

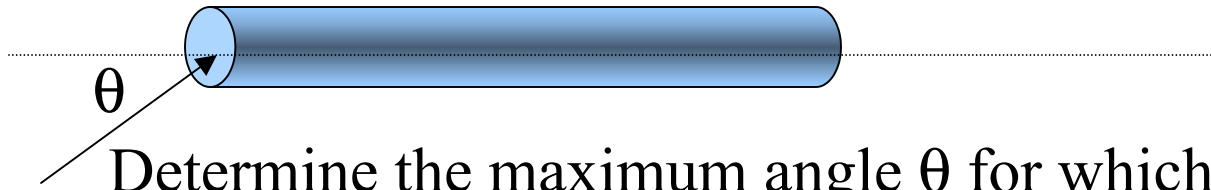
Announcements

1. Reminder – problem solving sessions – Tuesdays @ 6 PM
2. Physics seminar this week on “[Signal Processing](#)”
3. Today’s topics –

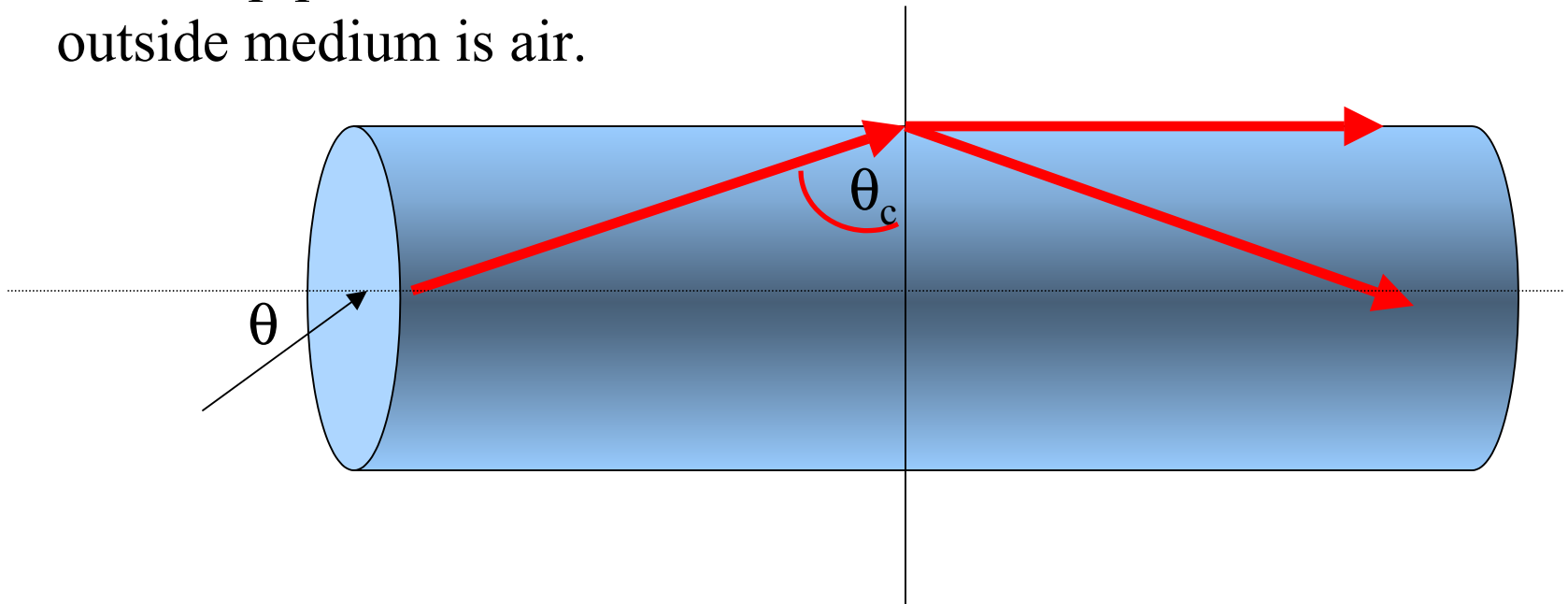
A few homework hints

Chapter 36 -- Image formation using mirrors and lenses

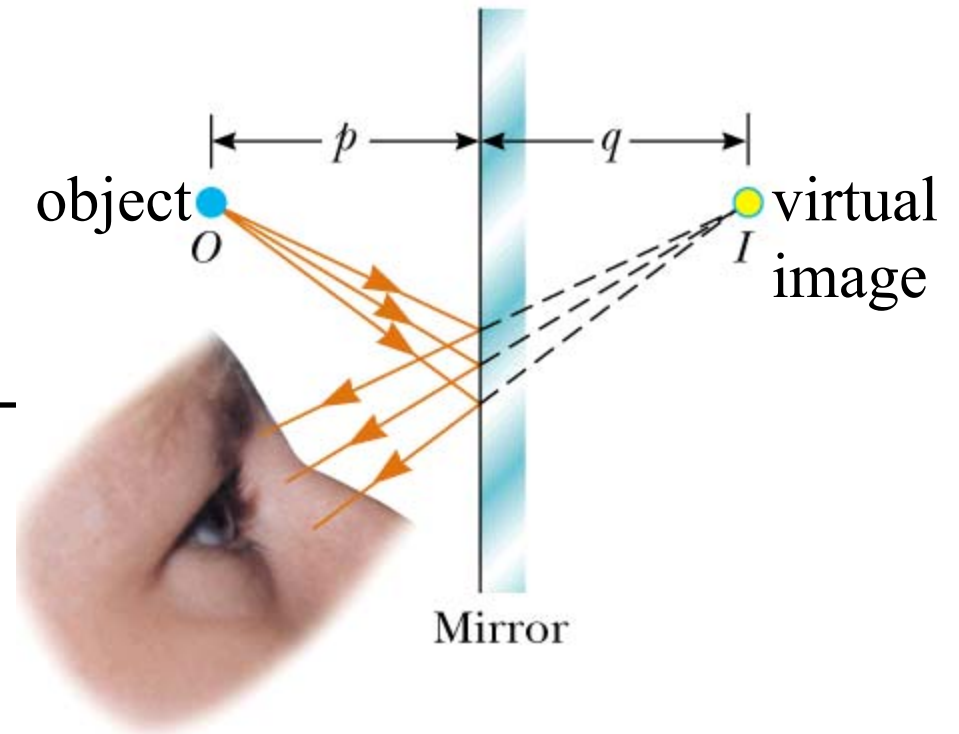
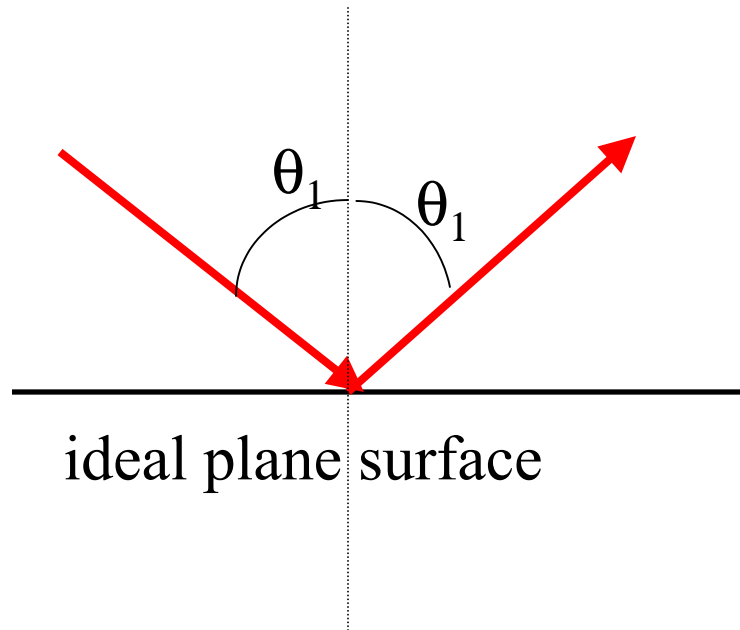
Homework problem 35.38:



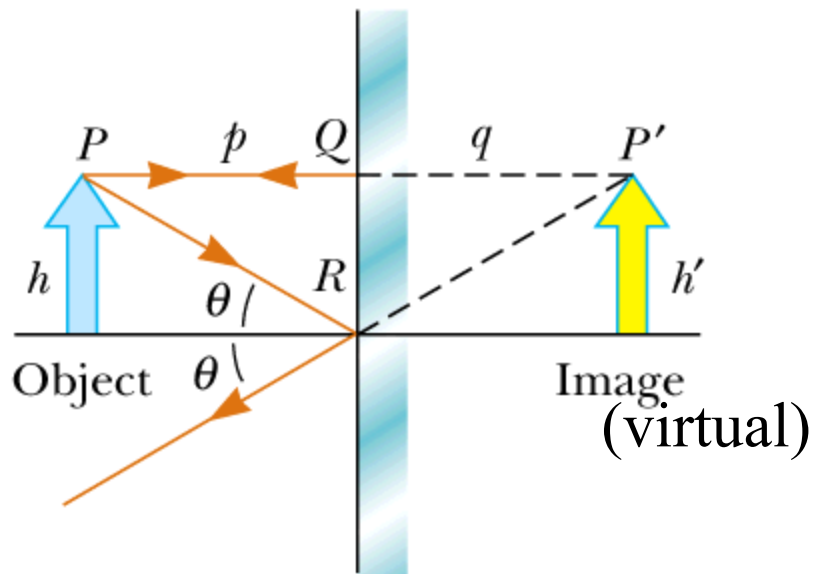
Determine the maximum angle θ for which the light rays incident on the end of the paper shown in the figure are subject to total internal reflection along the walls of the pipe. Assume that the pipe has an index of refraction of $n = 1.36$ and the outside medium is air.



Images formed from reflected light



Analysis of image from plane mirror



Geometrical relationships

$$|q| = p \quad h = h'$$

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

Some details:

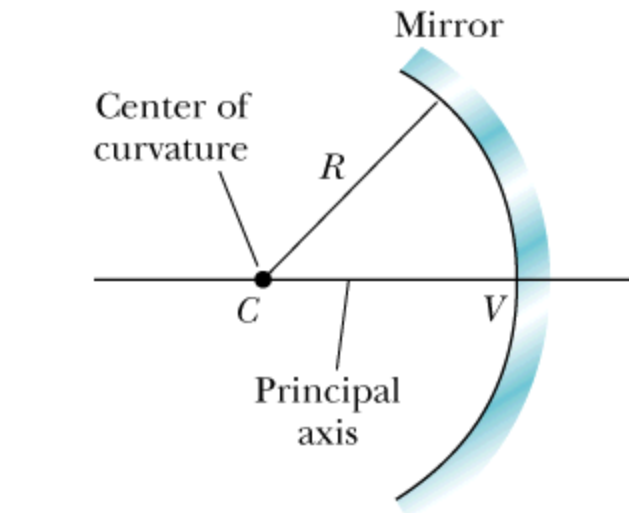
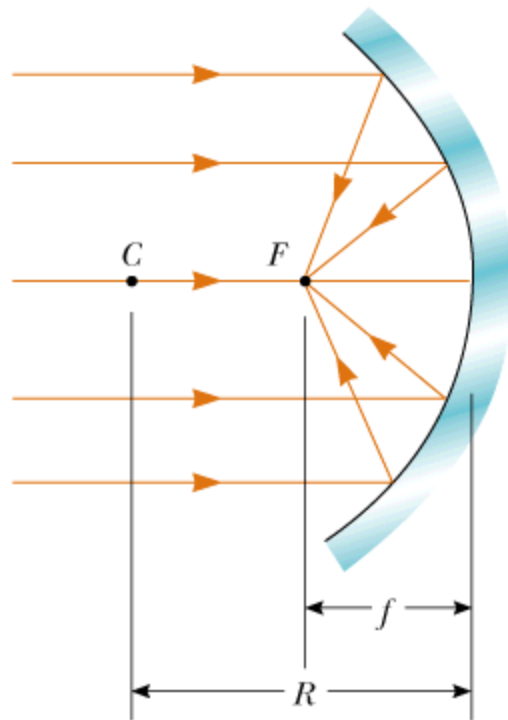
By convention,

$q < 0$ for virtual image

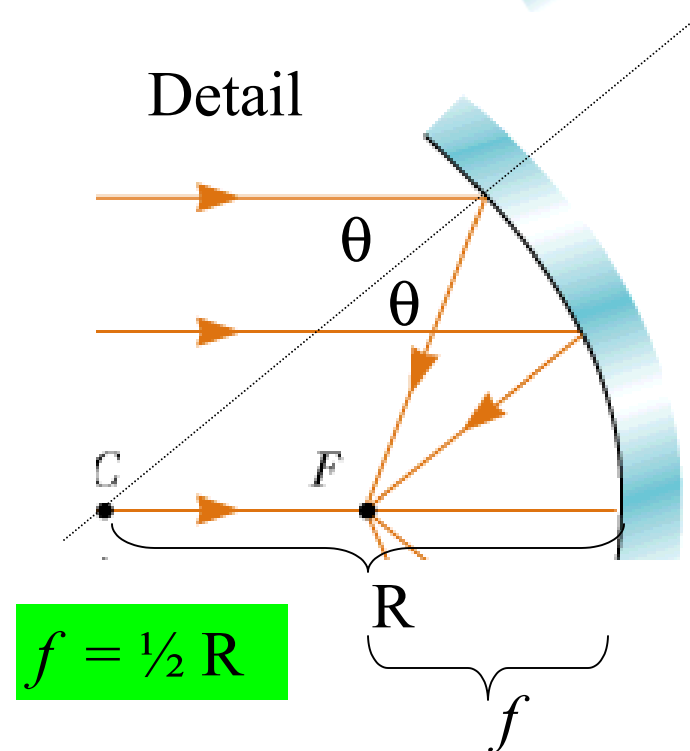
$$\frac{1}{q} + \frac{1}{p} = 0 = \frac{1}{\infty}$$

Spherical mirrors -- concave

Reflection of parallel light rays:



Detail



Wrong image in your text!!!

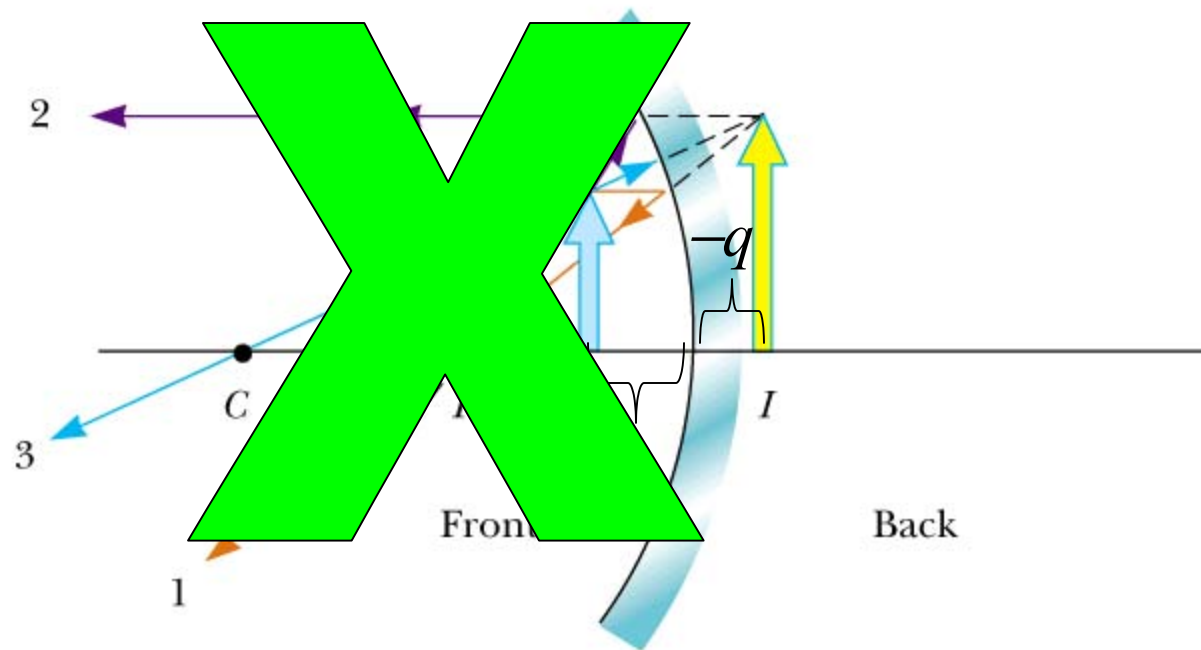
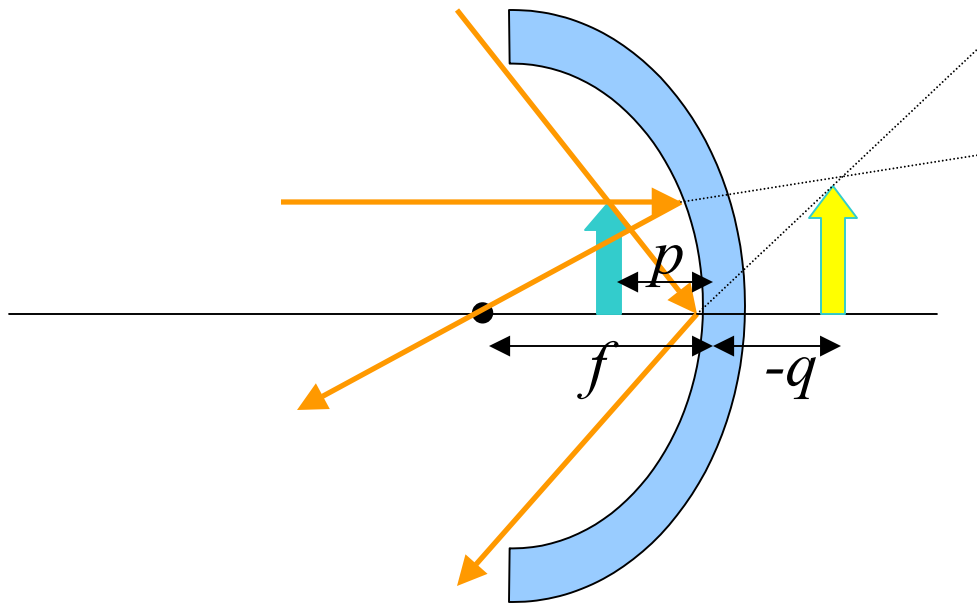
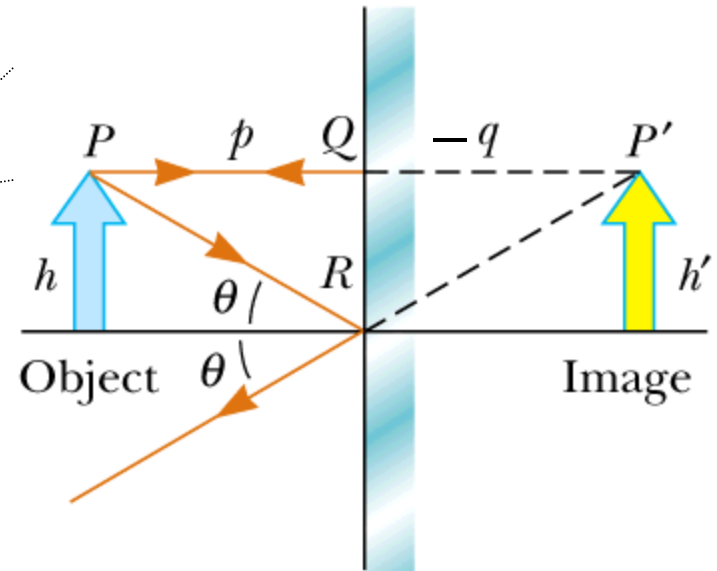


Image formed in concave mirror:



Plane mirror:



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

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

Example: $f = 4$ cm

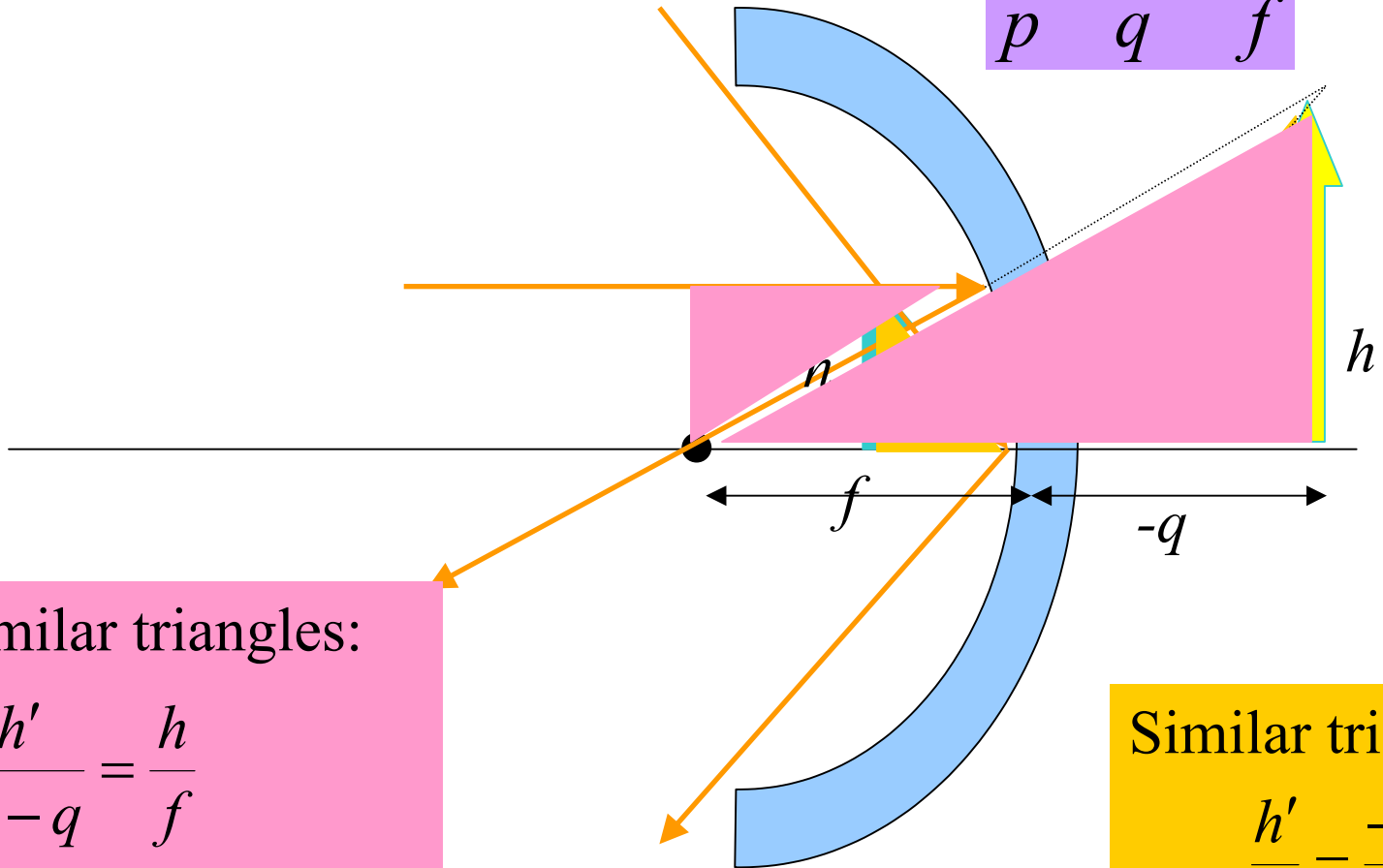
$$p = 1$$
 cm

$$q = -1.33$$
 cm

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

“Proof” of mirror equation:

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



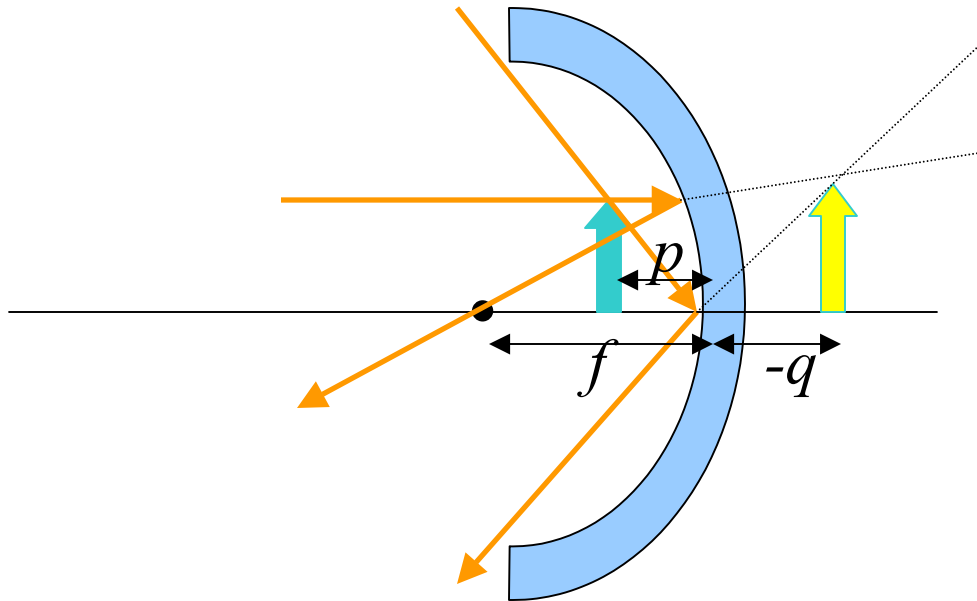
Similar triangles:

$$\begin{aligned} \frac{h'}{f - q} &= \frac{h}{f} \\ \Rightarrow \frac{h'}{h} &= \frac{f - q}{f} = \frac{-q}{p} \end{aligned}$$

Similar triangles:

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

Image formed by concave mirror:

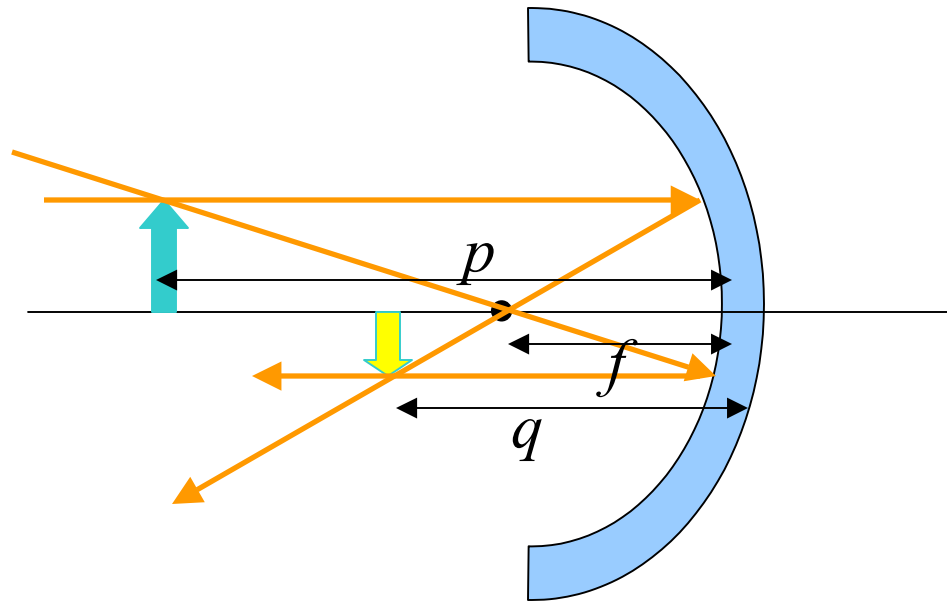


General result for virtual image formed by concave mirror

$$p < f$$

image is upright and increased in size

Image formed by concave mirror:



Example: $f = 4$ cm

$$p = 10 \text{ cm}$$

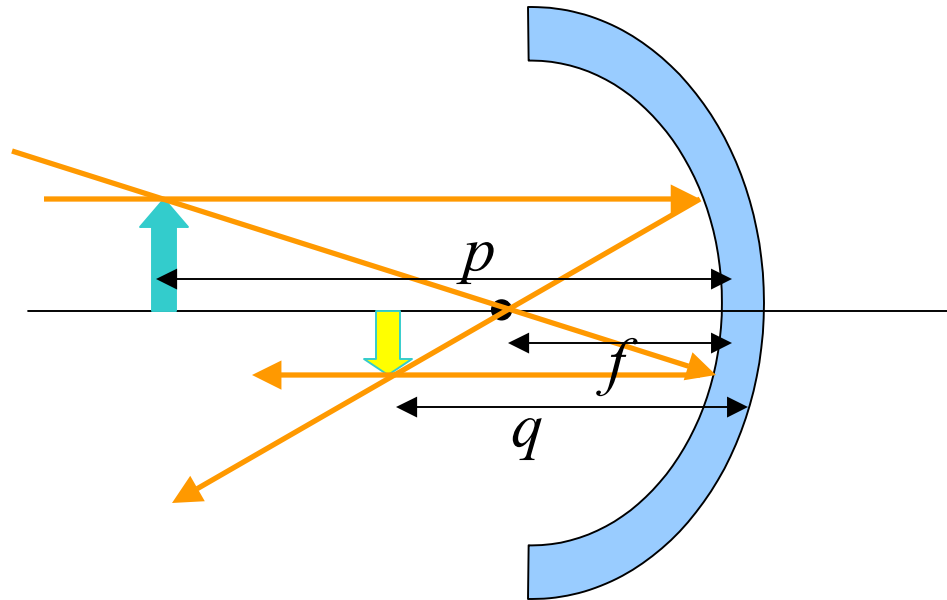
$$q = 6.67 \text{ cm}$$

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

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

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

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

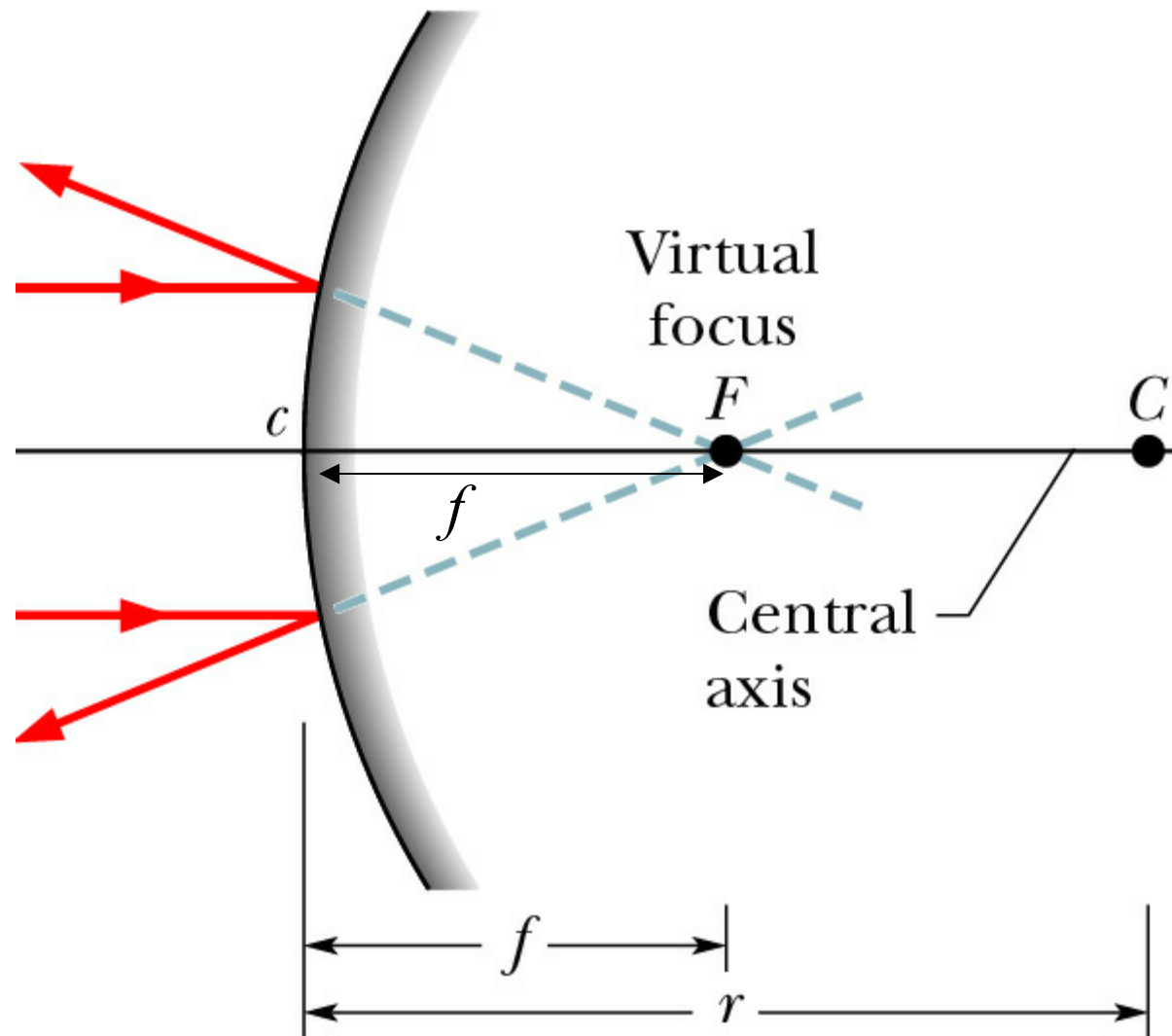
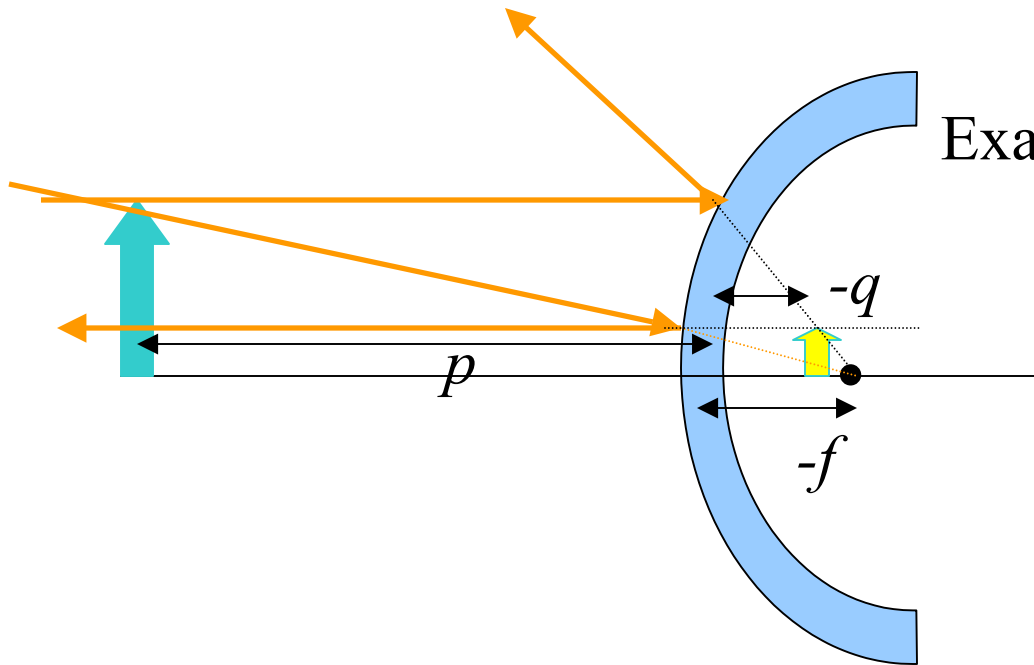


Image formed by convex mirror:



Example: $f = -4$ cm

$$p = 16 \text{ cm}$$

$$q = -3.2 \text{ cm}$$

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

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

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

General result for virtual image formed
by convex mirror:

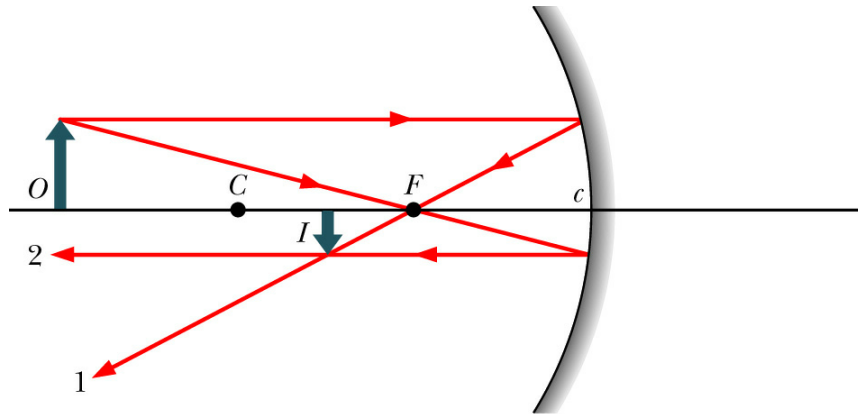
image is upright and decreased
in size

Peer instruction question:

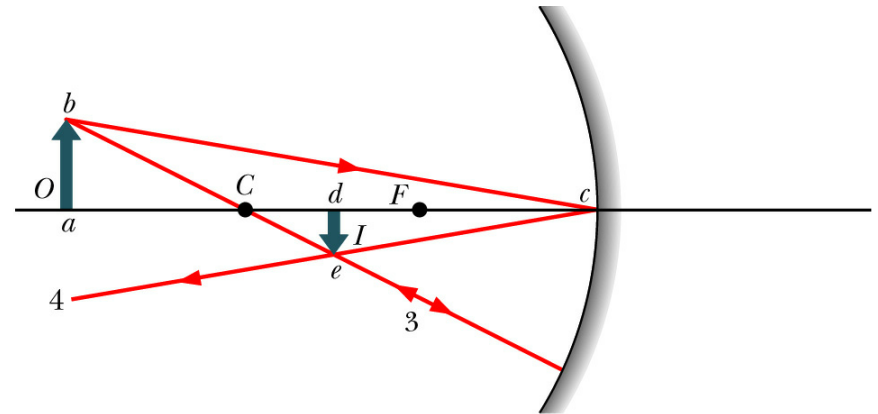
Can the image formed by a convex mirror ever be *increase* in size? (A) yes (B) no

Is it possible to form a real image with a convex mirror?
(A) yes (B) no

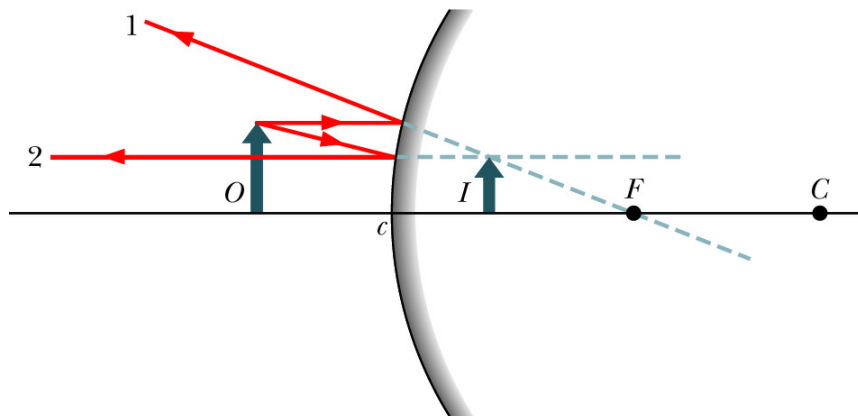
Alternative ray diagrams for spherical mirrors:



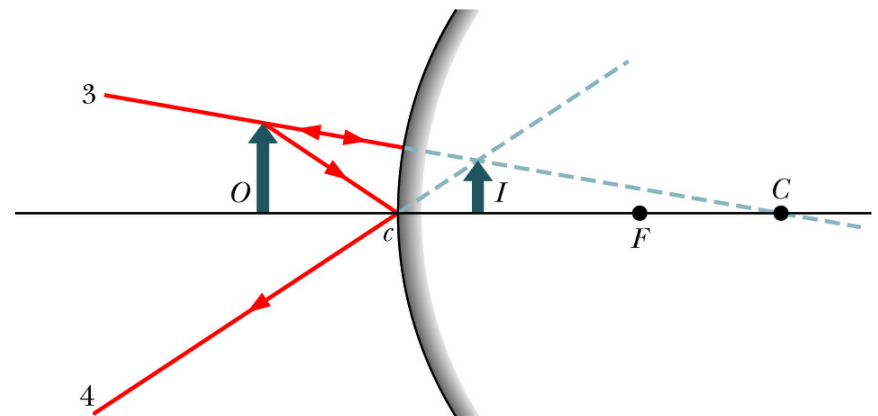
(a)



(b)



(c)



(d)