

Your Comments

This pre-lecture was almost a "mirror" image of the last one!

This stuff makes sense!!! Yay!!!

I was not sure about the angle at which the beam reflects from a concave mirror.

Keeping all these signs in order seems confusing, any good tricks or just memorize which is which?

Does virtual exist? I don't understand how it could exist

What are some applications of concave and convex mirrors?

I found this awesome, short video on seeing without glasses. It ties right into optics and lenses, and I think it's really quite interesting. https://www.youtube.com/watch?v=OydgR_7_DjI

In chem 204, we are learning about chiral molecules, which are actually used to polarize light. Its cool to see that physics and chemistry can intersect and for me to see that as a freshman.

Physics 212

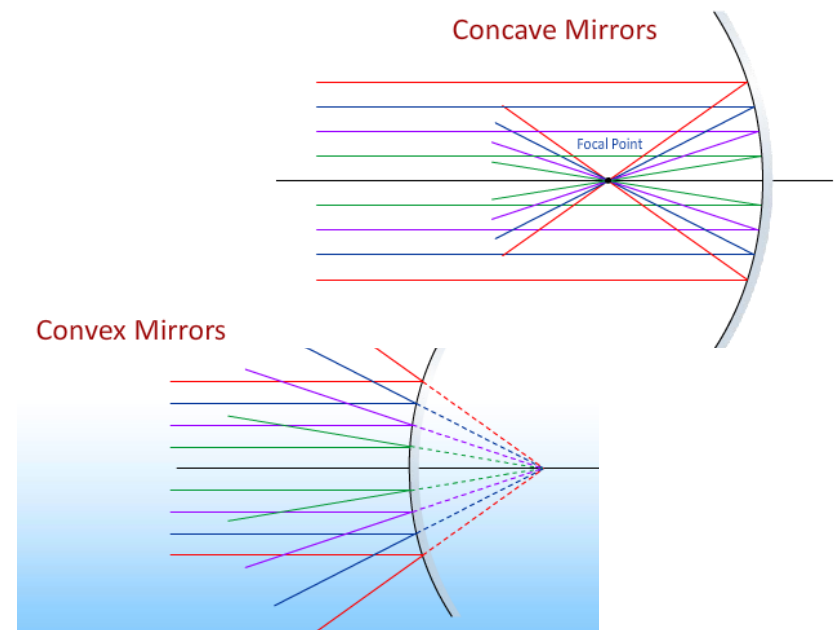
Lecture 27

Today's Concept:

Mirrors

Exam Tomorrow Night at 7:00

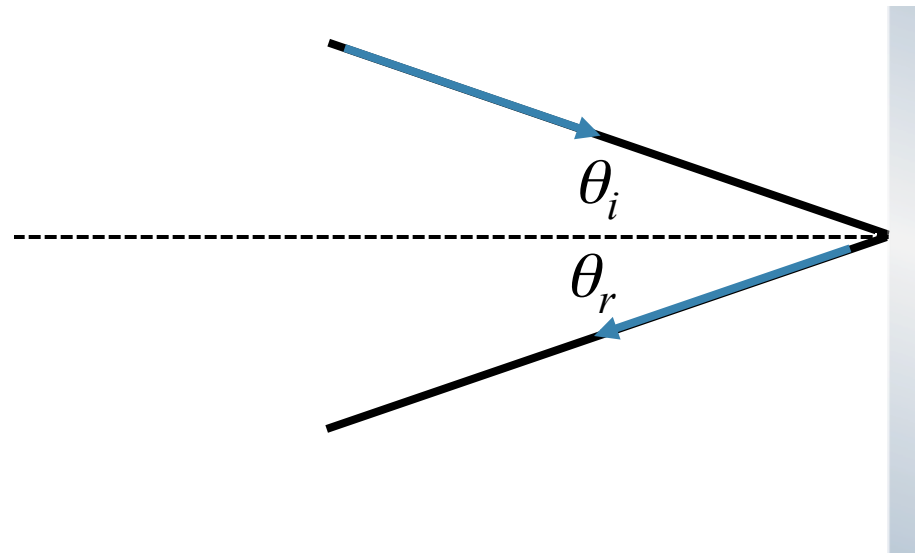
- Covers material in Lectures 19 – 26
- Bring your ID: Rooms determined by discussion section (see link)



Reflection

Angle of incidence = Angle of reflection

$$\theta_i = \theta_r$$

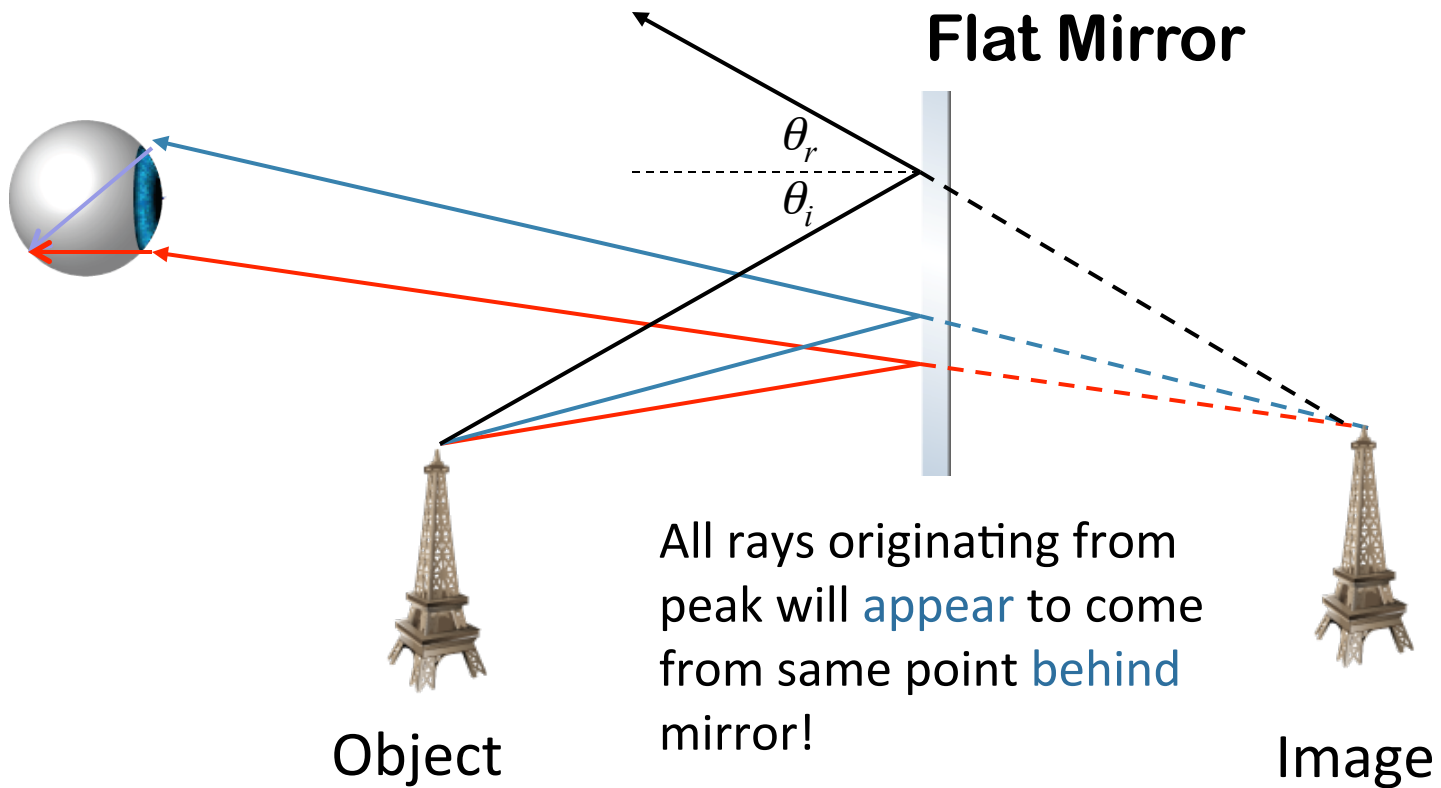


That's all of the physics – everything else is just geometry!

Flat Mirror

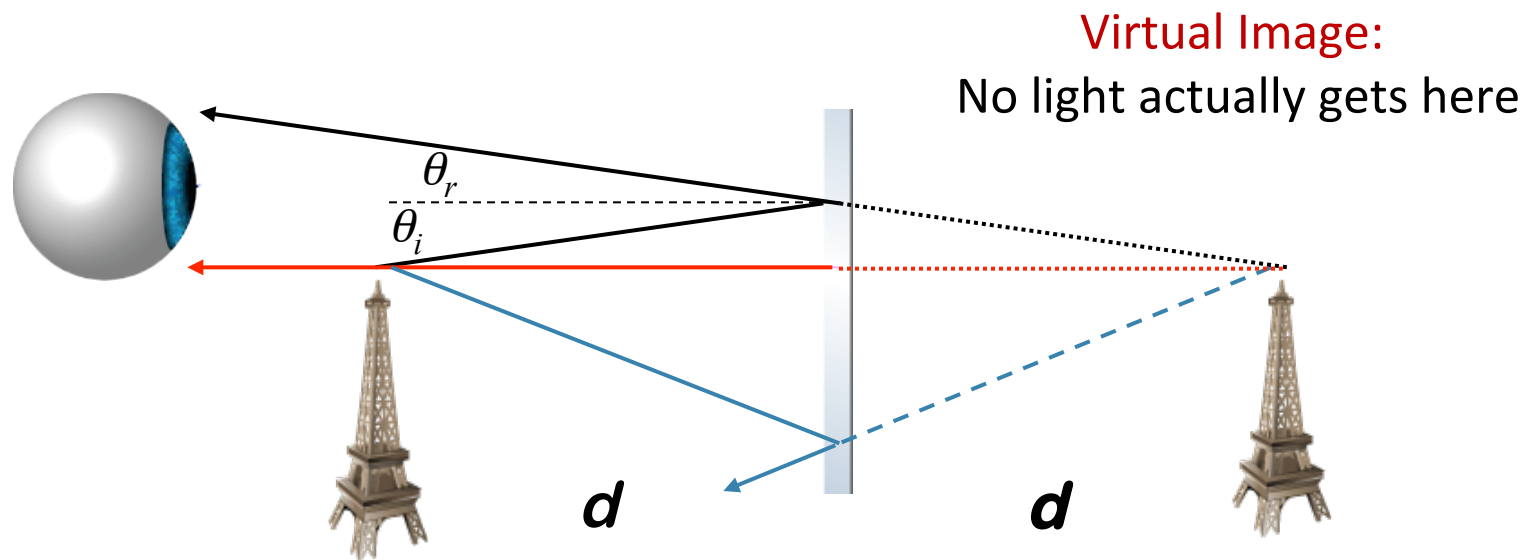
All you see is what reaches your eyes

You think object's location is where rays **appear** to come from.



Flat Mirror

- 1) Draw first ray perpendicular to mirror $0 = \theta_i = \theta_r$
- 2) Draw second ray at angle. $\theta_i = \theta_r$
- 3) Lines appear to intersect a distance d behind mirror. This is the image location.



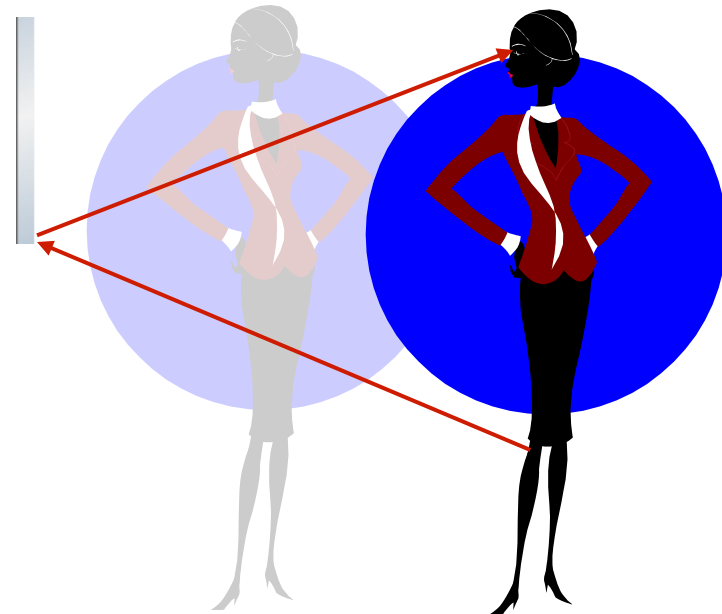
Clicker Question



A woman is looking at her reflection in a flat vertical mirror.
The lowest part of her body she can see is her knee.

If she stands **closer to the mirror**, what will be the lowest part of her reflection she can see in the mirror.

- A) Above her knee
- B) Her knee
- C) Below her knee

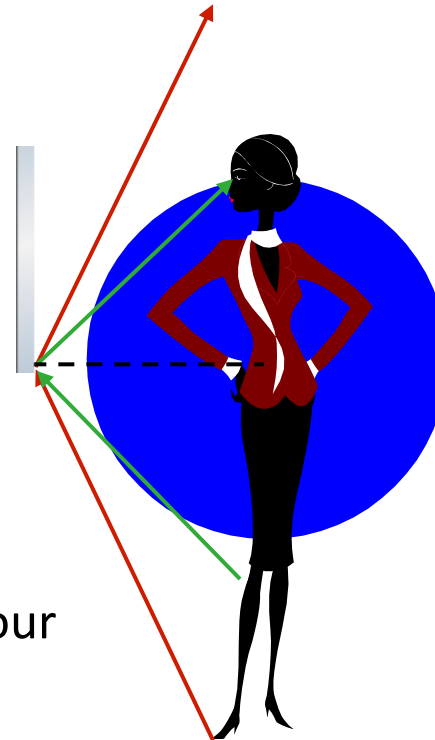


Clicker Question



A woman is looking at her reflection in a flat vertical mirror. The lowest part of her body she can see is her knee. If she stands **closer to the mirror**, what will be the lowest part of her reflection she can see in the mirror.

- A) Above her knee
- ☒ B) Her knee
- C) Below her knee



If the light doesn't get to your eye then you can't see it

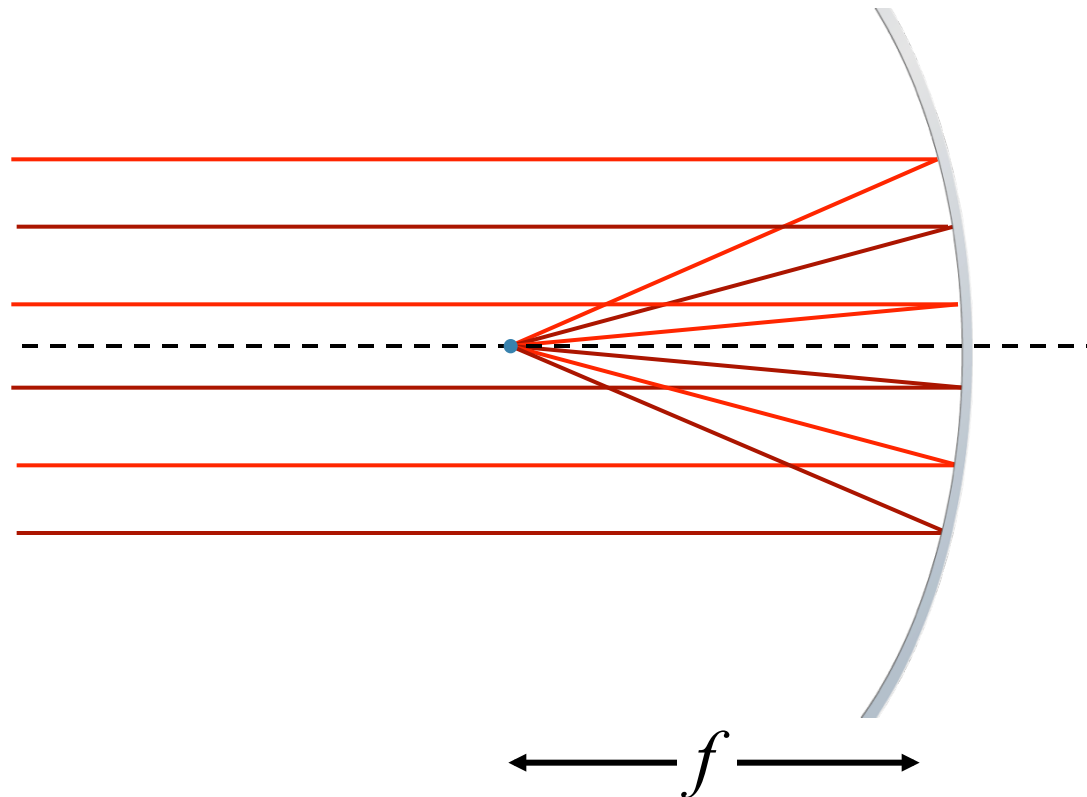
You will also get Images from Curved Mirrors:

Is this how wacky mirrors work? You know, the ones that distort your body.



Concave: Consider the case where the shape of the mirror is such that light rays parallel to the axis of the mirror are all “focused” to a common spot a distance f in front of the mirror:

Note: analogous to “converging lens”
Real object can produce real image

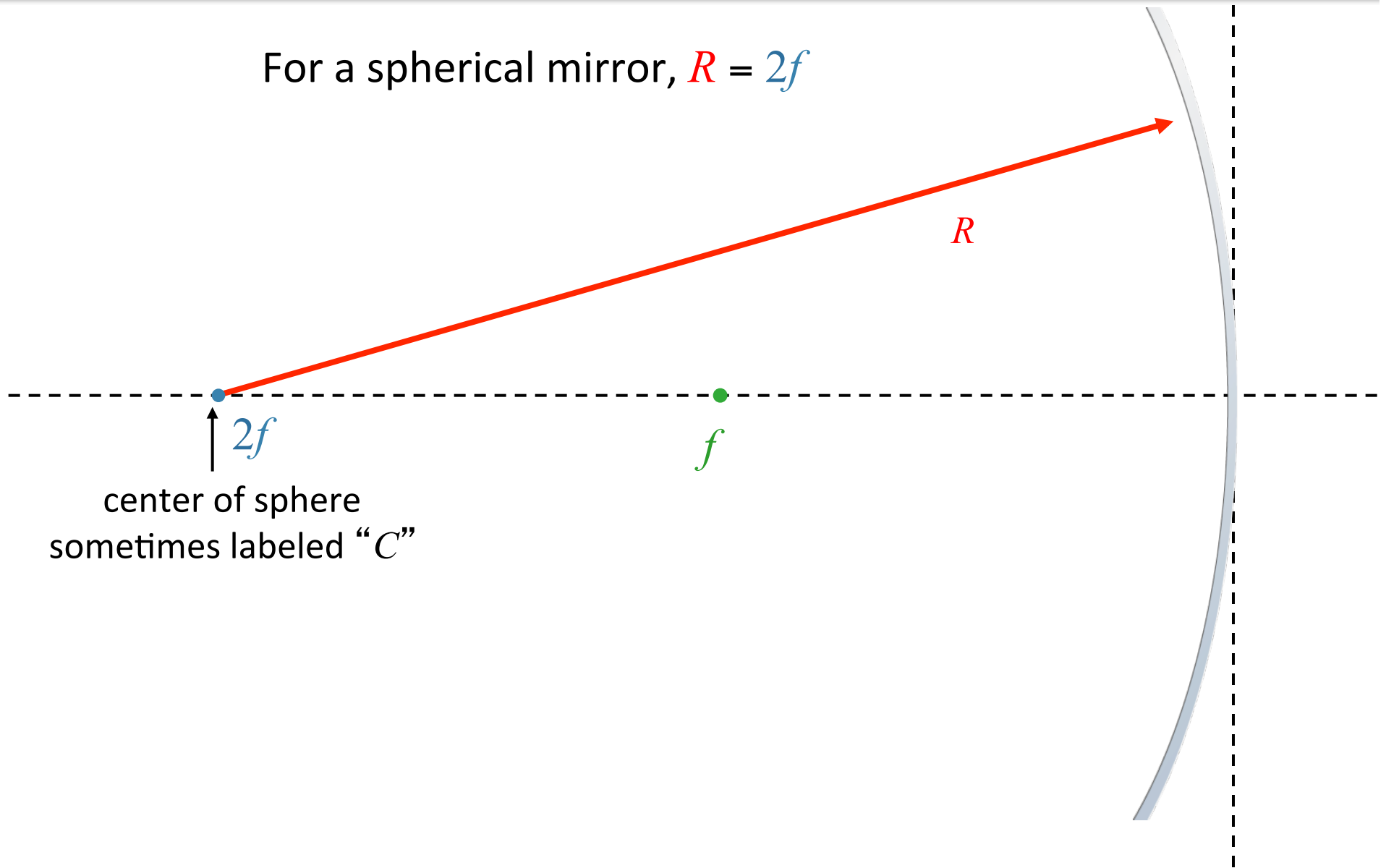


These mirrors are often sections of spheres (assumed in this class).

For such “spherical” mirrors, we assume all angles are small even though we draw them big to make it easy to see...

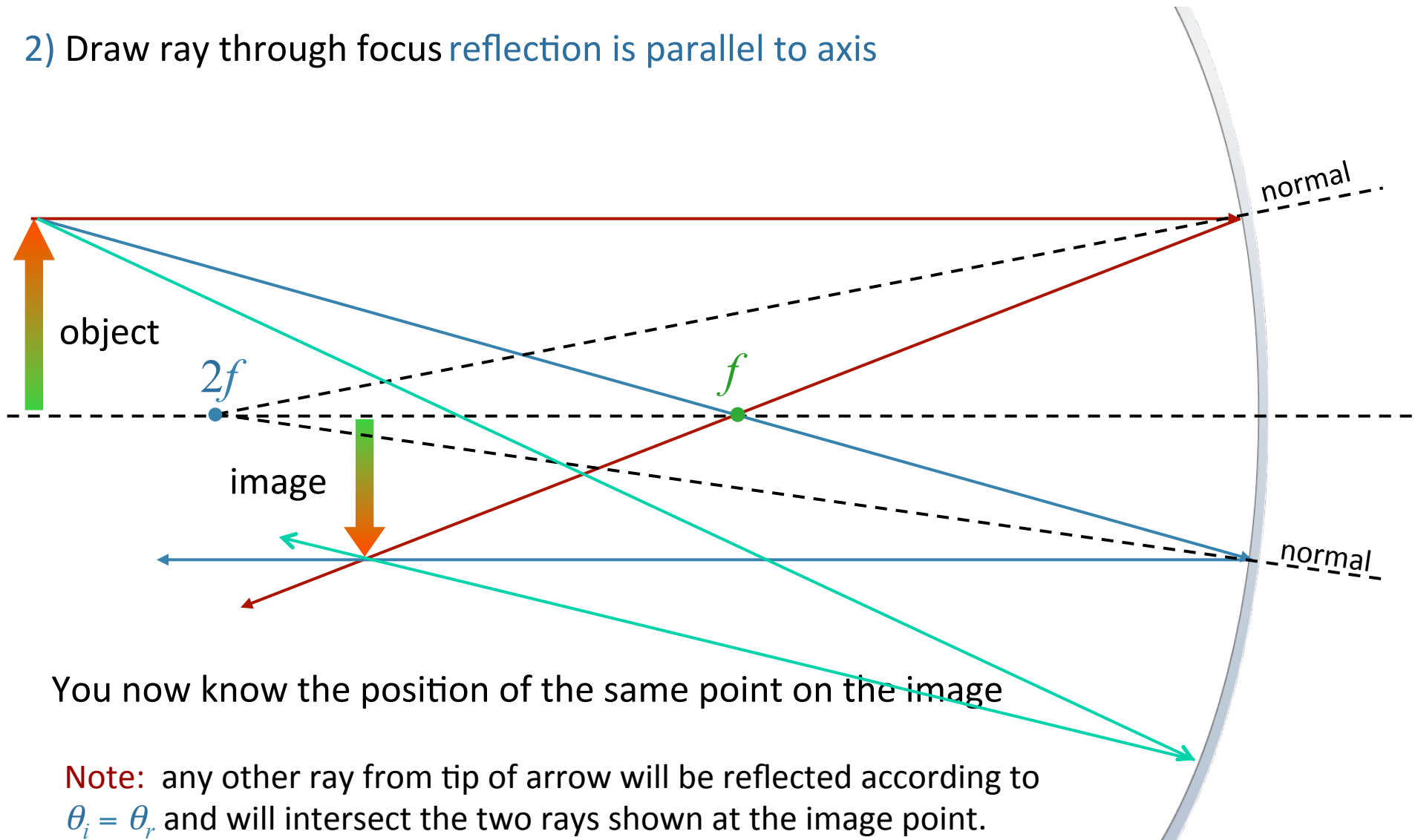
Aside:

For a spherical mirror, $R = 2f$



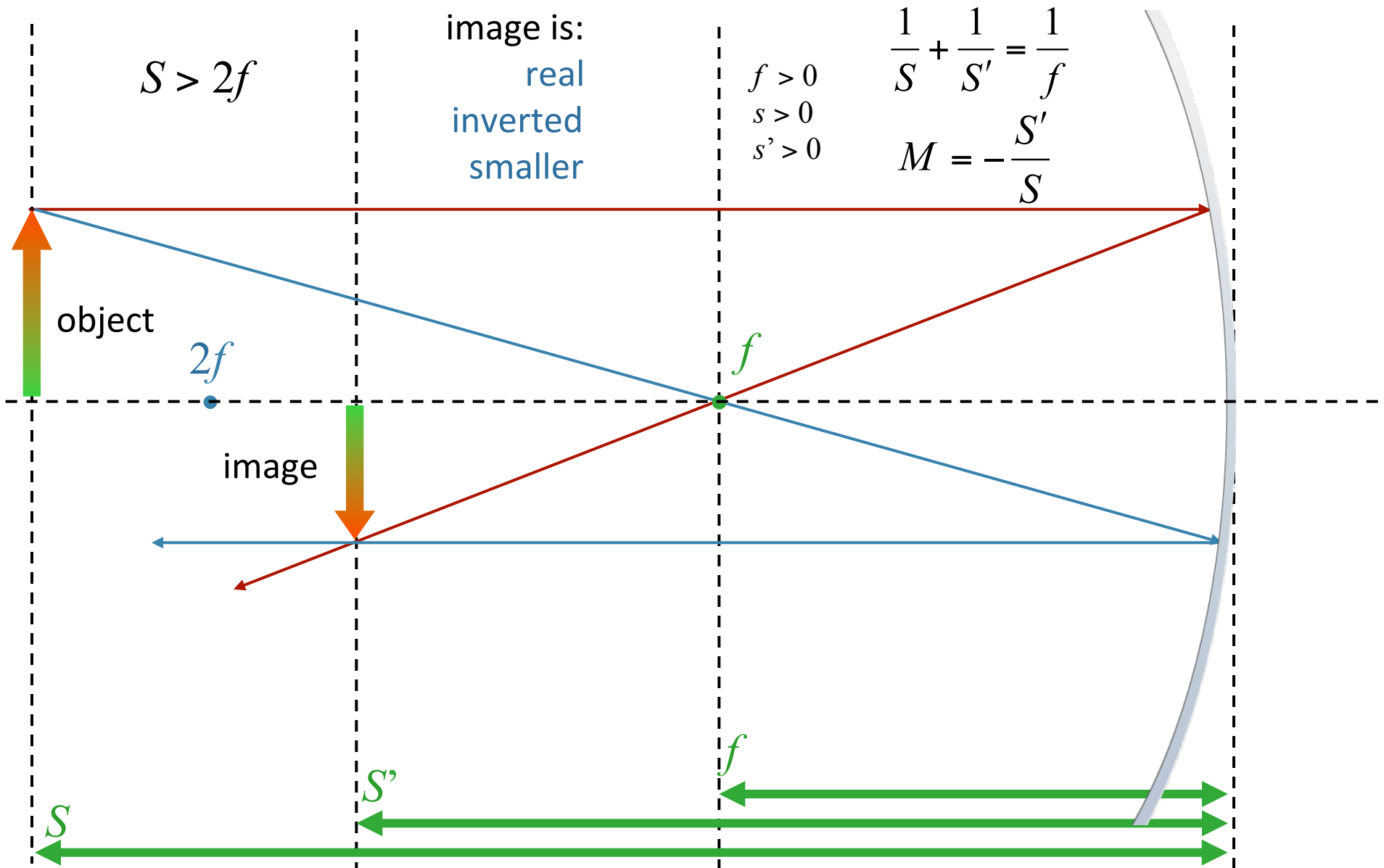
Recipe for Finding Image:

- 1) Draw ray parallel to axis reflection goes through focus
- 2) Draw ray through focus reflection is parallel to axis

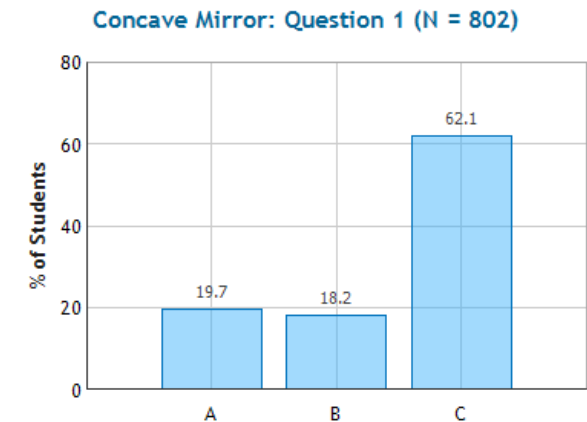
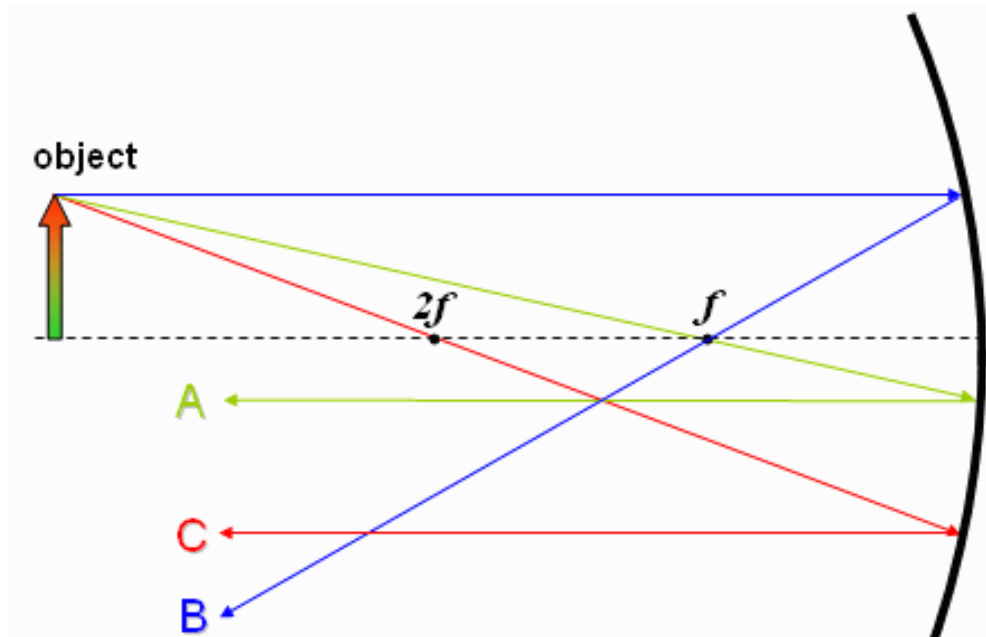


You now know the position of the same point on the image

Note: any other ray from tip of arrow will be reflected according to $\theta_i = \theta_r$ and will intersect the two rays shown at the image point.



Checkpoint 1a

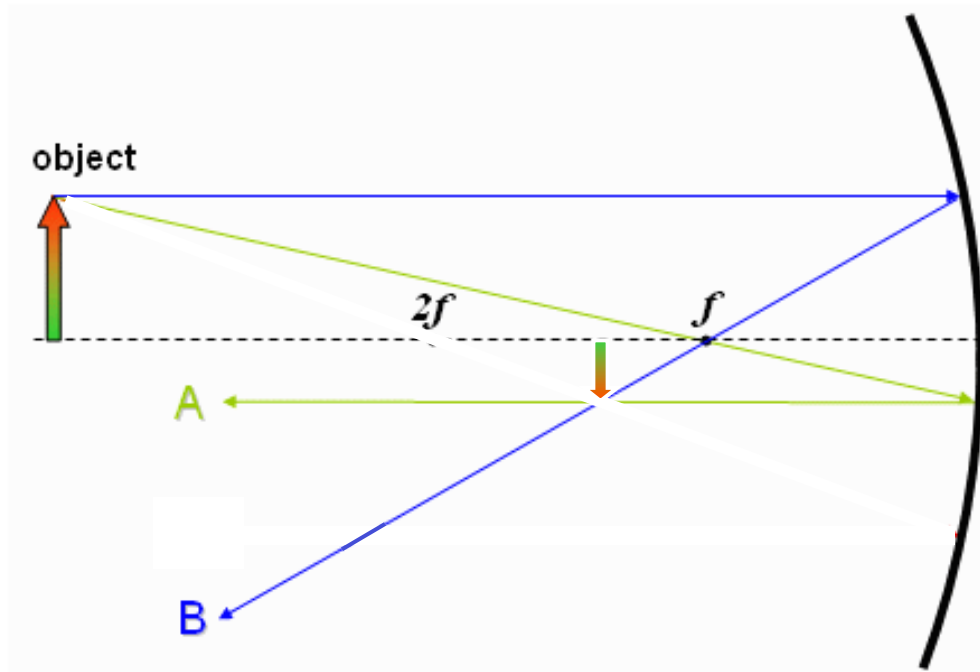


The diagram above shows three light rays reflected off a concave mirror. Which ray is NOT correct?

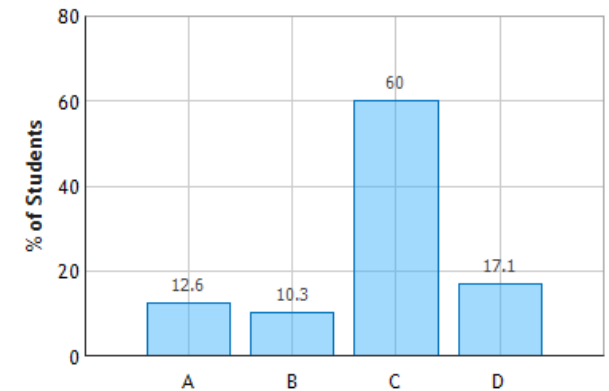
A **B** **C**

Rays parallel to the axis of the mirror must pass through the focus. Ray C passes through $2f$, not f , but was drawn parallel to the axis.

CheckPoints 1b



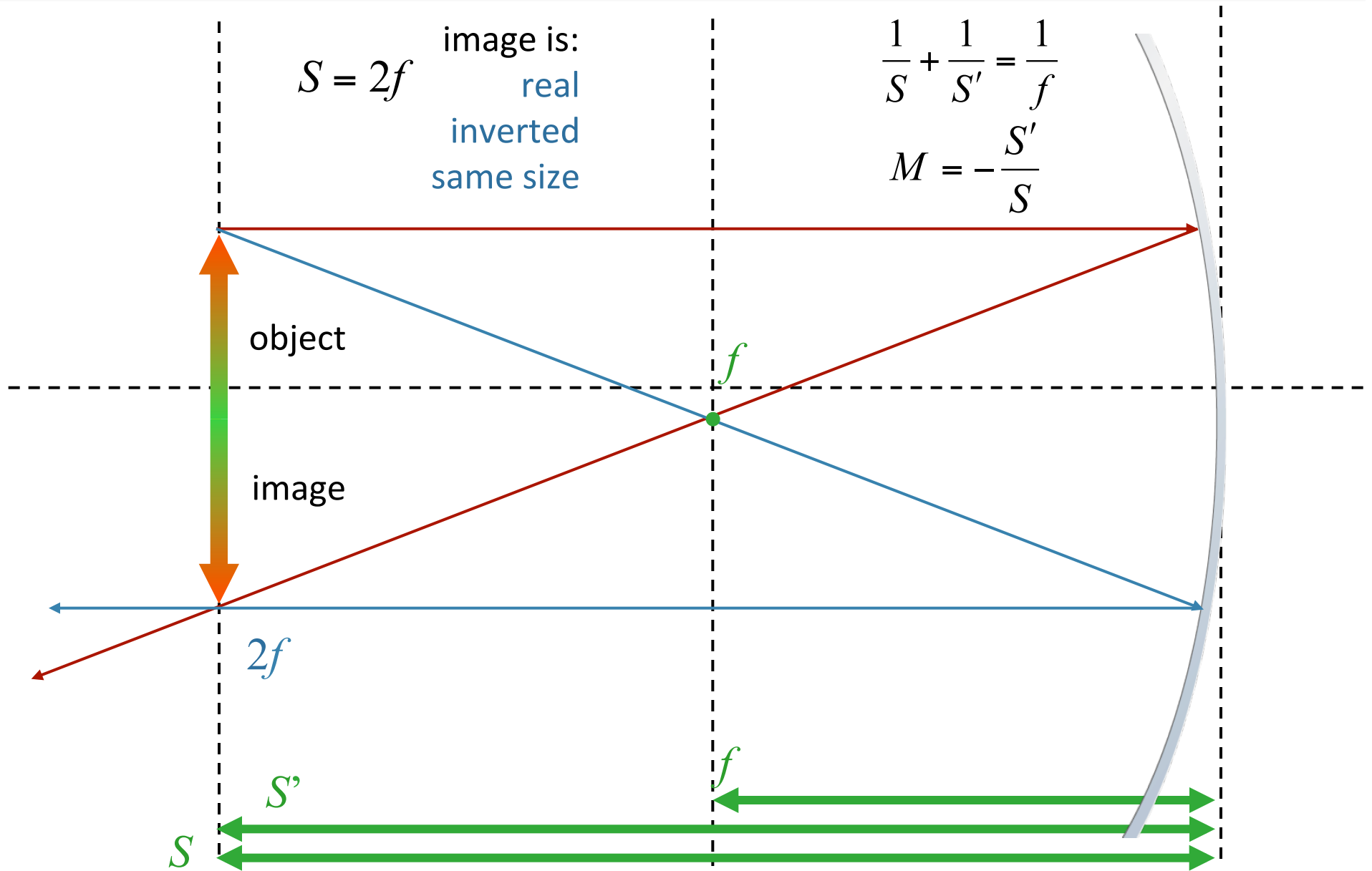
Concave Mirror: Question 3 (N = 802)

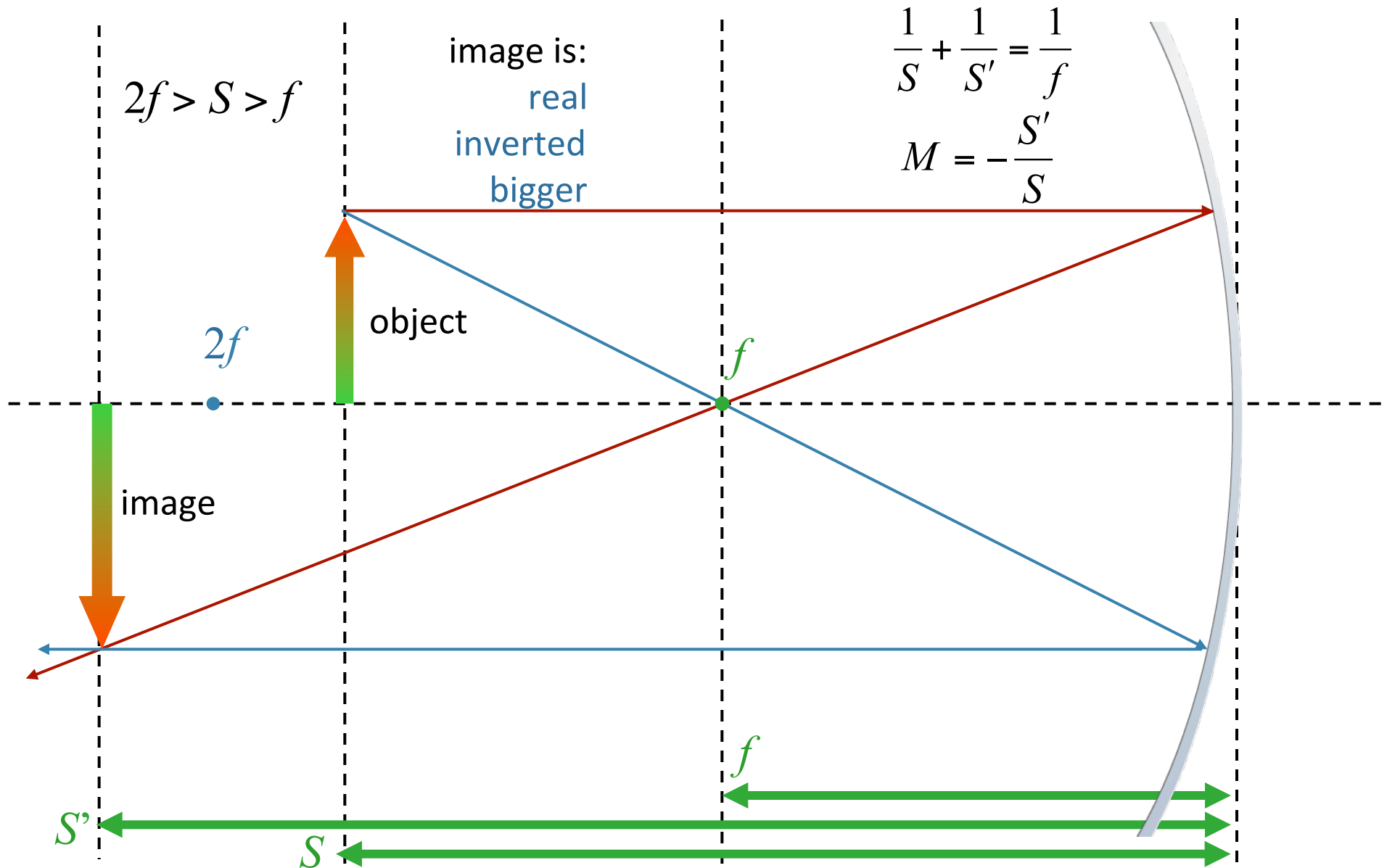


The diagram above shows two light rays reflected off a concave mirror. The image is

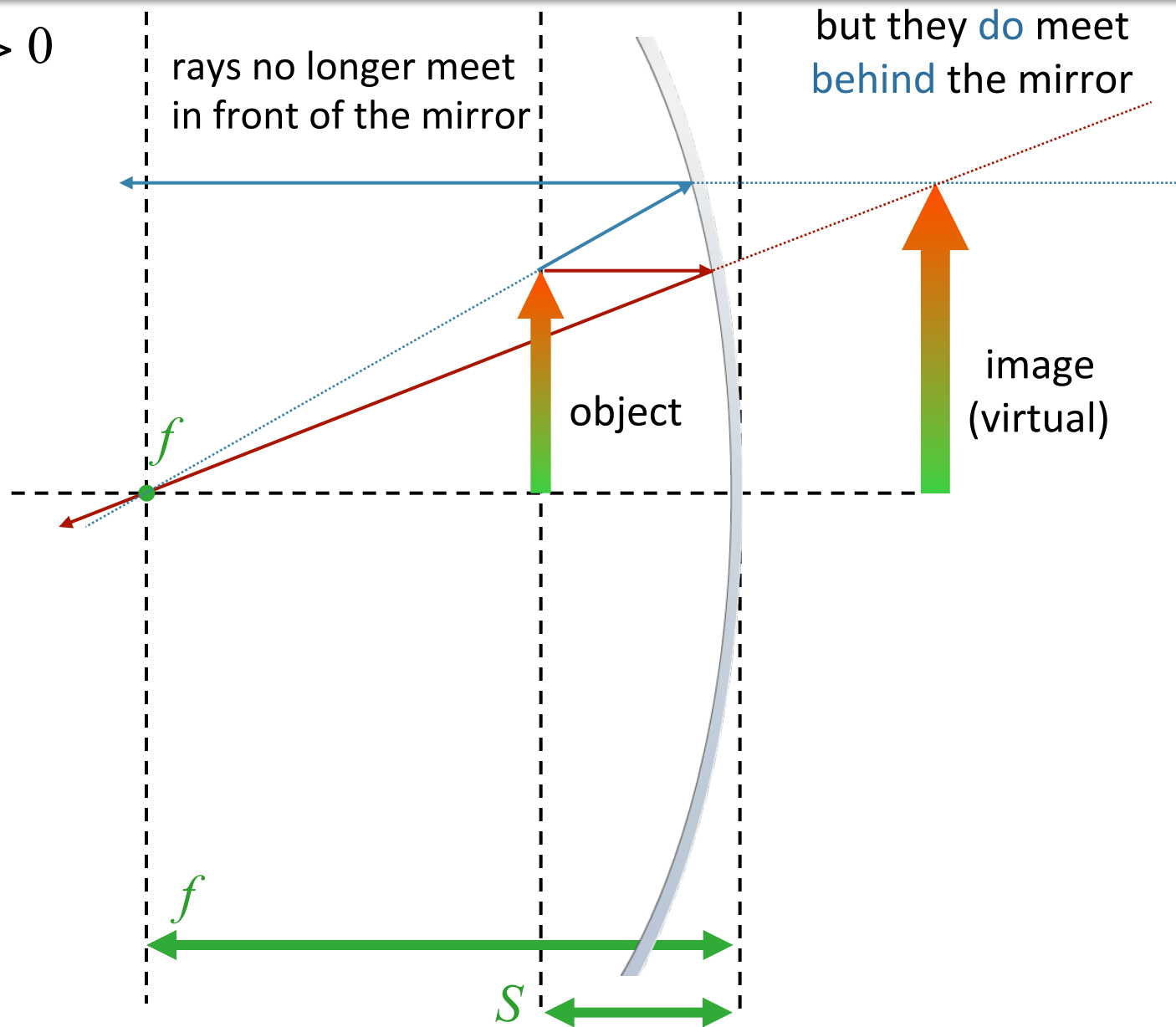
- A. Upright and reduced
- C. Inverted and reduced**

- B. Upright and enlarged
- D. Inverted and enlarged



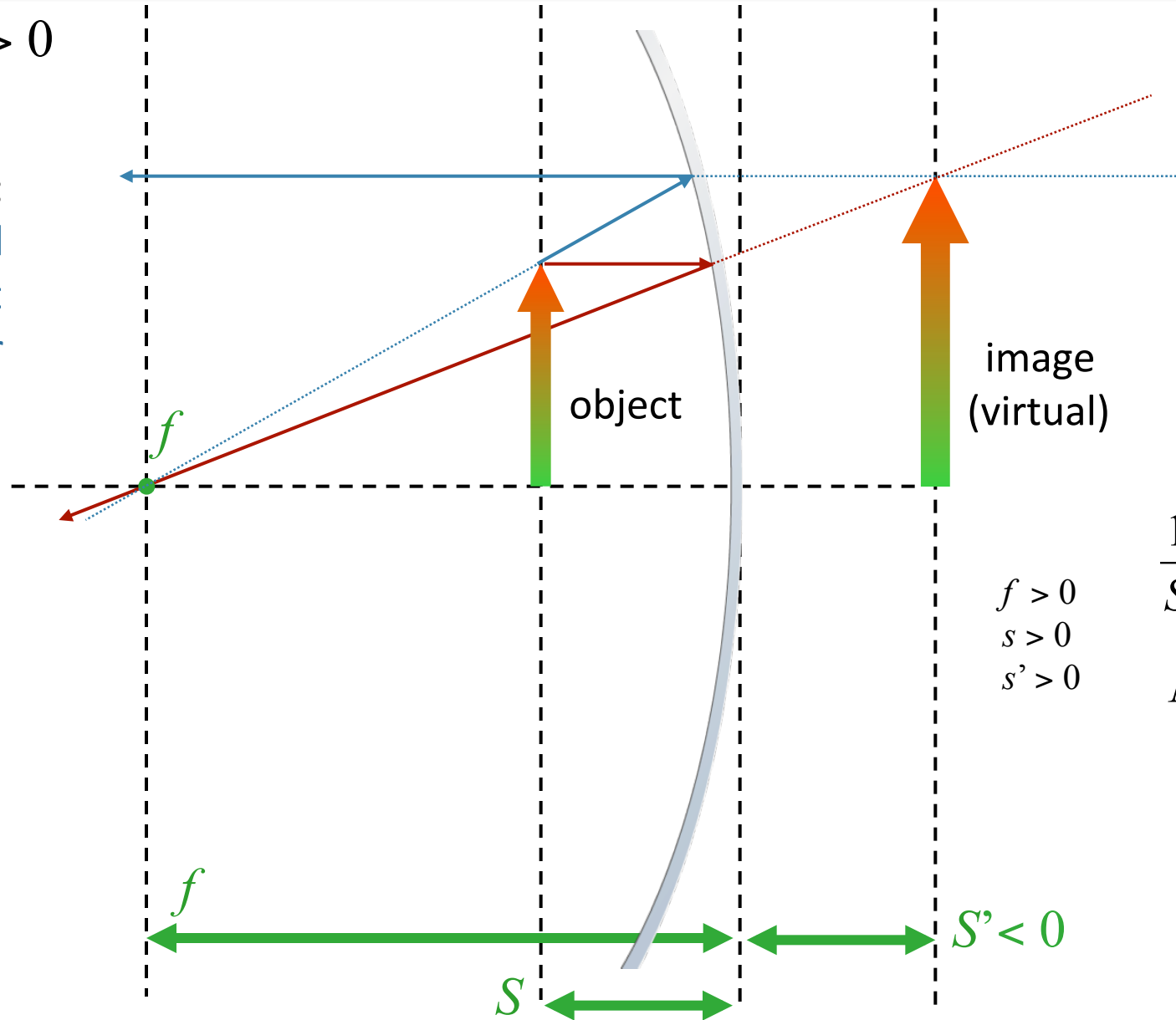


$$f > S > 0$$



$$f > S > 0$$

image is:
virtual
upright
bigger



$$\begin{aligned} f &> 0 \\ s &> 0 \\ s' &> 0 \end{aligned}$$

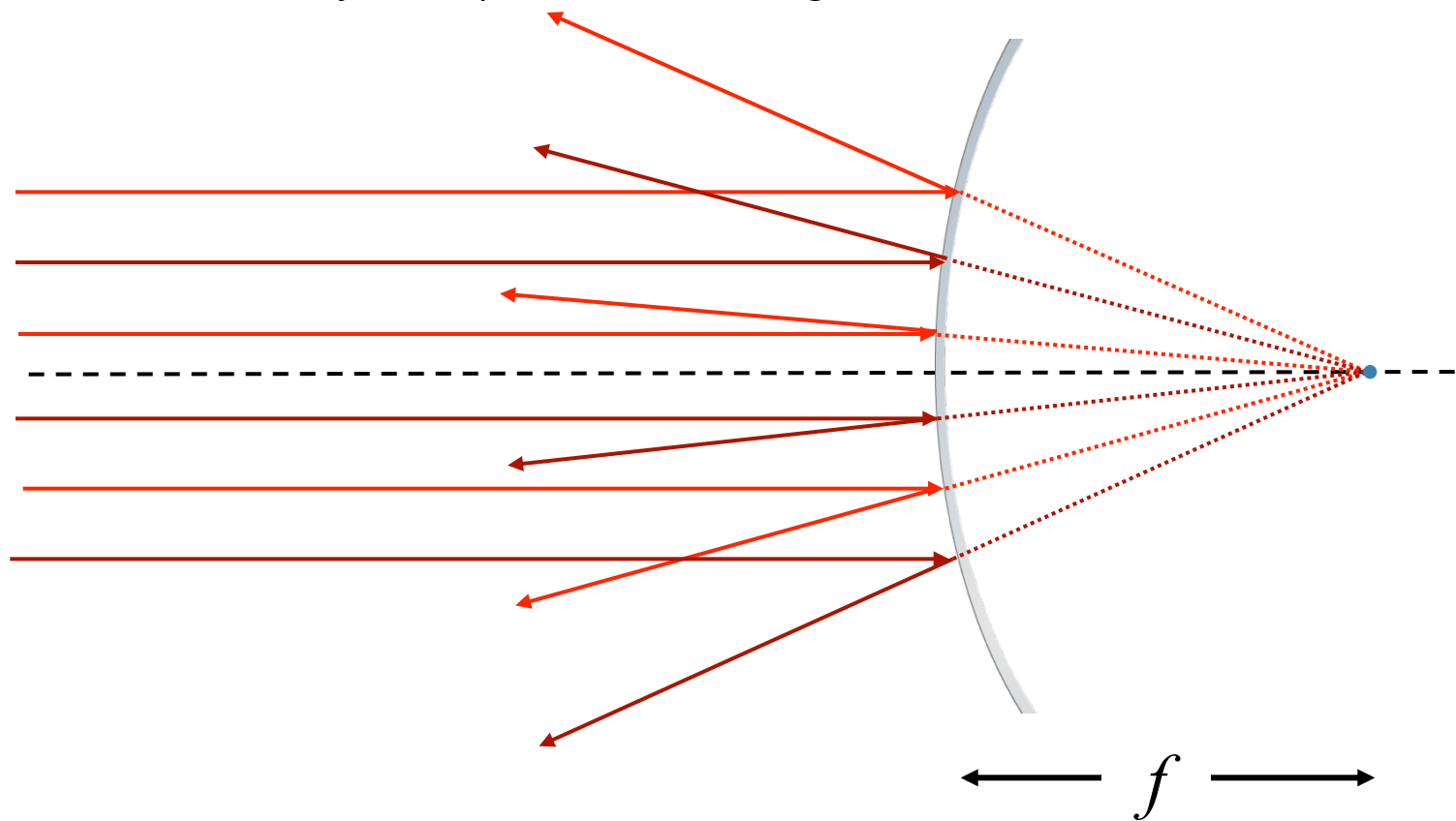
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f}$$

$$M = -\frac{S'}{S}$$

Convex Mirror

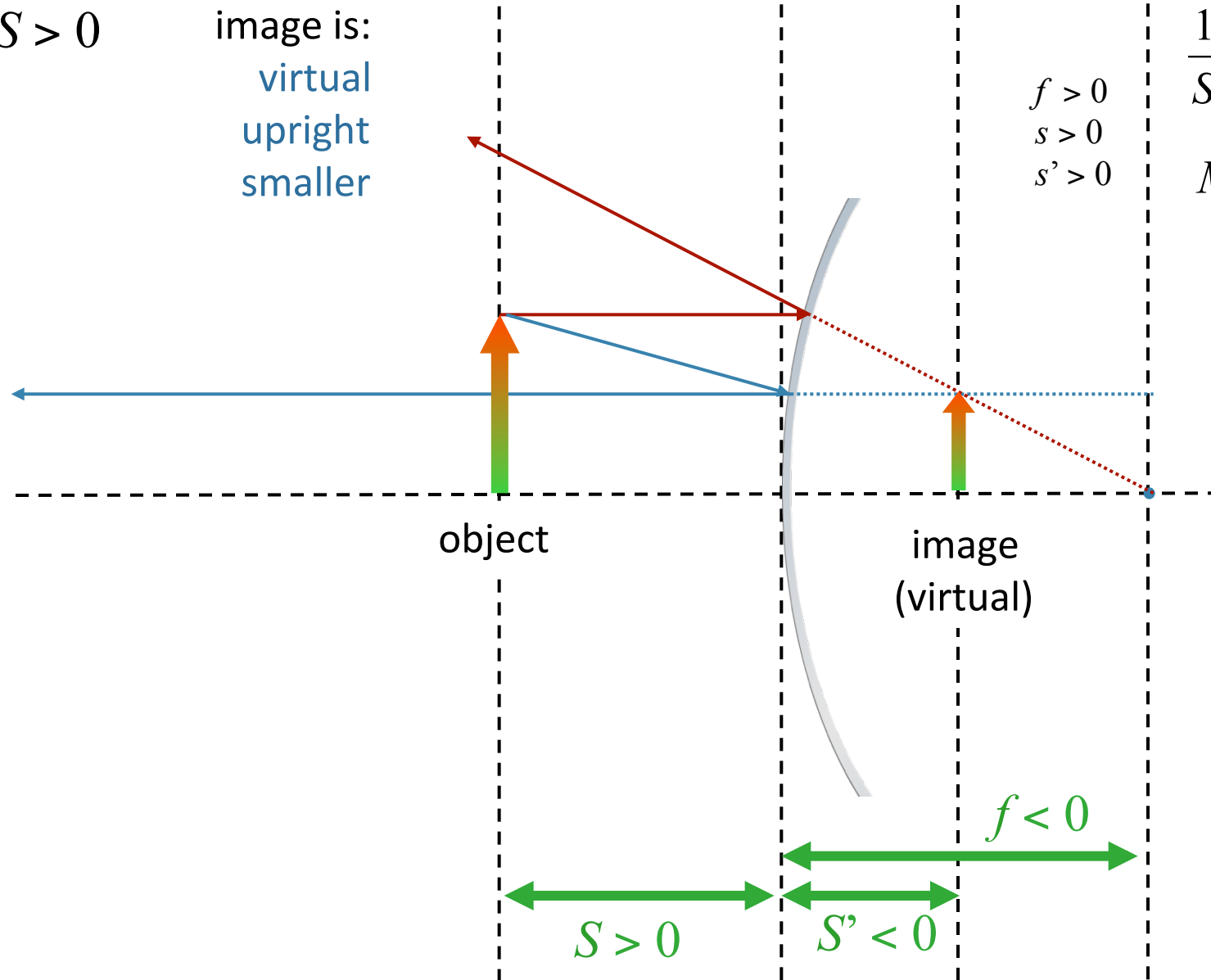
Convex: Consider the case where the shape of the mirror is such that light rays parallel to the axis of the mirror are all “focused” to a common spot a distance f behind the mirror:

Note: analogous to “diverging lens”
Real object will produce virtual image



$$S > 0$$

image is:
virtual
upright
smaller



$$\begin{aligned} f &> 0 \\ s &> 0 \\ s' &> 0 \end{aligned}$$

$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f}$$

$$M = -\frac{S'}{S}$$

Executive Summary - Mirrors & Lenses:

$$S > 2f$$

real
inverted
smaller

$$2f > S > f$$

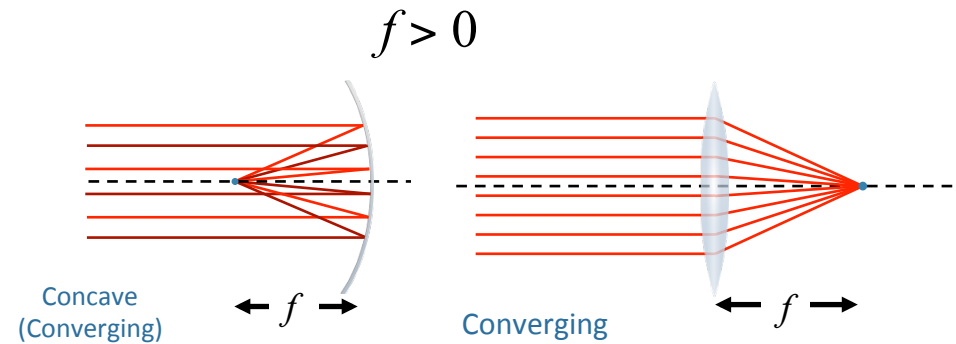
real
inverted
bigger

$$f > S > 0$$

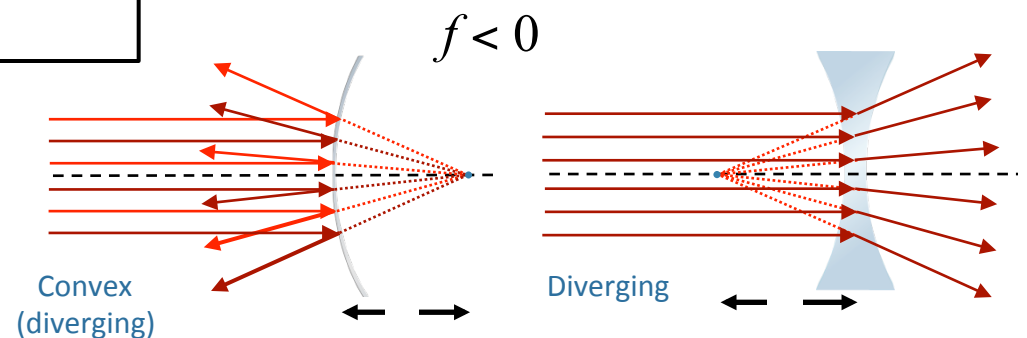
virtual
upright
bigger

$$S > 0$$

virtual
upright
smaller



$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \quad M = -\frac{S'}{S}$$



It's Always the Same:

$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \quad M = -\frac{S'}{S}$$

You just have to keep the signs straight:

s' is positive for a real image

f is positive when it can produce a real image

Lens sign conventions

S : positive if object is “upstream” of lens

S' : positive if image is “downstream” of lens

f : positive if converging lens

Mirrors sign conventions

S : positive if object is “upstream” of mirror

S' : positive if image is “upstream” of mirror

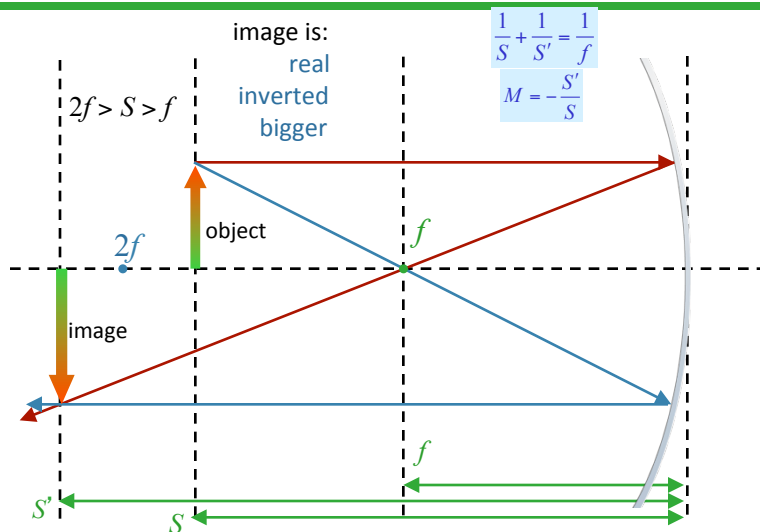
f : positive if converging mirror (concave)

Checkpoint 2a

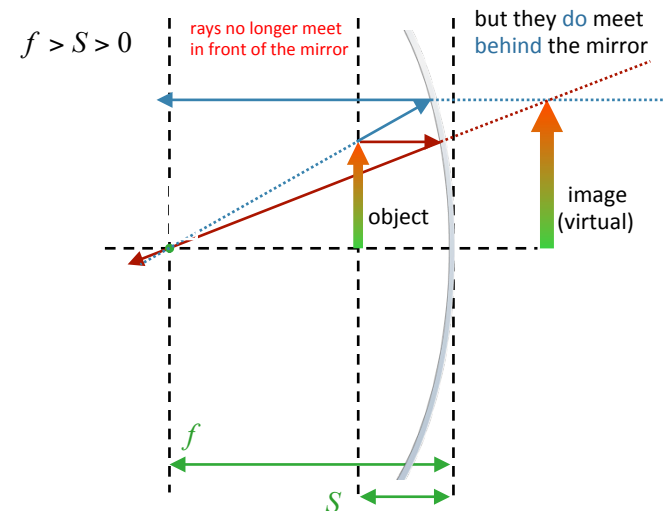


The image produced by a concave mirror of a real object is

- A. Always upright
- B. Always inverted
- C. Sometimes upright & sometimes inverted

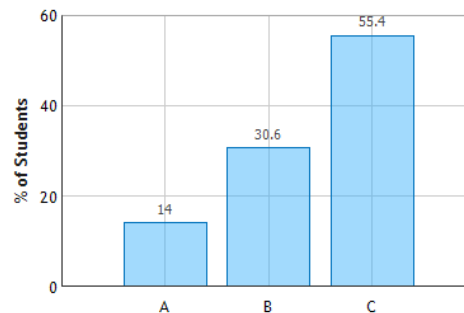


If the object is farther than focal length it will reflect an inverted image.



If the object is closer than focal length it will produce a virtual upright image.

Images from Mirrors: Question 1 (N = 800)

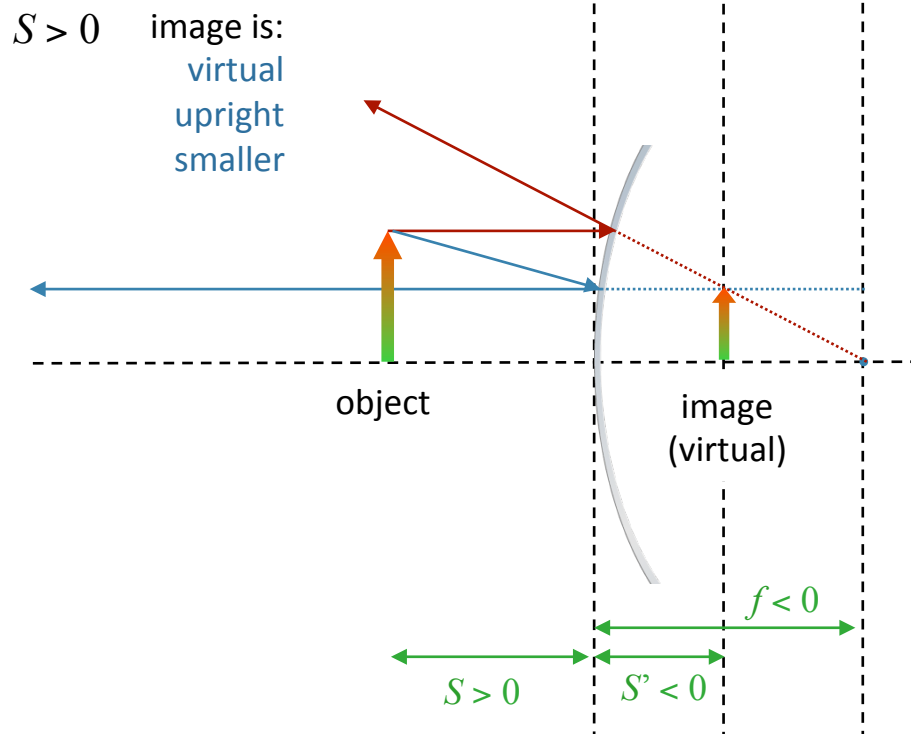


Checkpoint 2b

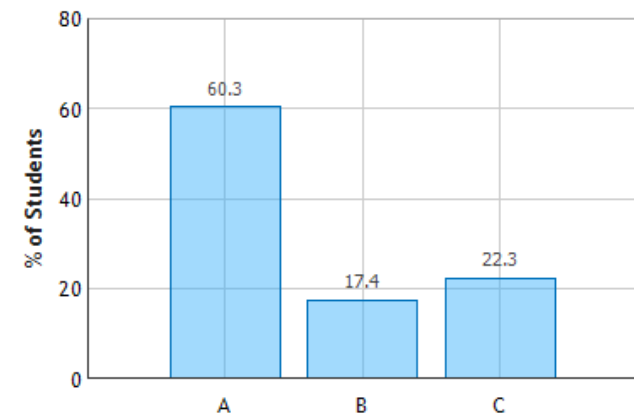


The image produced by a convex mirror of a real object is

- A. Always upright
- B. Always inverted
- C. Sometimes upright & sometimes inverted

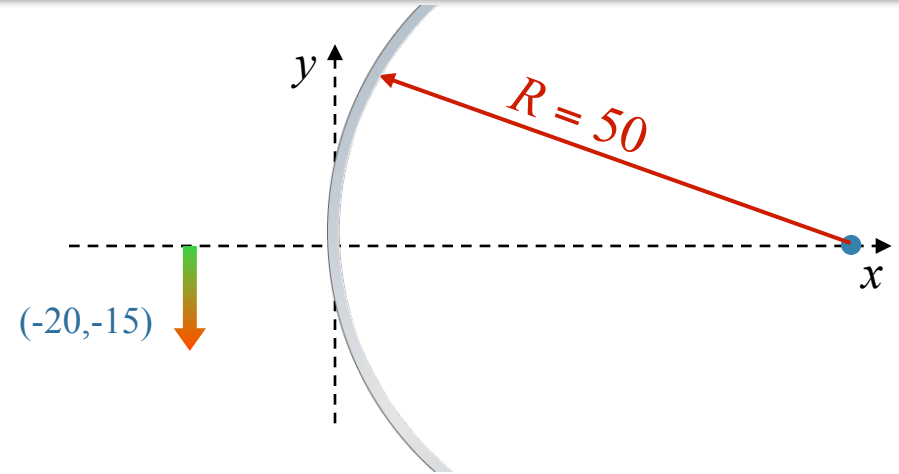


Images from Mirrors: Question 3 (N = 801)



Calculation

An arrow is located in front of a convex spherical mirror of radius $R = 50\text{cm}$. The tip of the arrow is located at $(-20\text{cm}, -15\text{cm})$.



Where is the tip of the arrow's image?

Conceptual Analysis

Mirror Equation: $1/s + 1/s' = 1/f$

Magnification: $M = -s' / s$

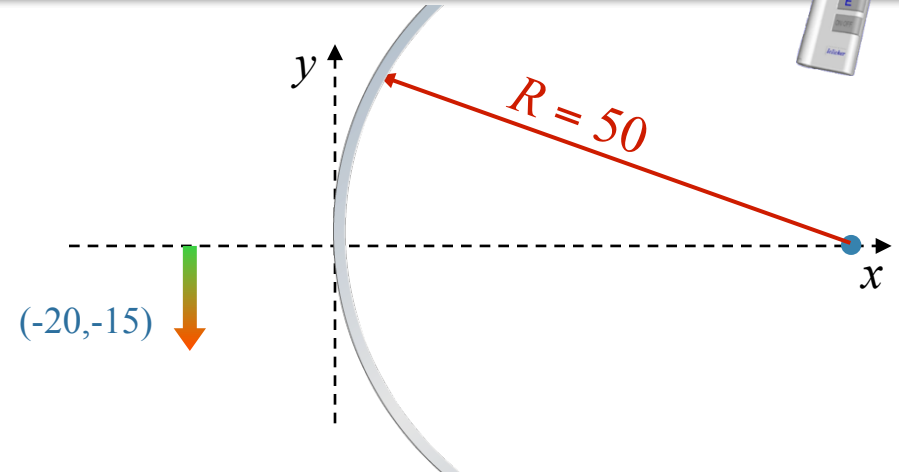
Strategic Analysis

Use mirror equation to figure out the x coordinate of the image

Use the magnification equation to figure out the y coordinate of the tip of the image

Calculation

An arrow is located in front of a convex spherical mirror of radius $R = 50\text{cm}$. The tip of the arrow is located at $(-20\text{cm}, -15\text{cm})$.

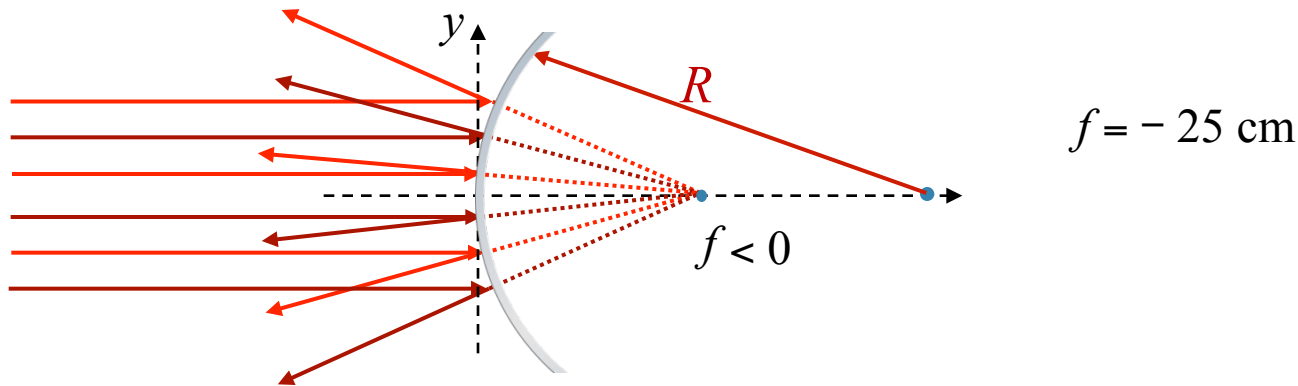


What is the focal length of the mirror?

- A) $f = 50\text{cm}$ B) $f = 25\text{cm}$ C) $f = -50\text{cm}$ **D) $f = -25\text{cm}$**

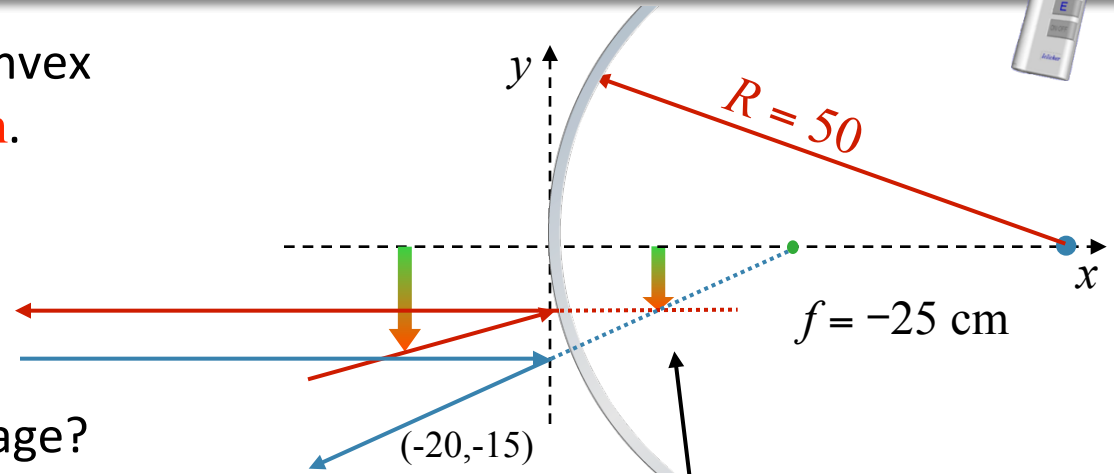
For a spherical mirror $|f| = R/2 = 25\text{cm}$.

Rule for sign: Positive on side of mirror where light goes after hitting mirror



Calculation

An arrow is located in front of a convex spherical mirror of radius $R = 50\text{cm}$. The tip of the arrow is located at $(-20\text{cm}, -15\text{cm})$.



What is the x coordinate of the image?

- A) 11.1 cm B) 22.5 cm C) -11.1 cm D) -22.5cm

Mirror
equation

$$\longrightarrow \frac{1}{s'} = \frac{1}{f} - \frac{1}{s}$$

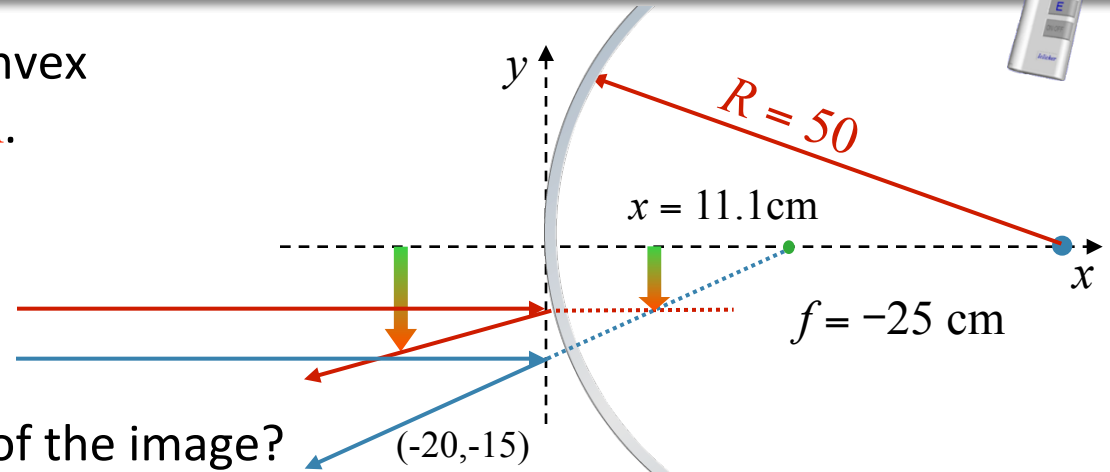
$$\longrightarrow s' = \frac{fs}{s - f} \quad \begin{array}{l} s = 20\text{ cm} \\ f = -25\text{ cm} \end{array}$$

$$\longrightarrow s' = \frac{(-25)(20)}{20 + 25} = -11.1\text{ cm}$$

Since $s' < 0$ the image is virtual (on the “other” side of the mirror)

Calculation

An arrow is located in front of a convex spherical mirror of radius $R = 50\text{cm}$. The tip of the arrow is located at $(-20\text{cm}, -15\text{cm})$.



What is the y coordinate of the tip of the image?

- A) -11.1 cm B) -10.7 cm C) -9.1 cm **D) -8.3cm**

Magnification equation $\rightarrow M = -\frac{S'}{S}$

$s = 20\text{ cm}$
 $s' = -11.1\text{ cm}$

$M = 0.556$

$$y_{\text{image}} = 0.55 y_{\text{object}} = 0.556 * (-15\text{ cm}) = -8.34\text{ cm}$$