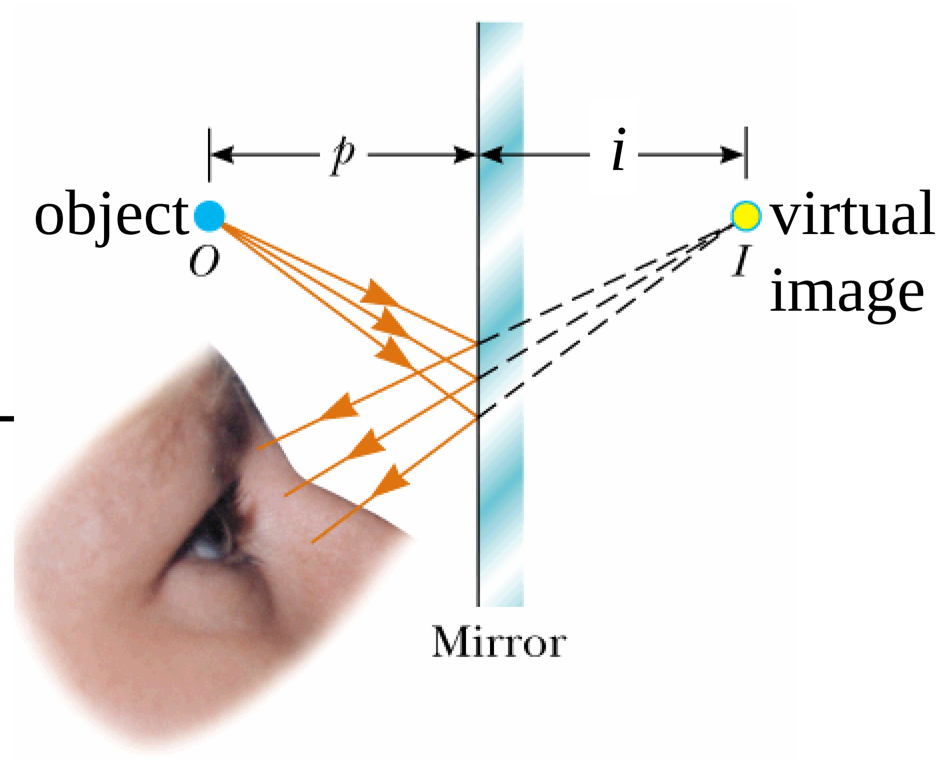
Announcements

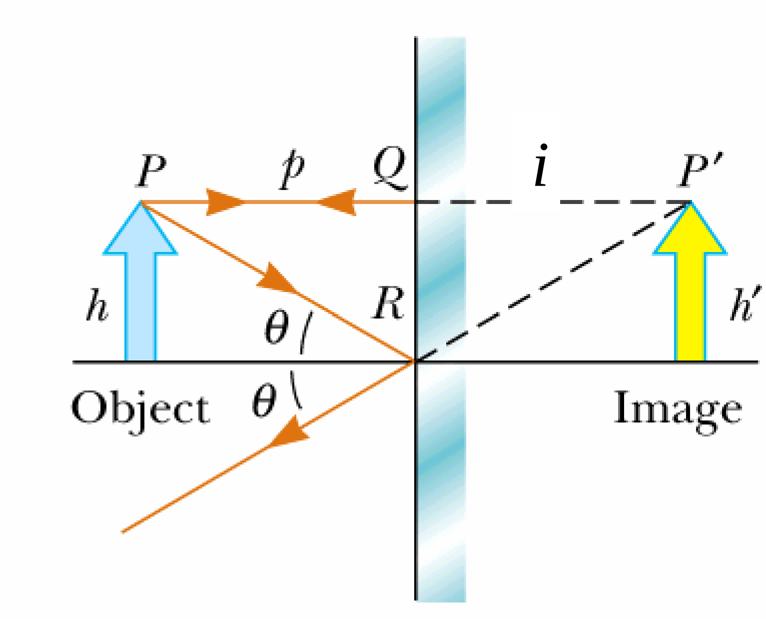
1. Exam 3 will be returned on Wednesday
2. Assignment #22 is available; due Wednesday night
3. Problem solving session Wednesdays at 6 PM??
4. General schedule for the remainder of the course:
   - Geometrical optics – images formed from mirrors and lenses, optical devices
   - Interference properties 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:

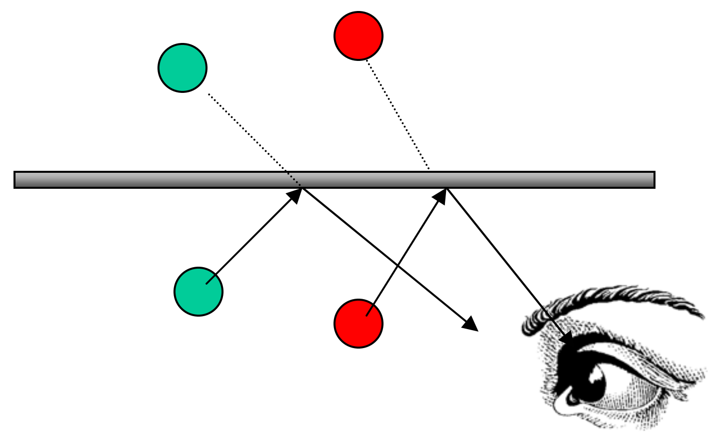




Analysis of mirror image



Mirror symmetry:



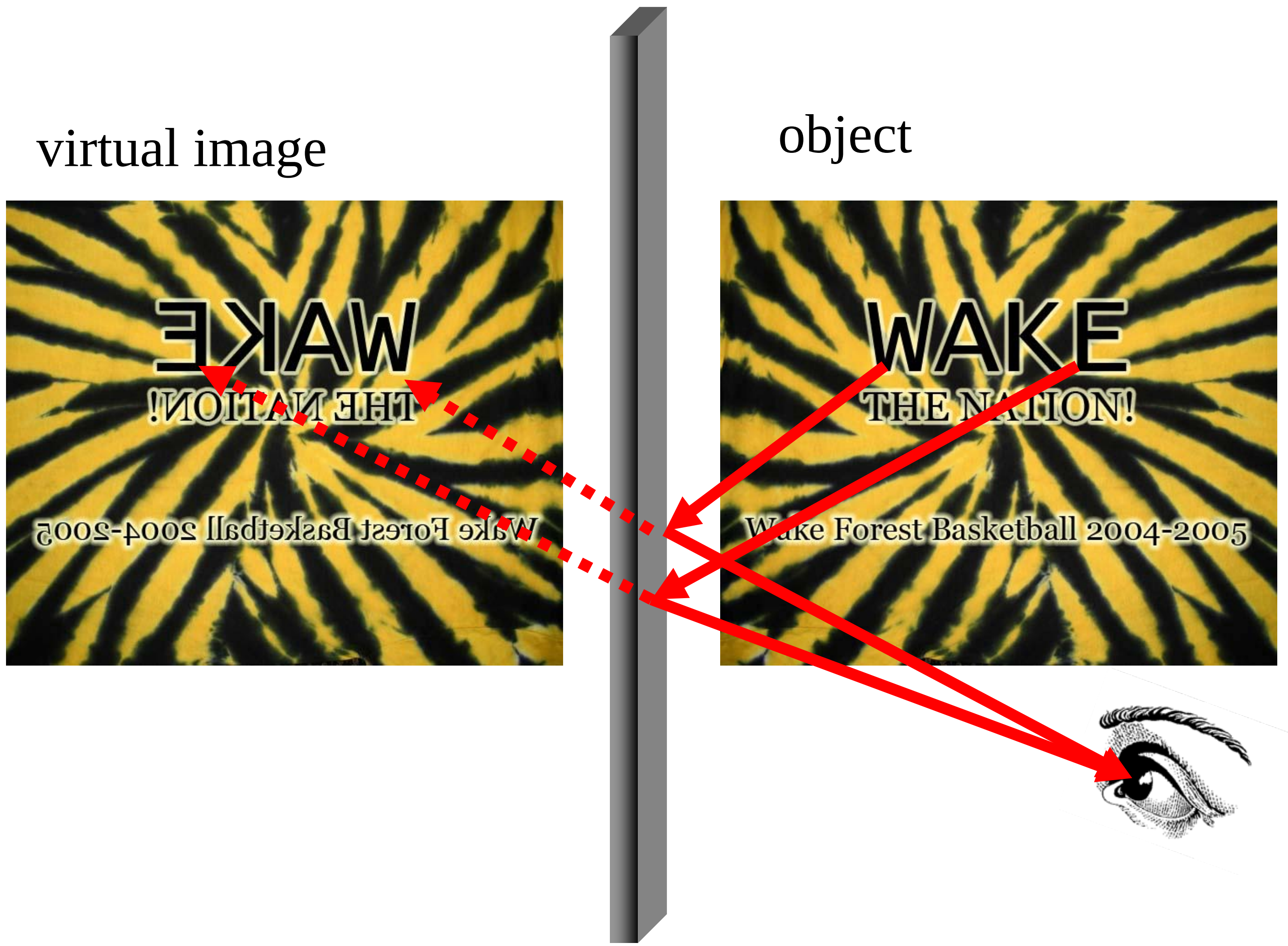
Using geometry:

$i = p \quad h = h'$

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

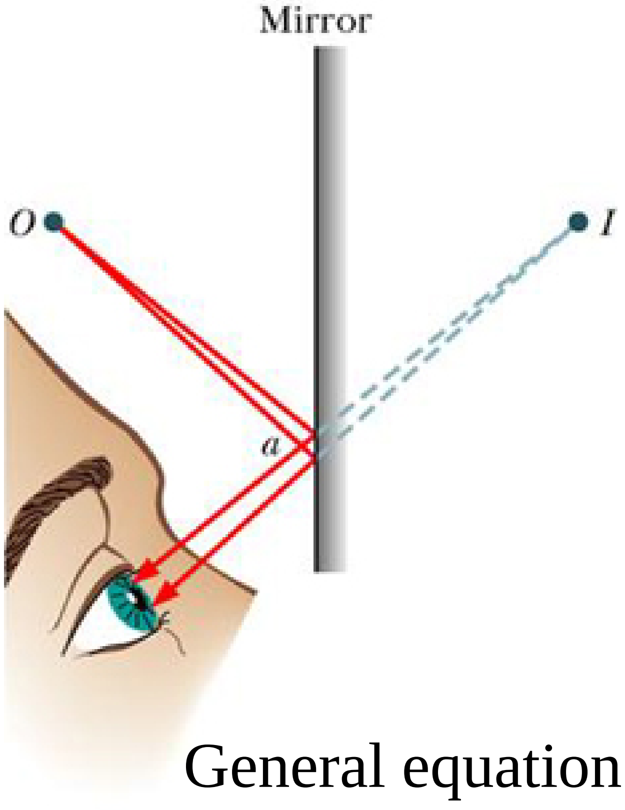

virtual image
object
WAKE

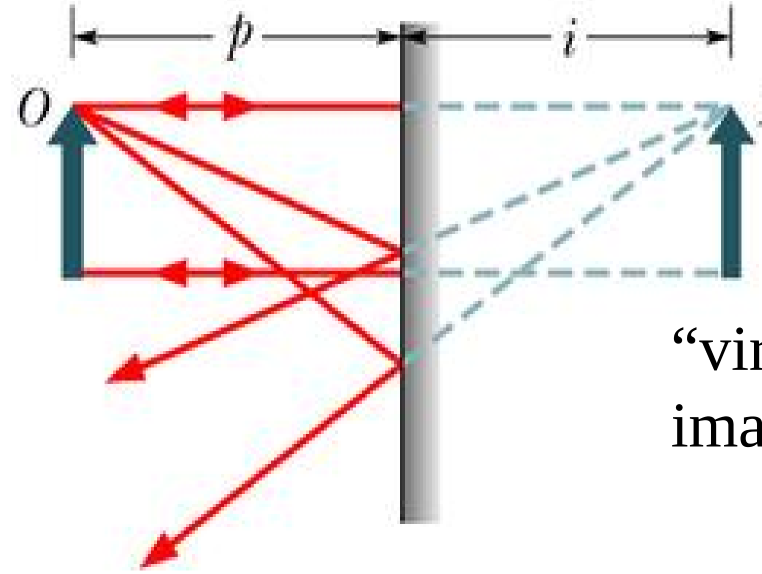
Online Quiz for Lecture 22
Geometrical optics -- Mar. 28, 2005

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





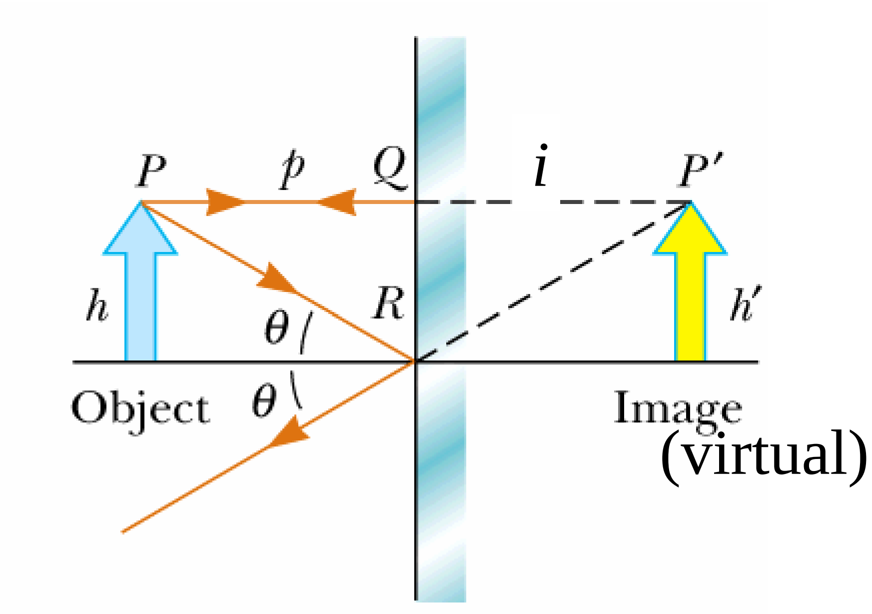
"virtual" image

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



Some details:

By convention,

$i < 0$ for virtual image

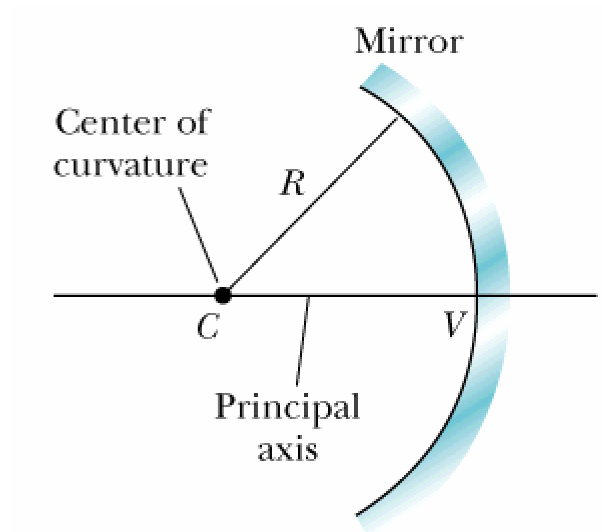
$$\frac{1}{i} + \frac{1}{p} = 0 = \frac{1}{\infty}$$

Geometrical relationships

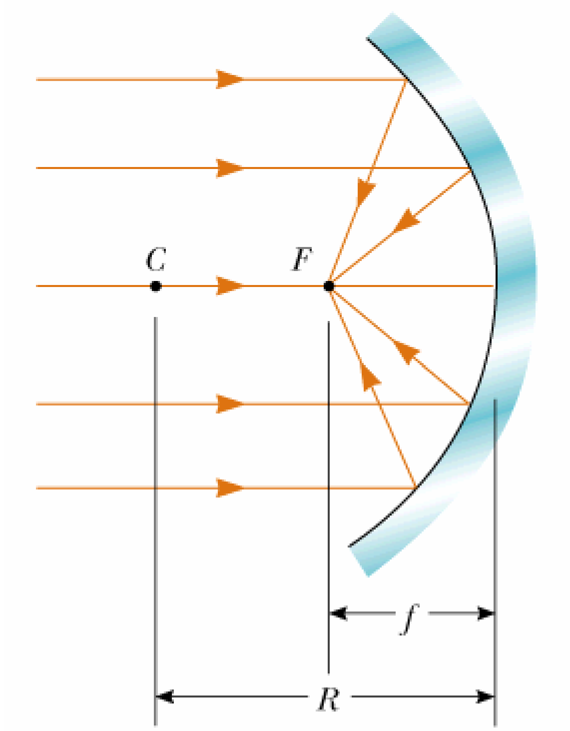
$|i| = p \qquad h = h'$

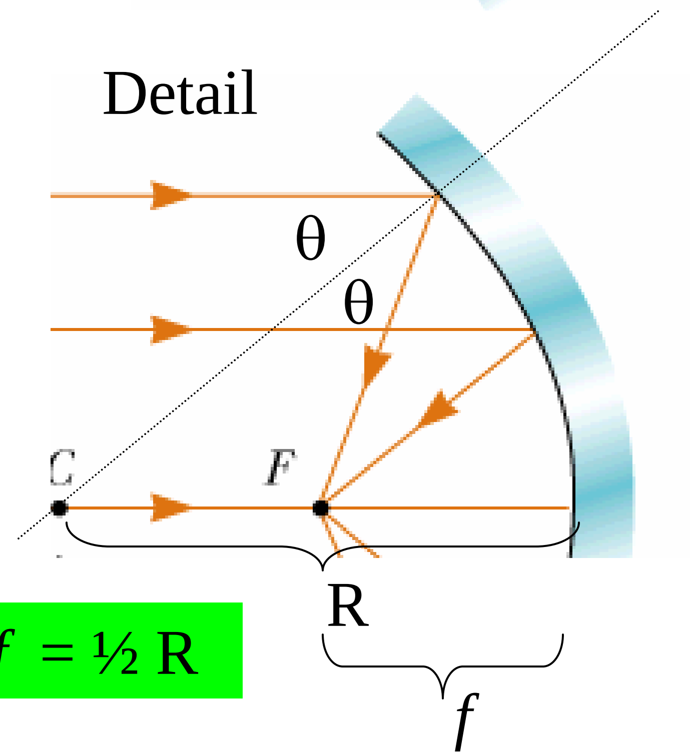
Magnification $M \equiv \frac{\text{Image height}}{\text{Object height}} = \frac{h'}{h}$

Spherical mirrors -- concave



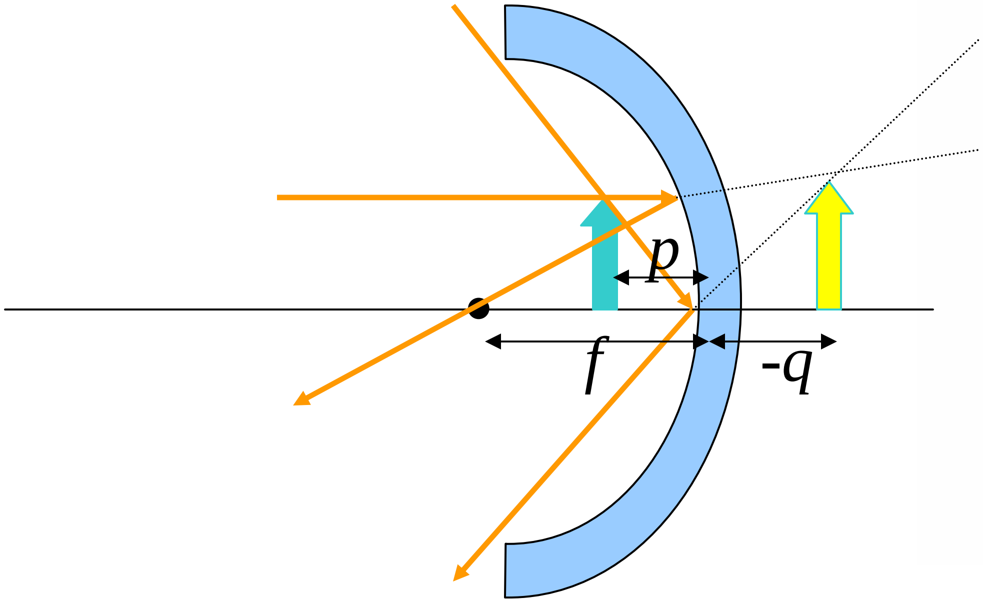
Reflection of parallel light rays:



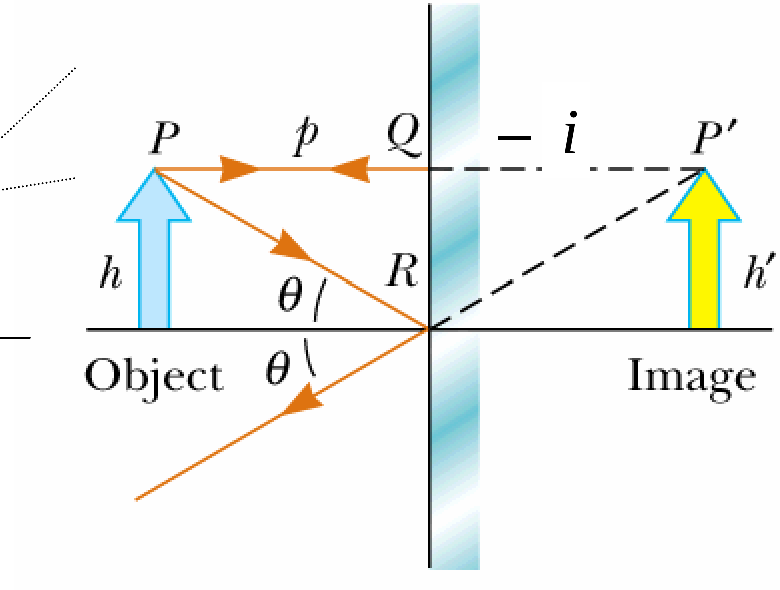


$f = \frac{1}{2} R$

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

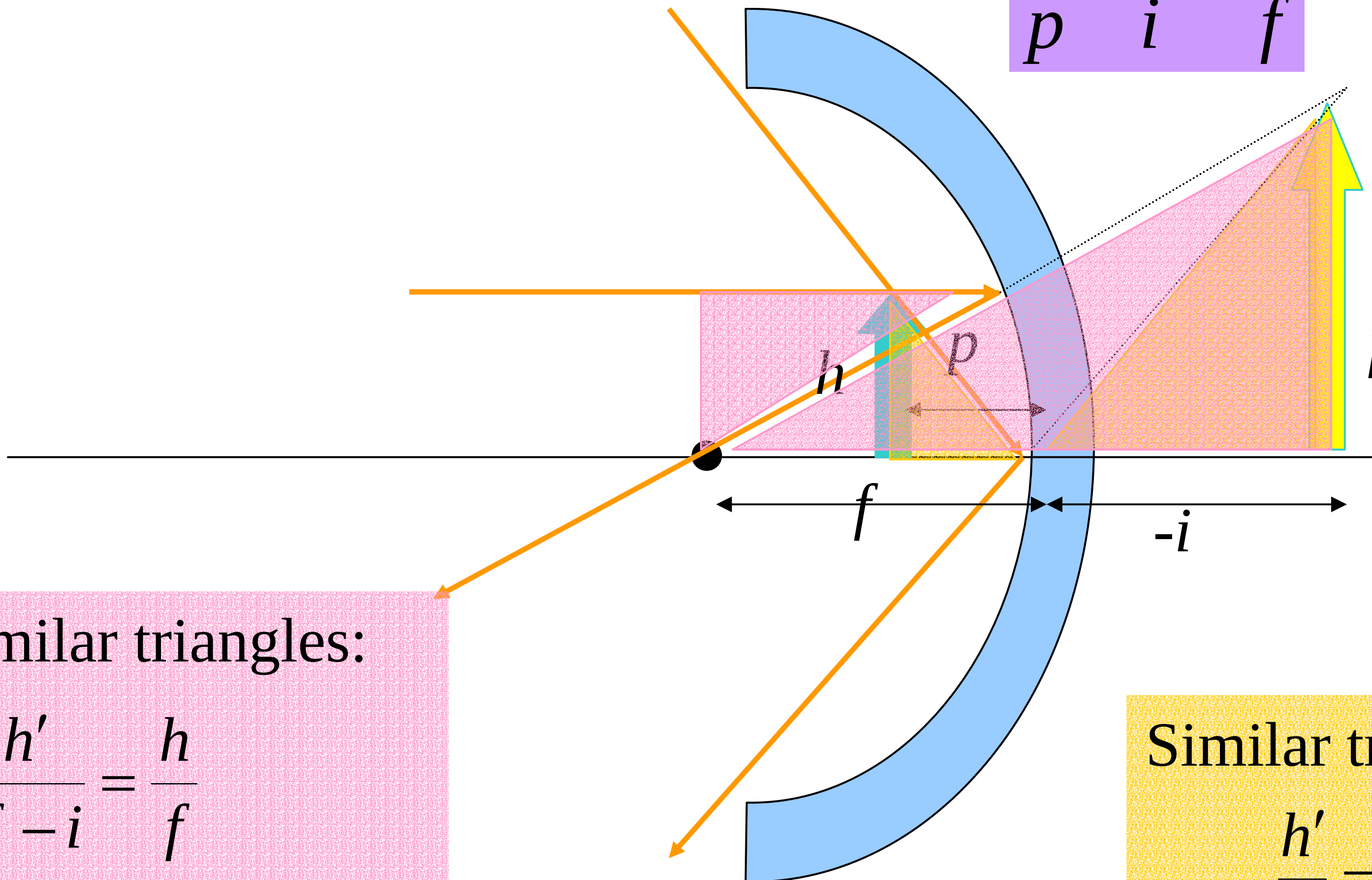
p = 1 cm

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:

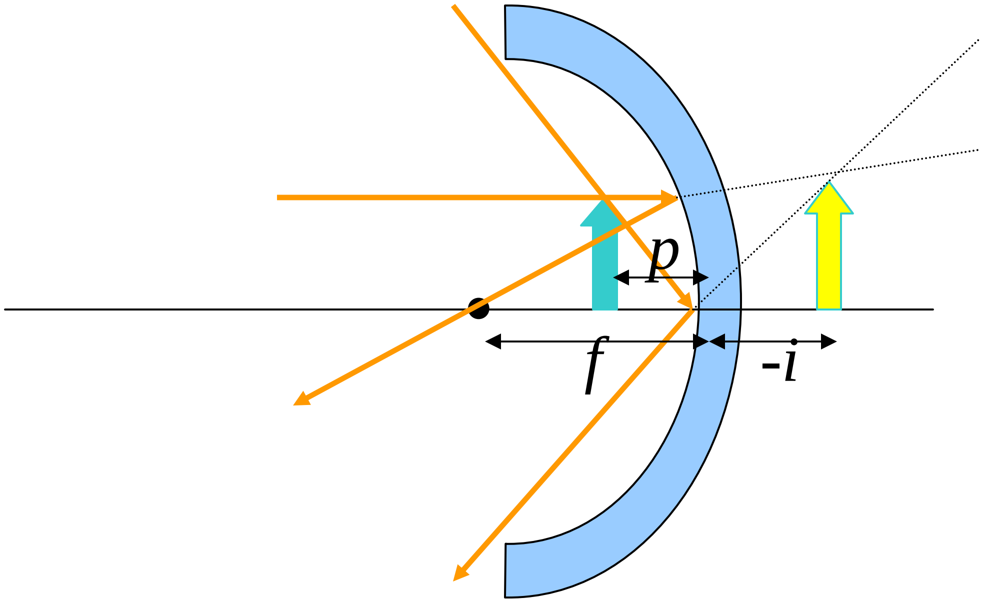
$$\frac{h'}{f-i}=\frac{h}{f}$$

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

Similar triangles:

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

Image formed by concave mirror:

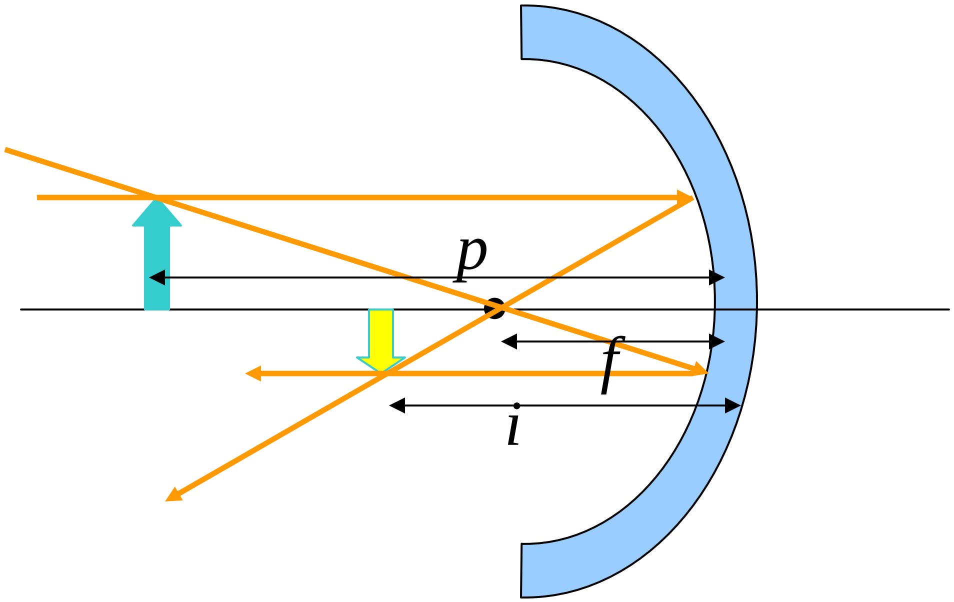


General result for virtual image formed by concave mirror

$$p < f$$

image is upright and increased in size

Image formed by concave mirror:



Example: $f = 4$ cm

$p = 10$ cm

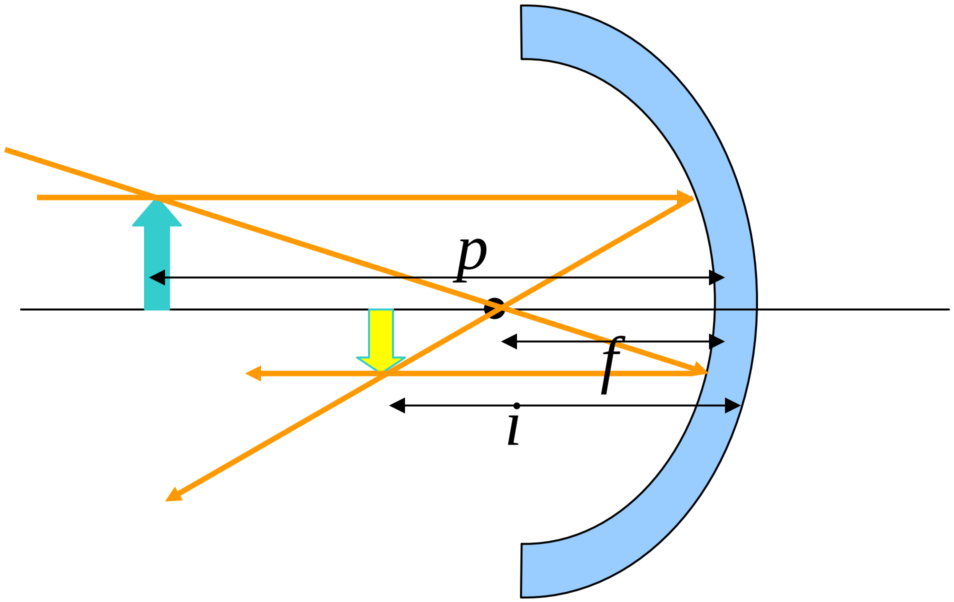
$i = 6.67$ cm

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

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

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

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

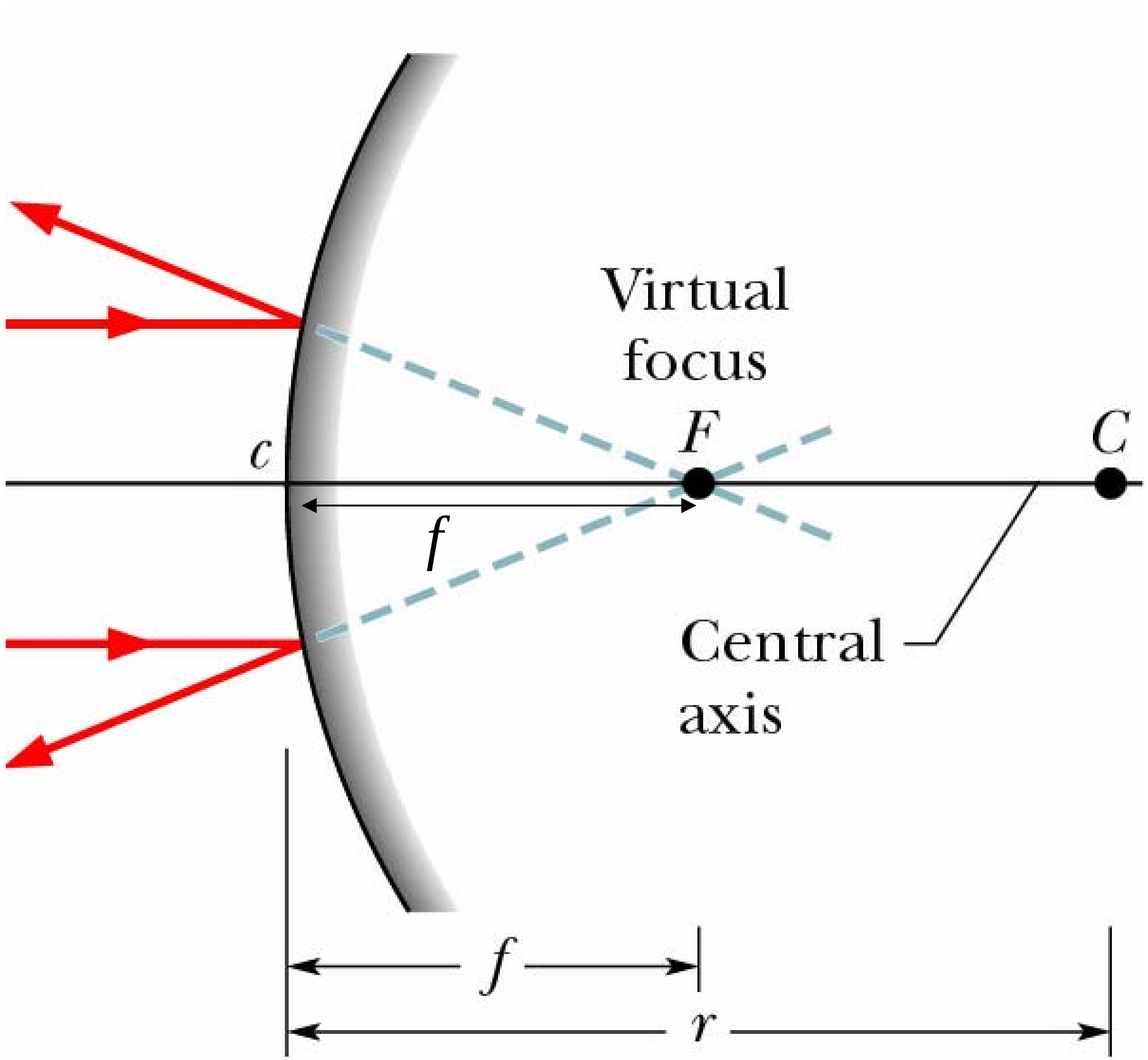
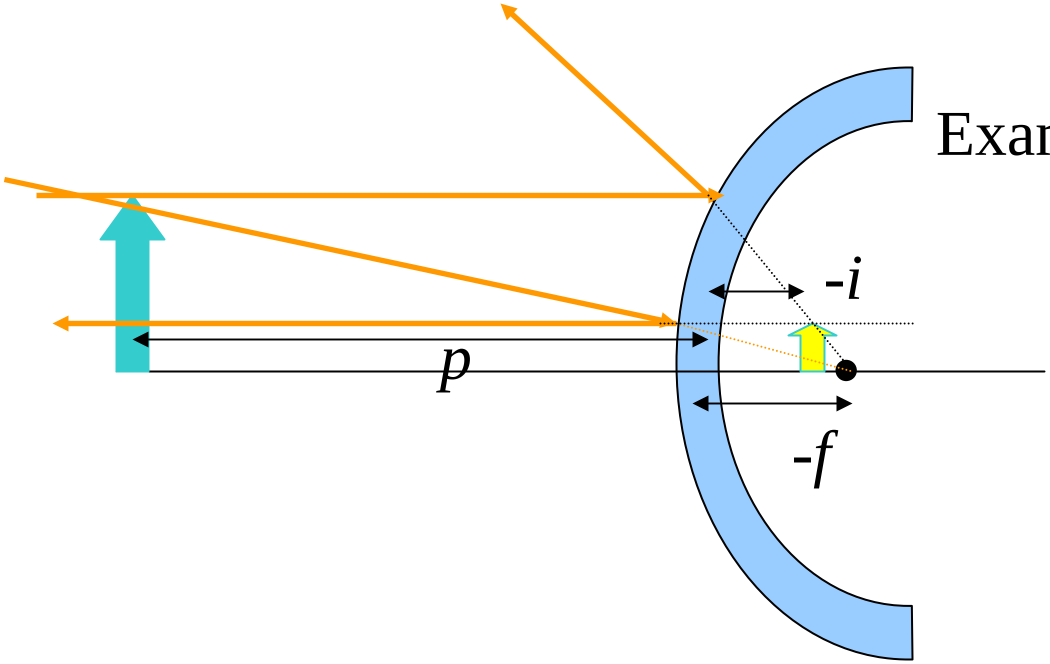


Image formed by convex mirror:



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

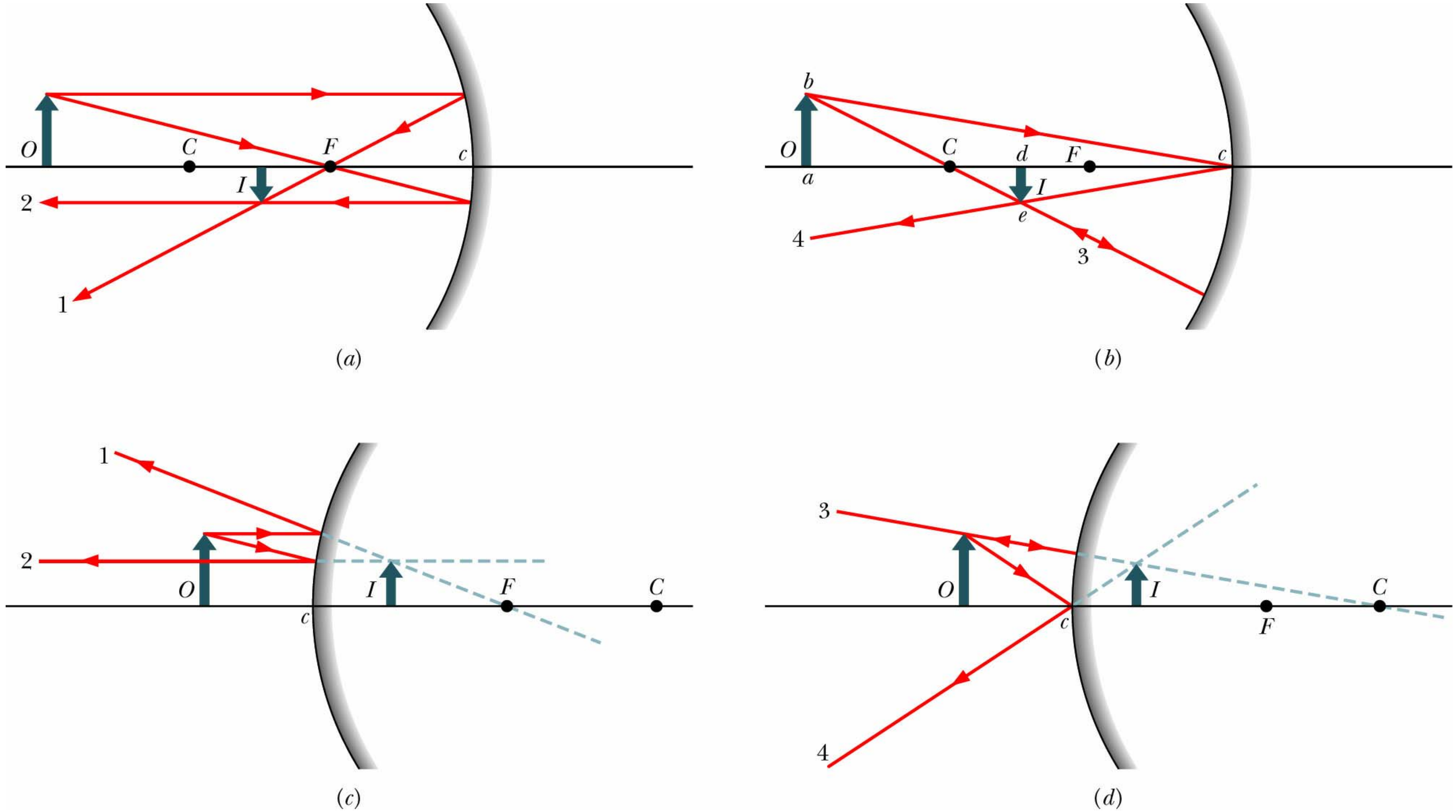
Peer instruction question:

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

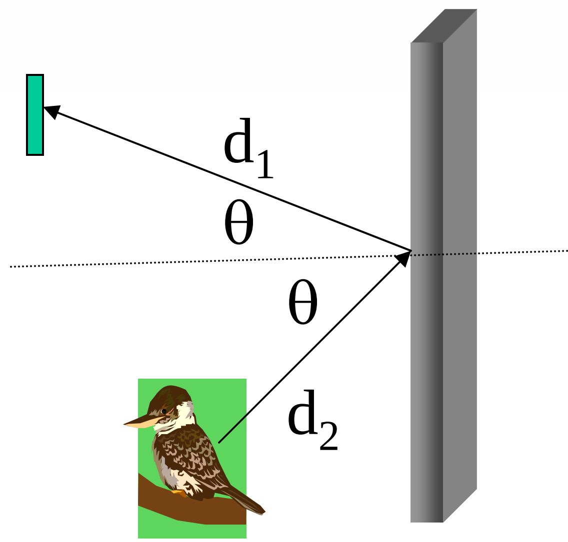
Alternative ray diagrams for spherical mirrors:



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 $d_1 + d_2$