Phys 102 – Lecture 18

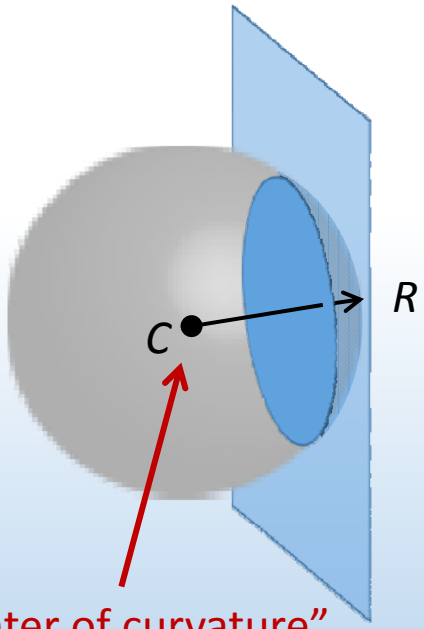
Spherical mirrors

Today we will...

- Learn about spherical mirrors
  - Concave mirrors
  - Convex mirrors
- Learn how spherical mirrors produce images
  - Ray diagrams – principal rays
  - Mirror & magnification equations

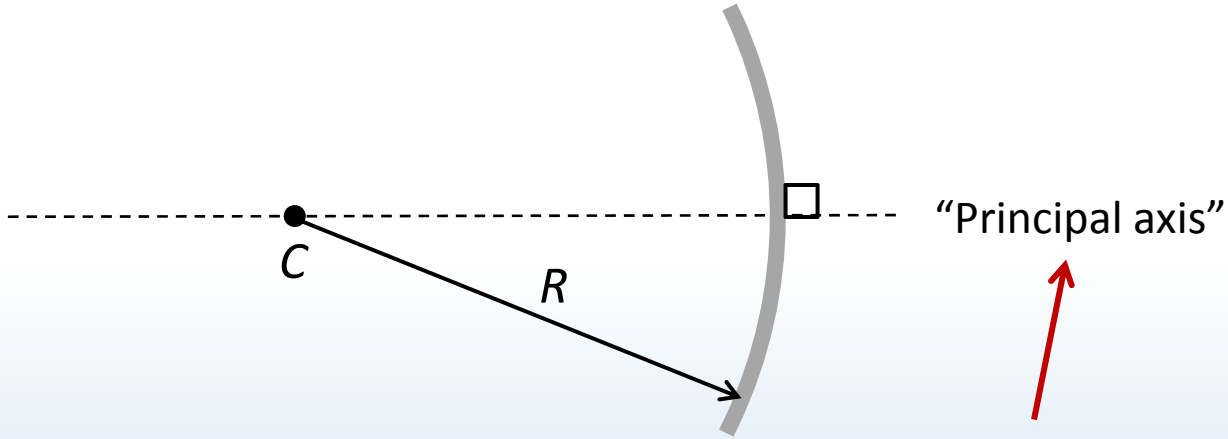
Curved mirrors

Spherical mirror – section of a sphere



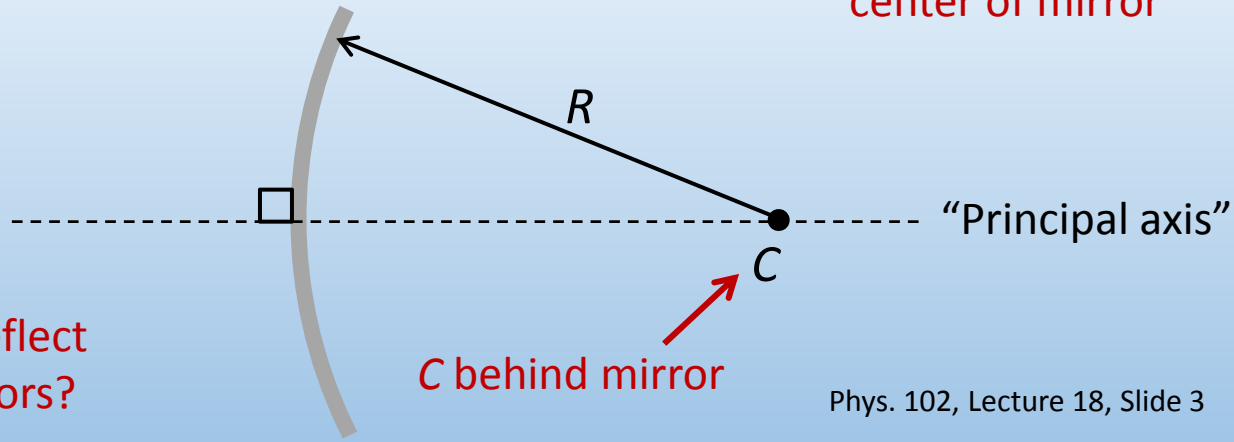
"Center of curvature"

"Concave" – inside surface of sphere



Line through *C* and center of mirror

"Convex" – outside surface of sphere

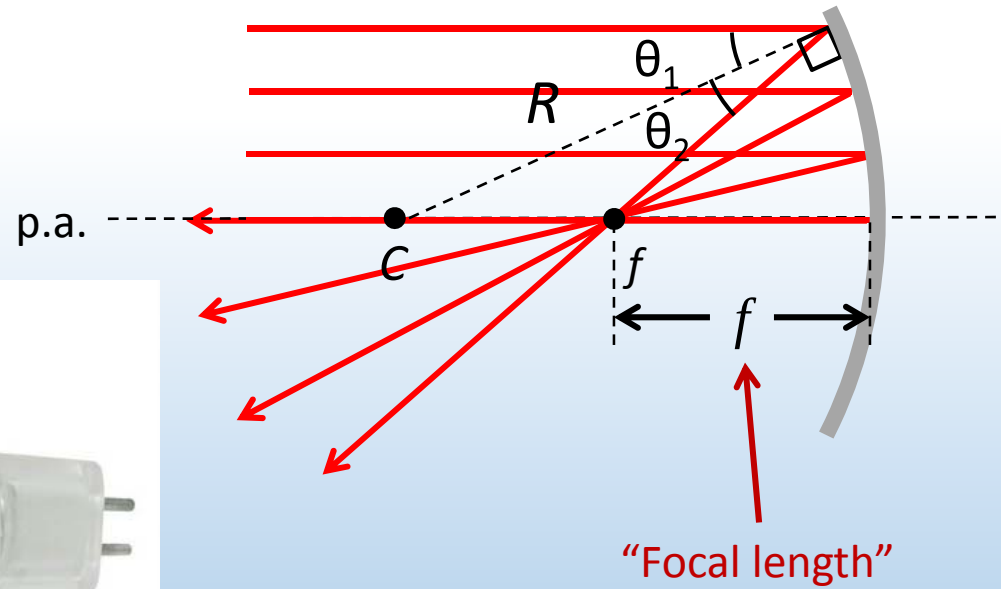


C behind mirror

How does light reflect off spherical mirrors?

Concave mirror reflection

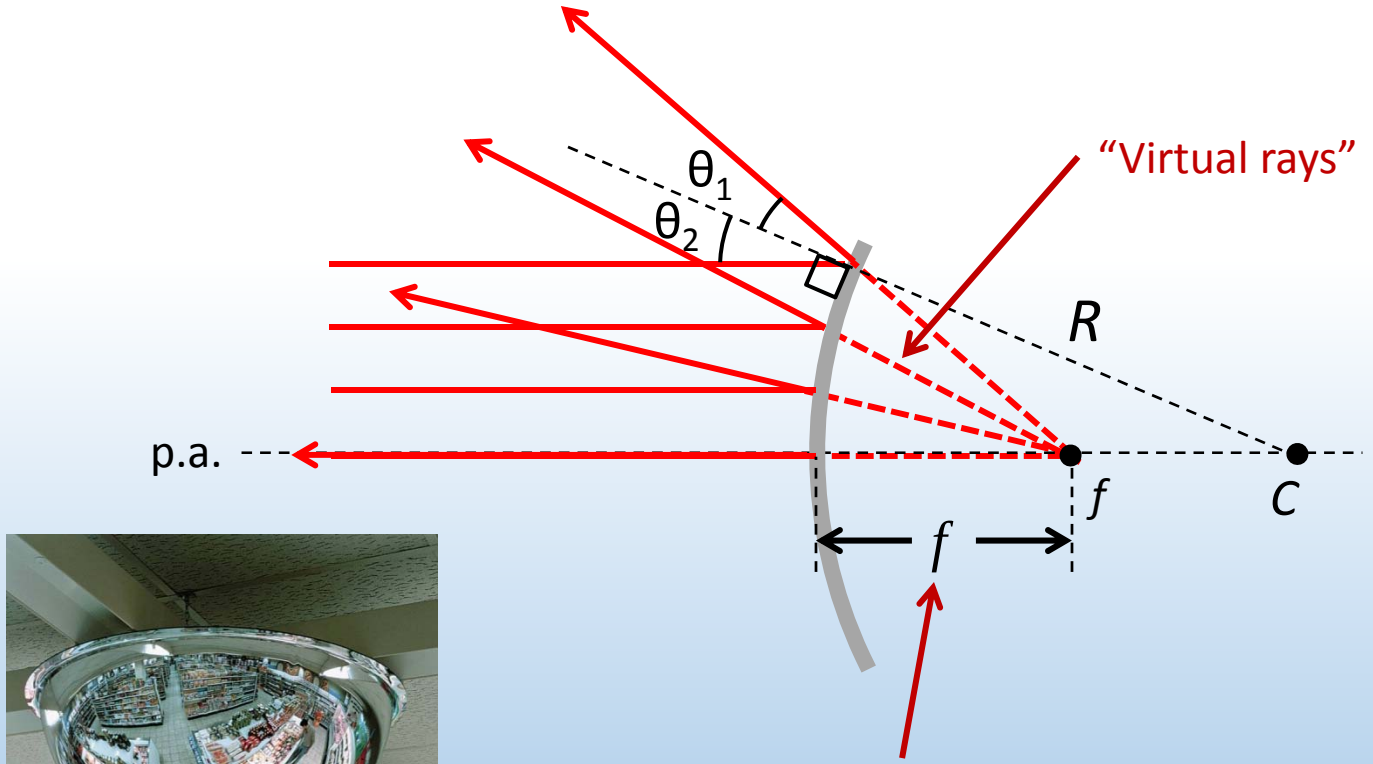
Concave mirror – rays || to p.a. reflect through focal point *f* in *front* of mirror



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

Convex mirror reflection

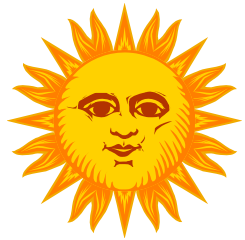
Convex mirror – rays || to p.a. reflect as if they originated from focal point *f* *behind* mirror



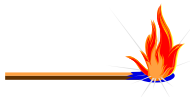
$$f = -\frac{R}{2}$$

ACT: CheckPoint 1.1 & 1.2

What kind of mirror can be used to start a fire?



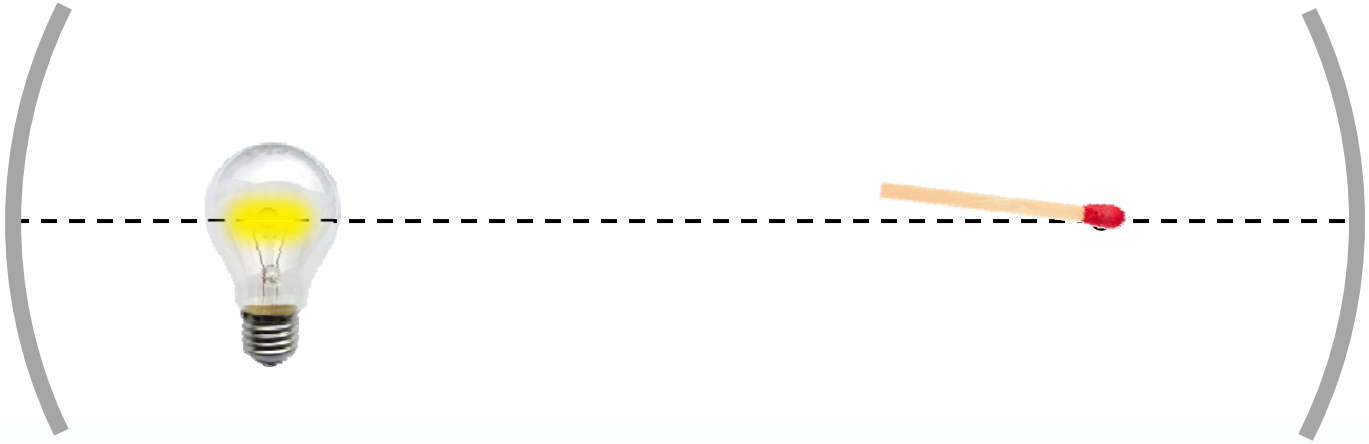
A. Concave
B. Convex
C. Plane



How far from the object to be ignited should the mirror be held?

A. farther than the focal length
B. closer than the focal length
C. at the focal length

Lighting a match



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Rays traveling through focus before hitting mirror are reflected parallel to Principal Axis.

Rays traveling parallel to Principal Axis before hitting mirror are reflected through focus

Images & spherical mirrors

Like plane mirrors, spherical mirrors produce images of objects

Key approaches:

- Ray diagrams
- Mirror & magnification equations

Principal rays – concave mirror

Ray from object traveling:

1) parallel to principal axis, reflects through *f*
2) through *f*, reflects parallel to principal axis
3) through *C*, reflects through *C*

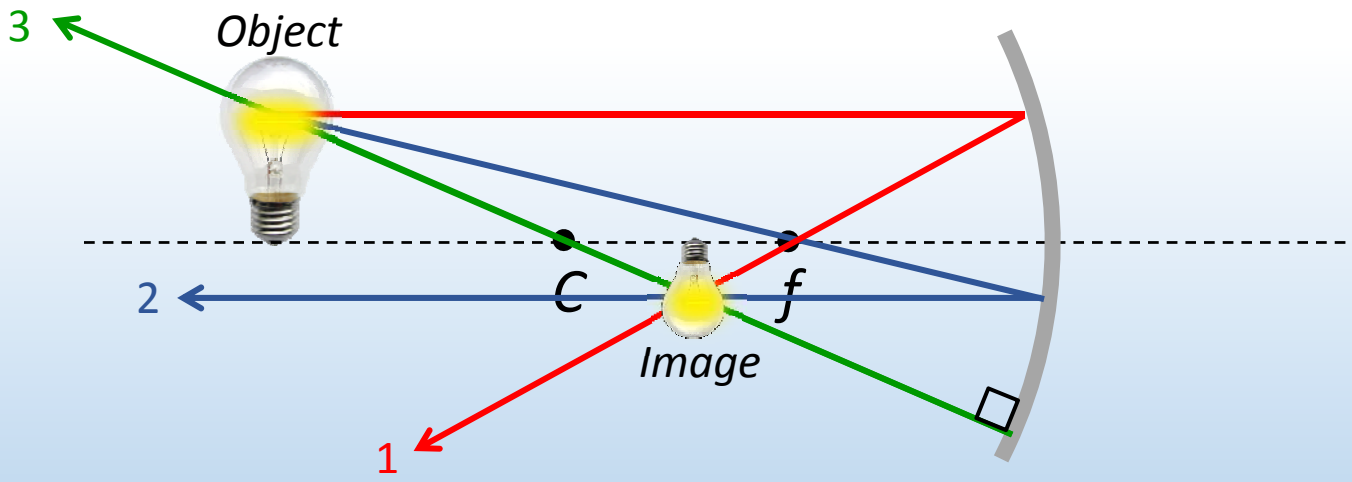


Image is:

Real (light rays cross)

Inverted (opposite direction as object)

Reduced (smaller than object)

Principal rays – convex mirror

Ray from object traveling:

1) parallel to principal axis, reflects through *f*
2) through *f*, reflects parallel to principal axis
3) through *C*, reflects through *C*

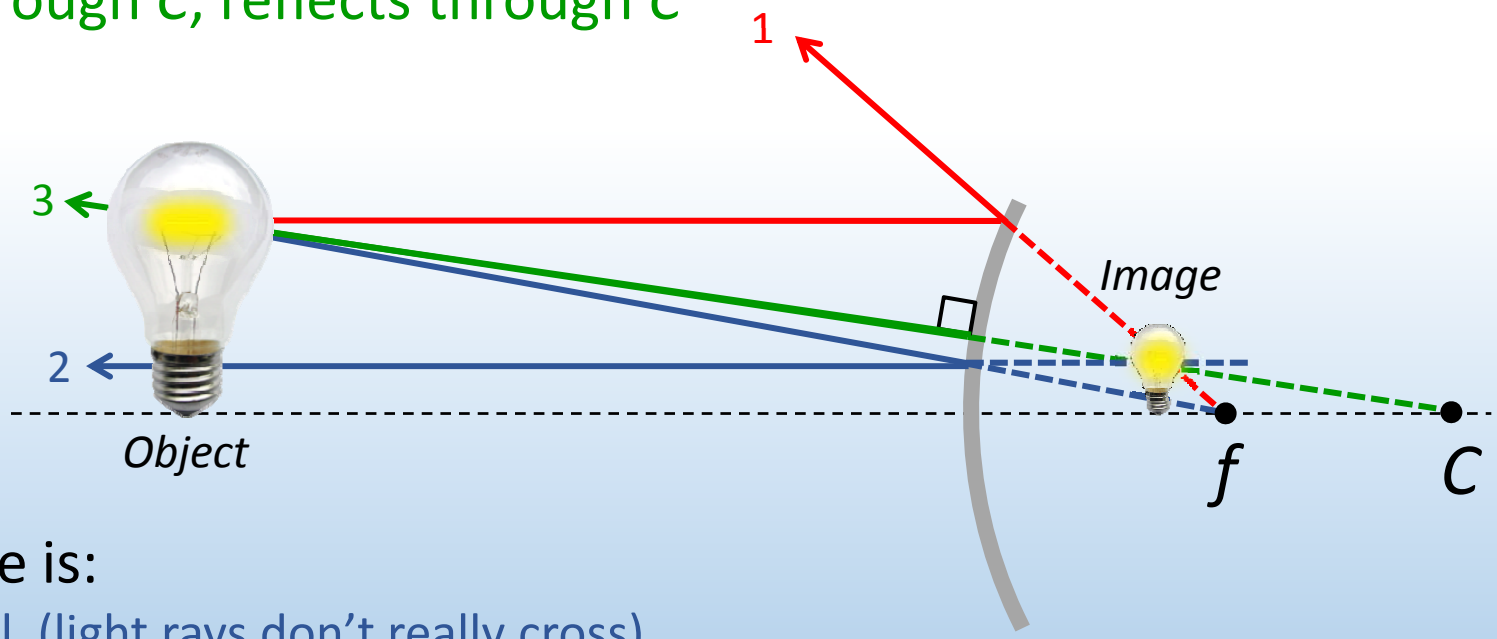
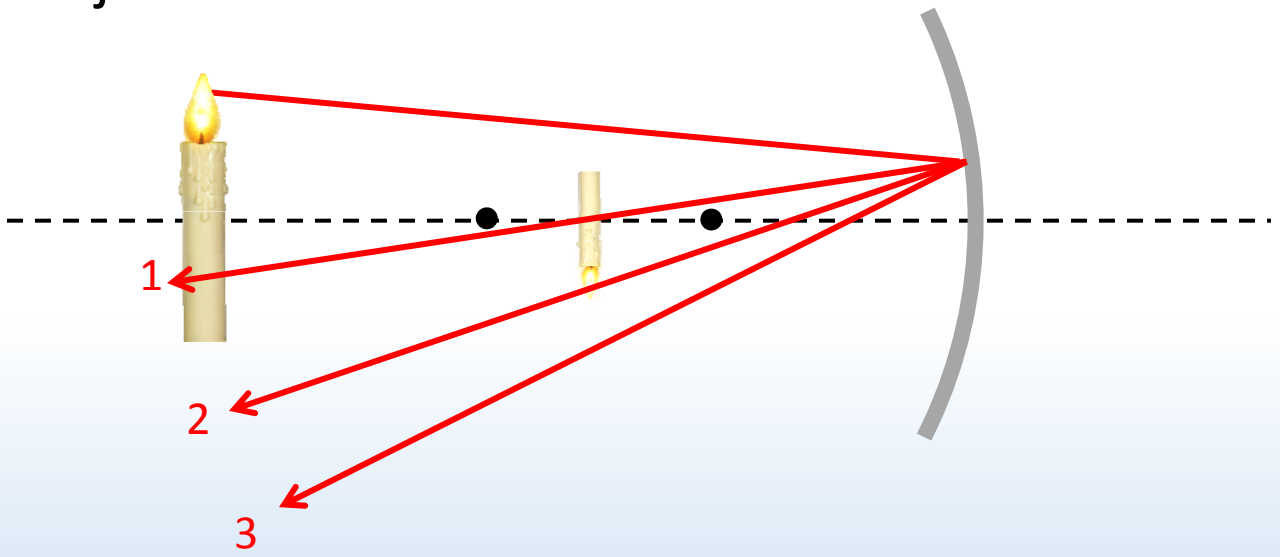


Image is:

Virtual (light rays don't really cross)
Upright (same direction as object)
Reduced (smaller than object)

ACT: Image formation

The diagram below shows the object and image, and one ray from the object



Which arrow most accurately represents how the ray is reflected?

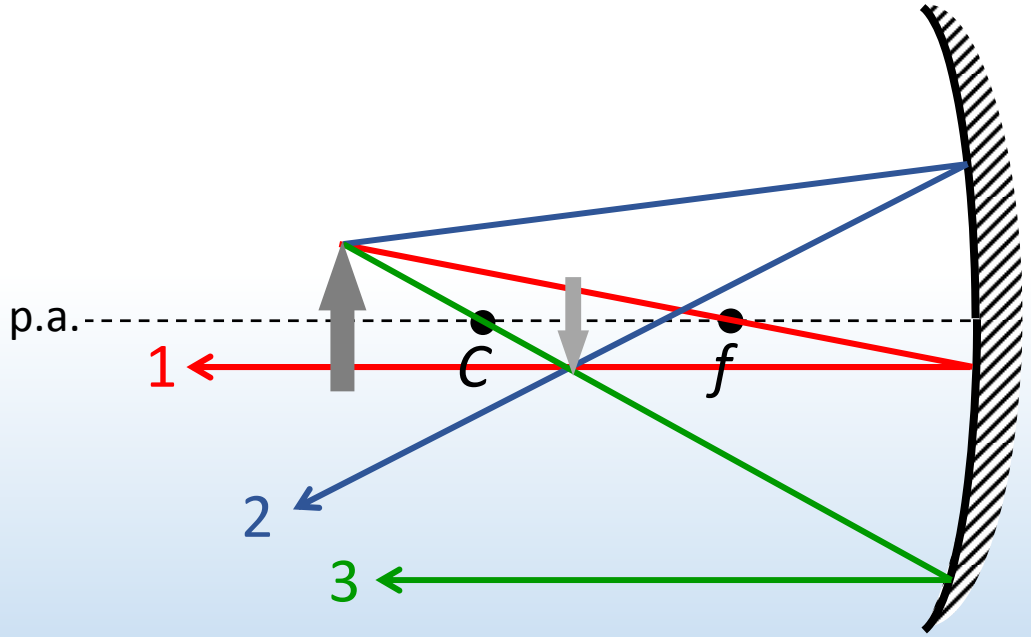
A. 1

B. 2

C. 3

ACT: CheckPoint 2.1

In the ray diagram below, which ray is NOT correct?



A. 1

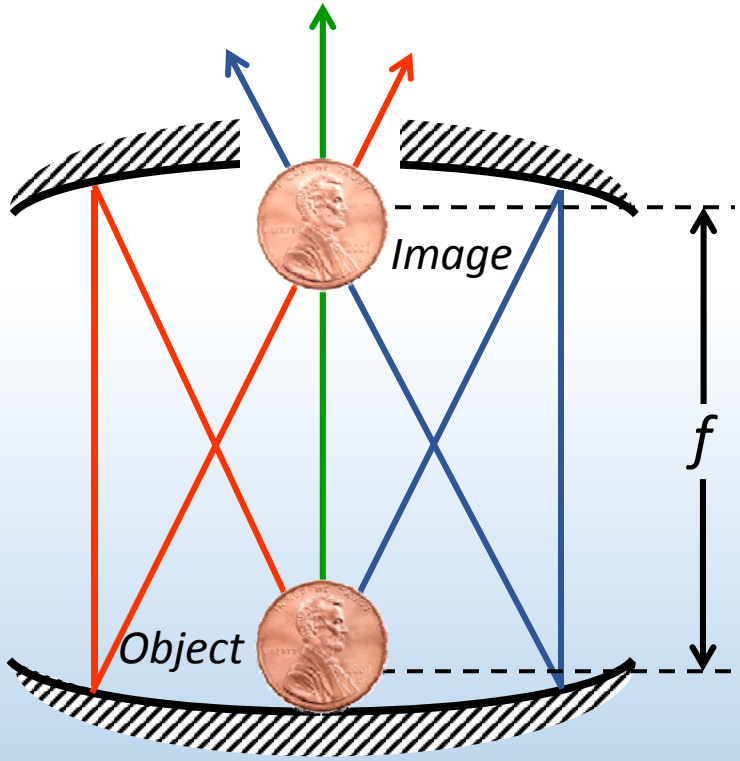
B. 2

C. 3

Optical illusion

Two identical concave mirrors

Each mirror is positioned at the focal point of the other



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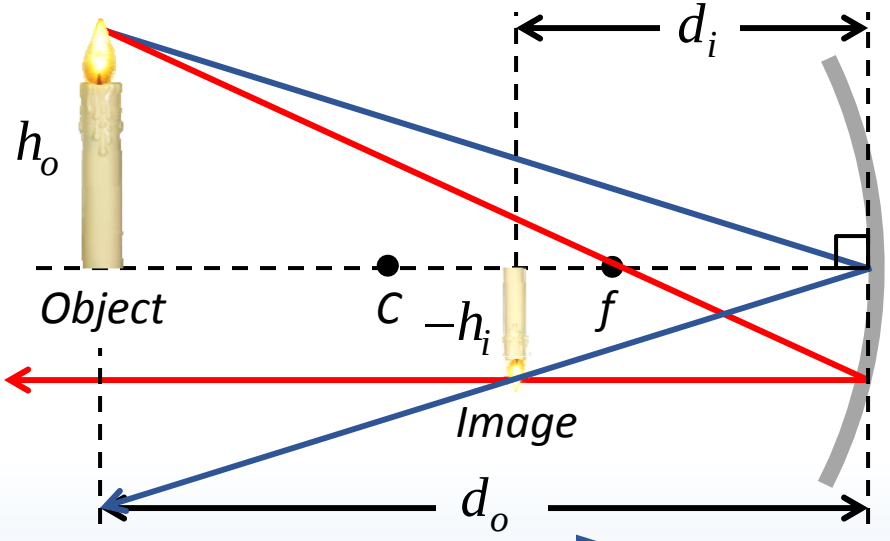
Mirror & magnification equations

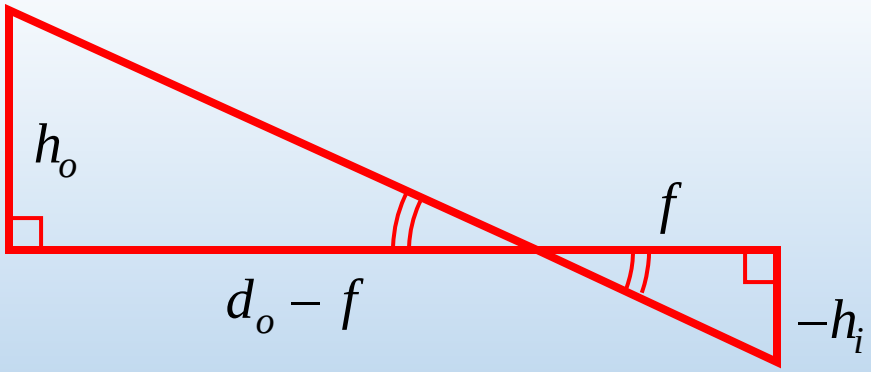
Mirror equation

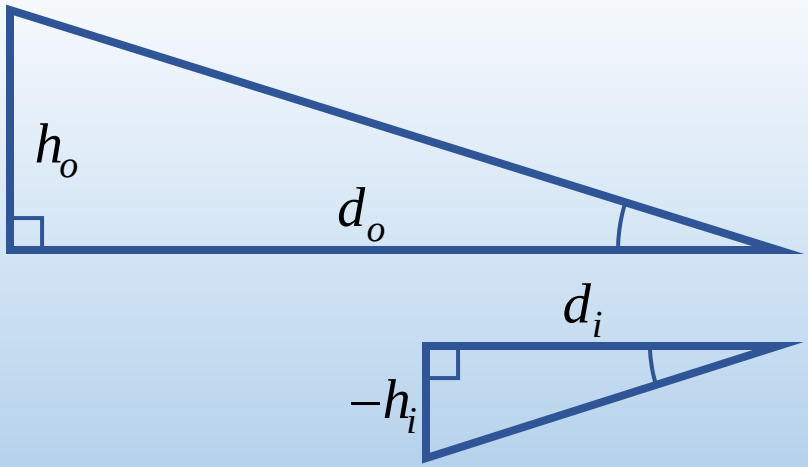
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$



Magnification

$$m \equiv \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

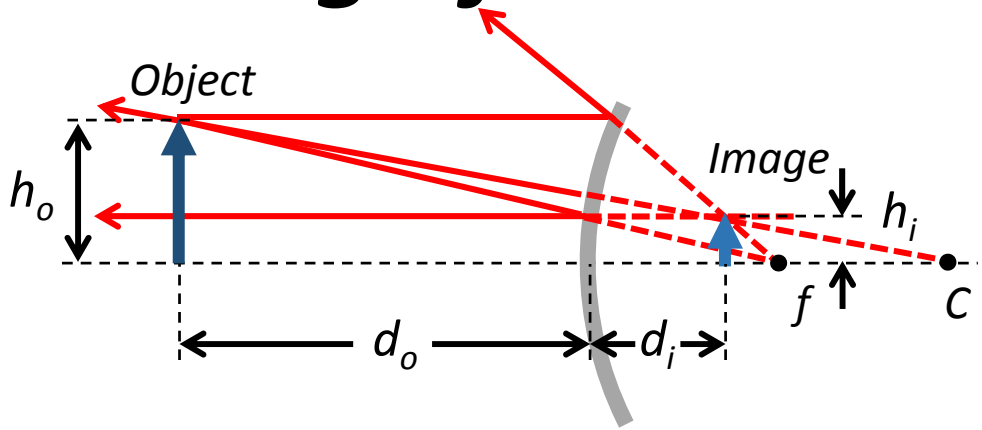




$$\frac{f}{d_o - f} = -\frac{h_i}{h_o} = \frac{d_i}{d_o}$$

So, $$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

Distance & magnification conventions



- d_o = distance object is from mirror:
  - > 0: object in front of mirror
  - < 0: object behind mirror
- d_i = distance image is from mirror:
  - > 0: real image (in front of mirror)
  - < 0: virtual image (behind mirror)
- f = focal length mirror:
  - > 0: concave mirror $+R/2$
  - < 0: convex mirror $-R/2$
- h_o = height of object:
  - > 0: always
- h_i = height of image:
  - > 0: image is upright
  - < 0: image is inverted
- $|m|$ = magnification:
  - < 1: image is reduced
  - > 1: image is enlarged

Calculation: concave mirror

A 6-cm tall candle is placed 24 cm in front of a *concave* mirror with a focal length f = +8 cm. Determine the image location, size, and whether it is upright or inverted

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

$$m = -\frac{d_i}{d_o}$$

$$h_i = m h_o$$

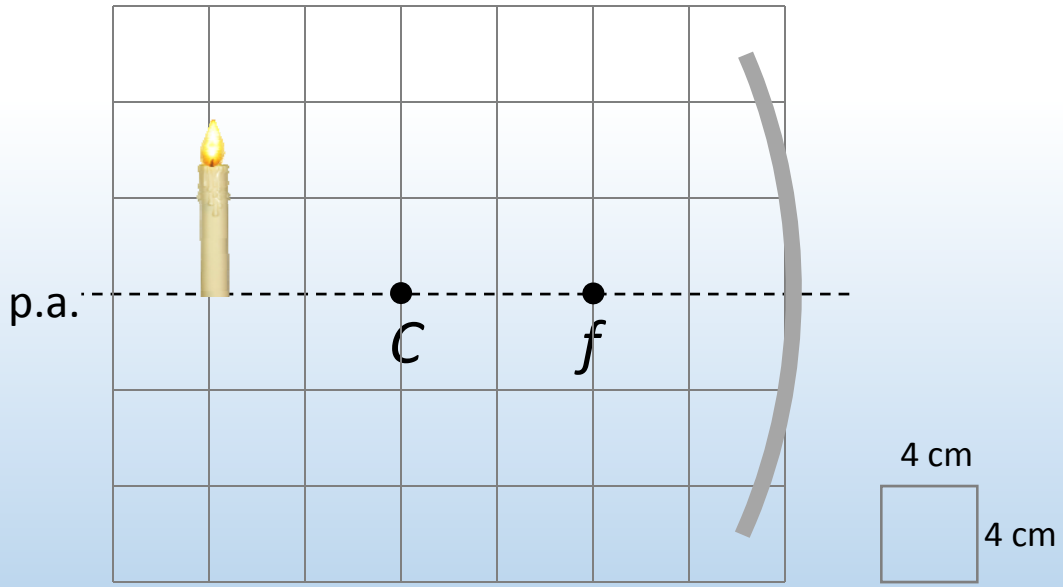
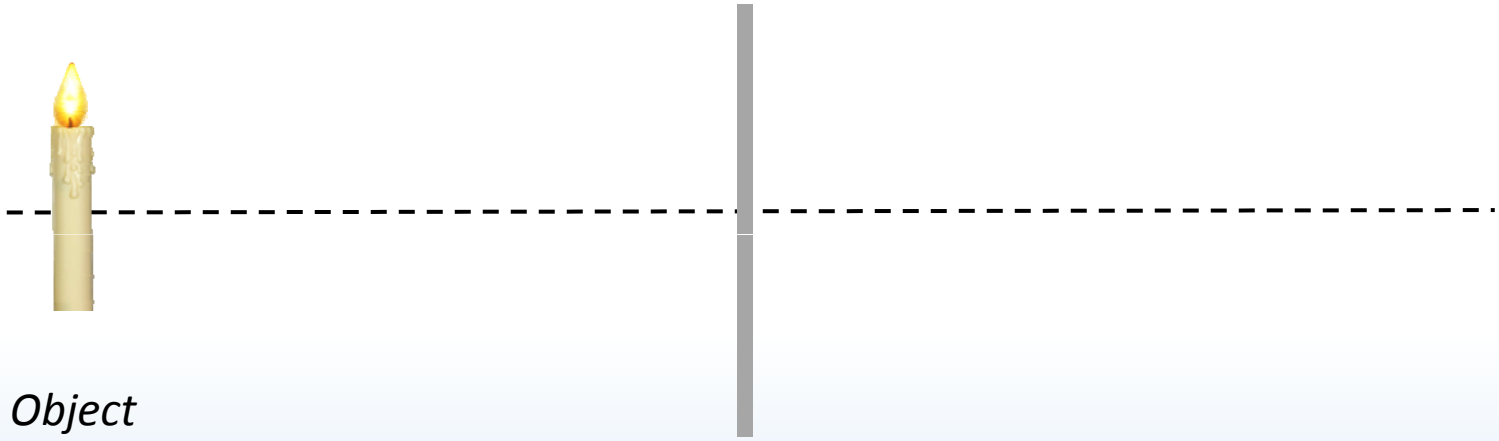


Diagram should agree!

ACT: Plane mirror

Concave mirrors have $f > 0$ and convex mirrors have $f < 0$



Object

What is the focal length f of a plane mirror?

A. $f = 0$

B. $f = \infty$

C. f is imaginary

Checkpoint 3.1

The image produced by a *concave* mirror of a real object is:

A. Always Real
B. Always Virtual
C. Sometimes Real, Sometimes Virtual

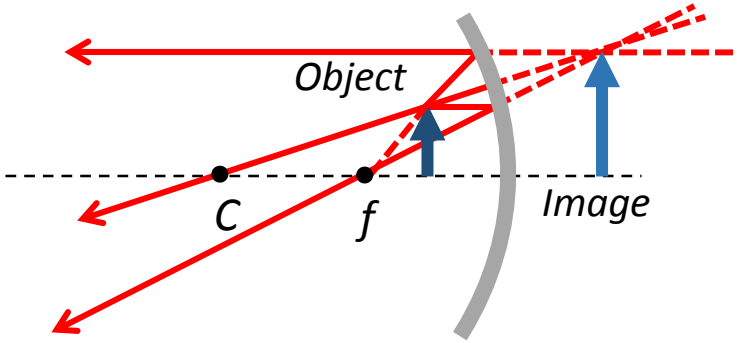
ACT: Concave Mirror

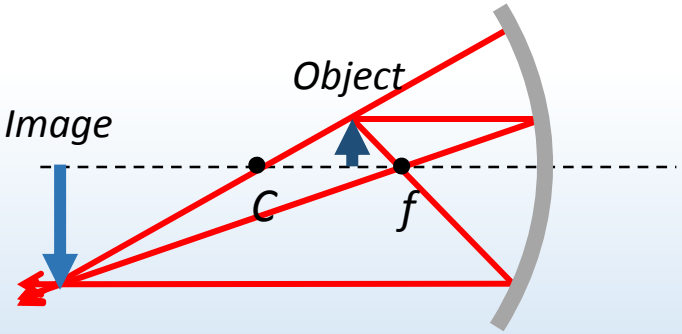
Where in front of a concave mirror should you place an object so that the image is *virtual*?

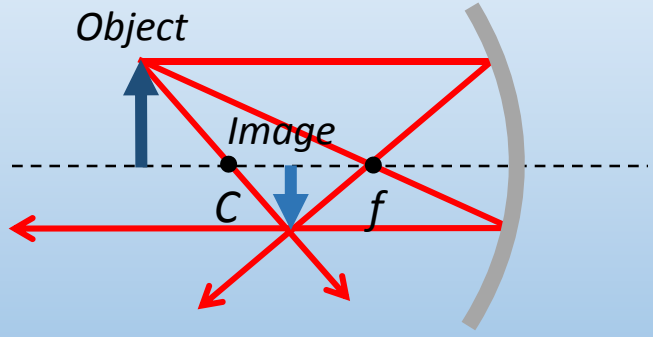
A. Closer than the focal length
B. Farther than the focal length
C. Either close or far
D. Not Possible

3 cases for concave mirrors

Object is:	Image is:
Inside *f*: $d_o < f$	Upright: $h_i > 0$ Enlarged: $m > 1$ Virtual: $d_i < 0$
Between *C* & *f*: $f < d_o < R$	Inverted: $h_i < 0$ Enlarged: $m > 1$ Real: $d_i > 0$
Past *C*: $R < d_o$	Inverted: $h_i < 0$ Reduced: $m < 1$ Real: $d_i > 0$







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Calculation: convex mirror

A 6-cm tall candle is placed 12 cm in front of a *convex* mirror with a focal length $f = -6$ cm. Determine the image location, size, and whether it is upright or inverted

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

$$m = -\frac{d_i}{d_o}$$

$$h_i = m h_o$$

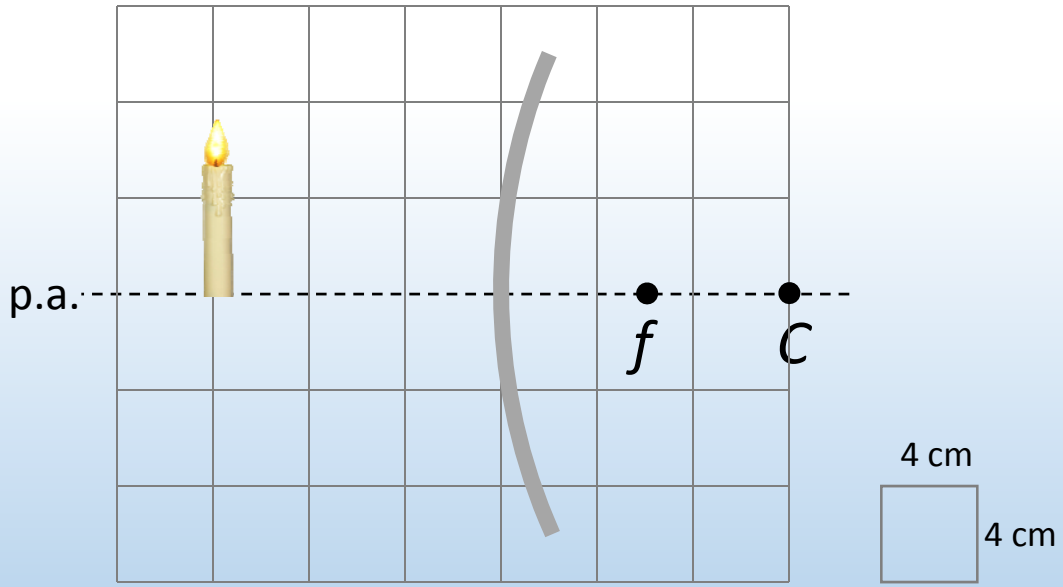


Diagram should agree!

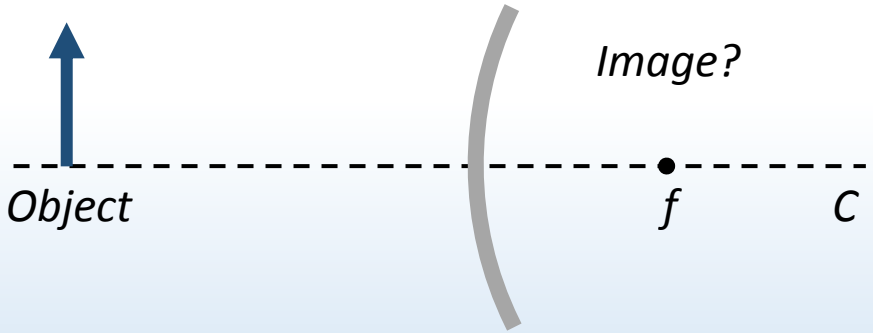
Checkpoint 3.2

The image produced by a convex mirror of a real object is

A. always real
B. always virtual
C. sometimes real and sometimes virtual

ACT: Convex mirror image

An object placed in front of a *convex* mirror will _____ produce an *upright* image



A. Always
B. Sometimes
C. Never

Summary of today's lecture

- Curved mirrors
- Principal rays – method for images
  - Parallel to p.a. –> reflects through *f*
  - Through *f* -> reflects parallel to p.a.
  - Through *C* -> reflects back through *C*
- Mirror & magnification equations
  - Numerical answer consistent with ray diagram

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad m \equiv \frac{h_i}{h_o}=-\frac{d_i}{d_o}$$