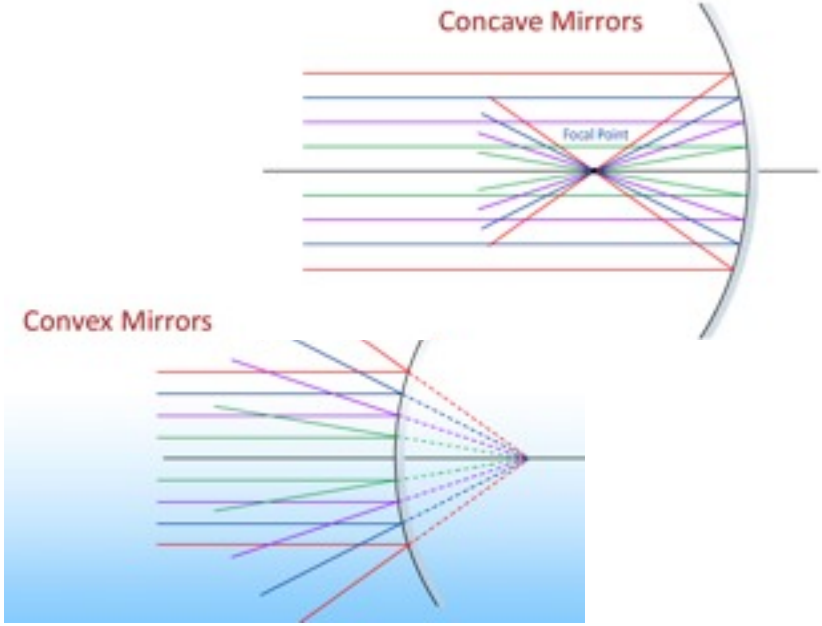
Physics 141
Lecture 27

Today's Concept:

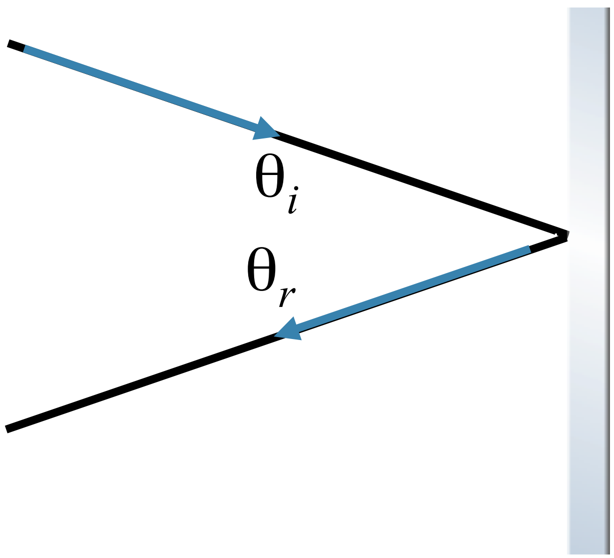
A) Mirrors



Reflection

Angle of incidence = Angle of reflection

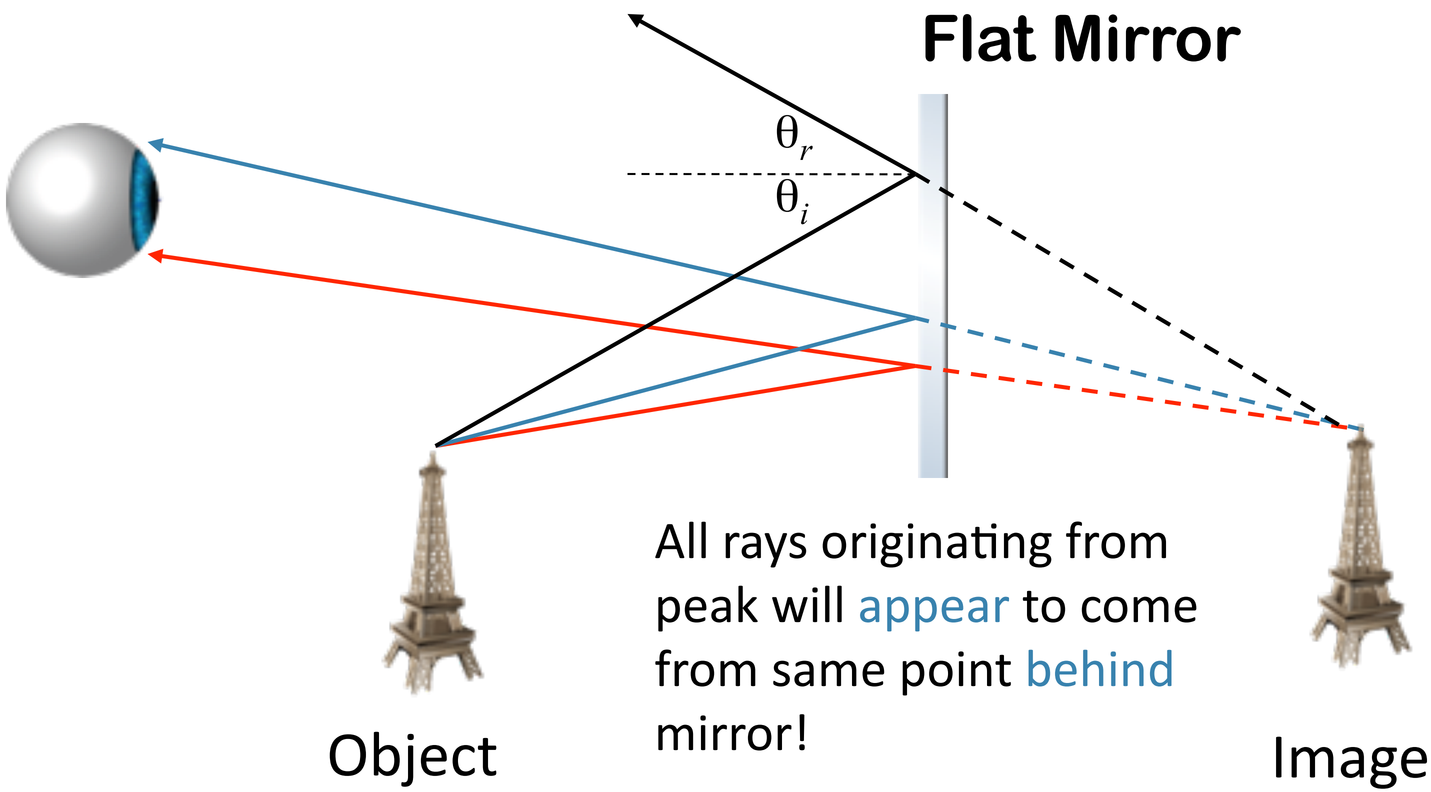
$$\theta_i = \theta_r$$



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

All you see is what reaches your eyes

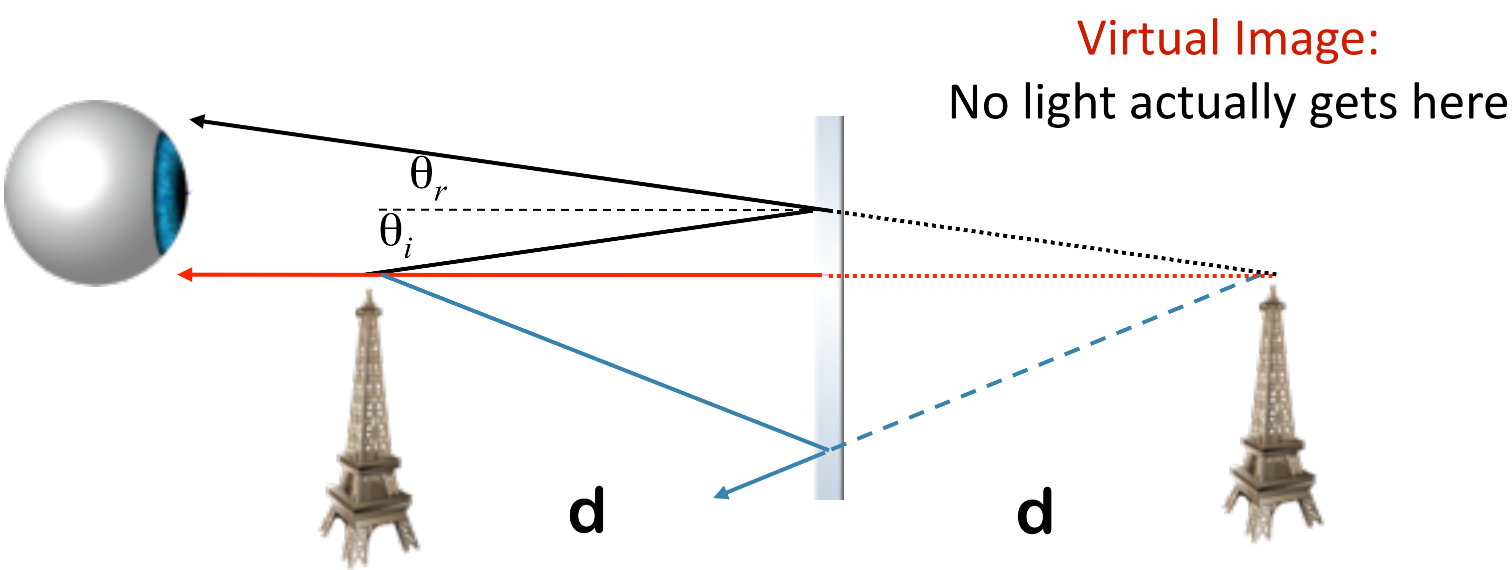
You think object's location is where rays appear to come from.



All rays originating from peak will appear to come from same point behind mirror!

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.

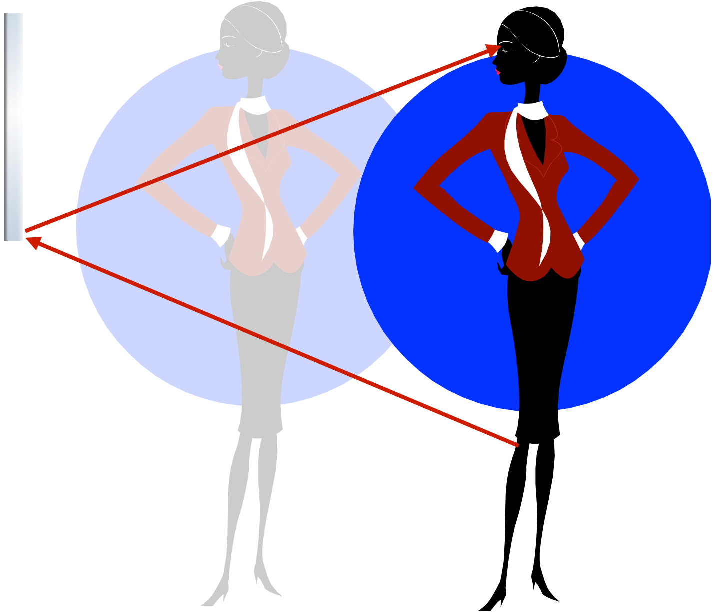


Clicker Question

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



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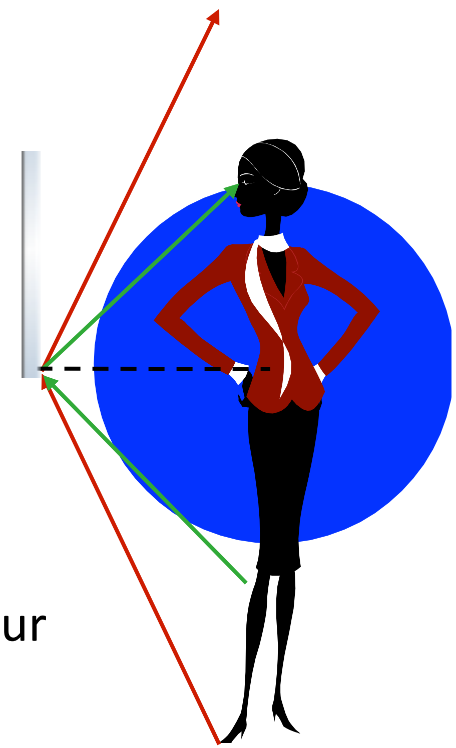
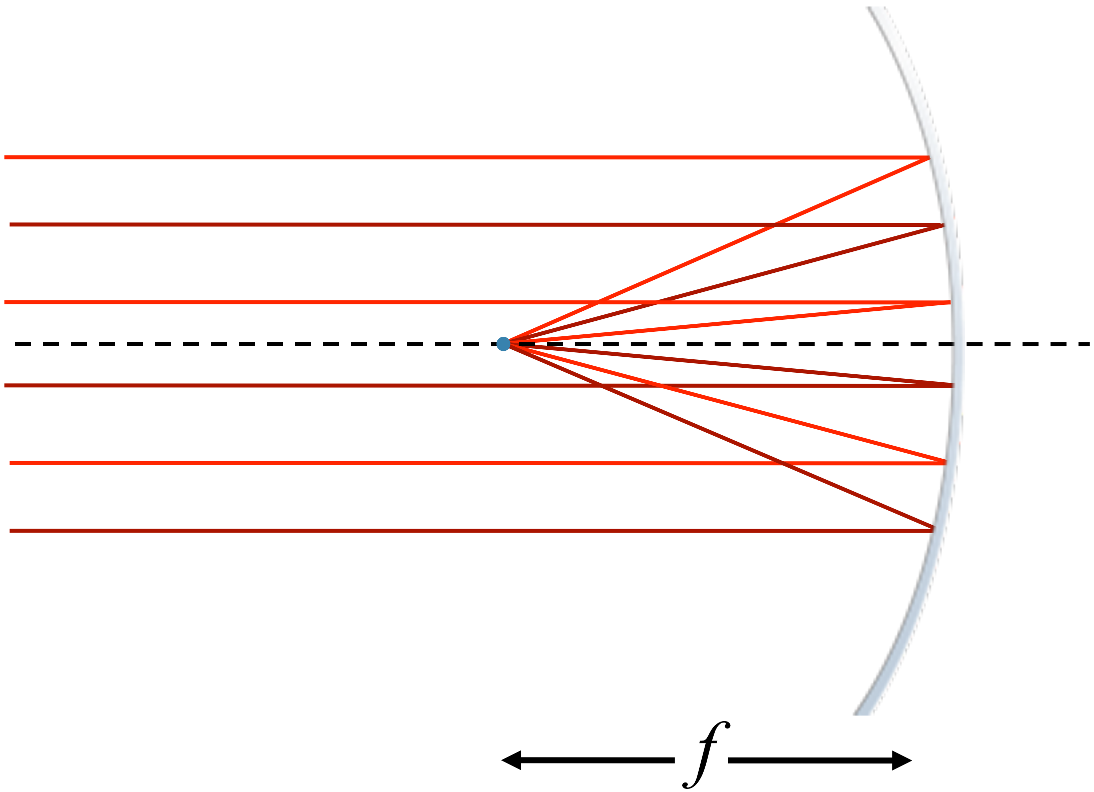


If the light doesn't get to your eye then you can't see it

You will also get Images from Curved Mirrors:

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

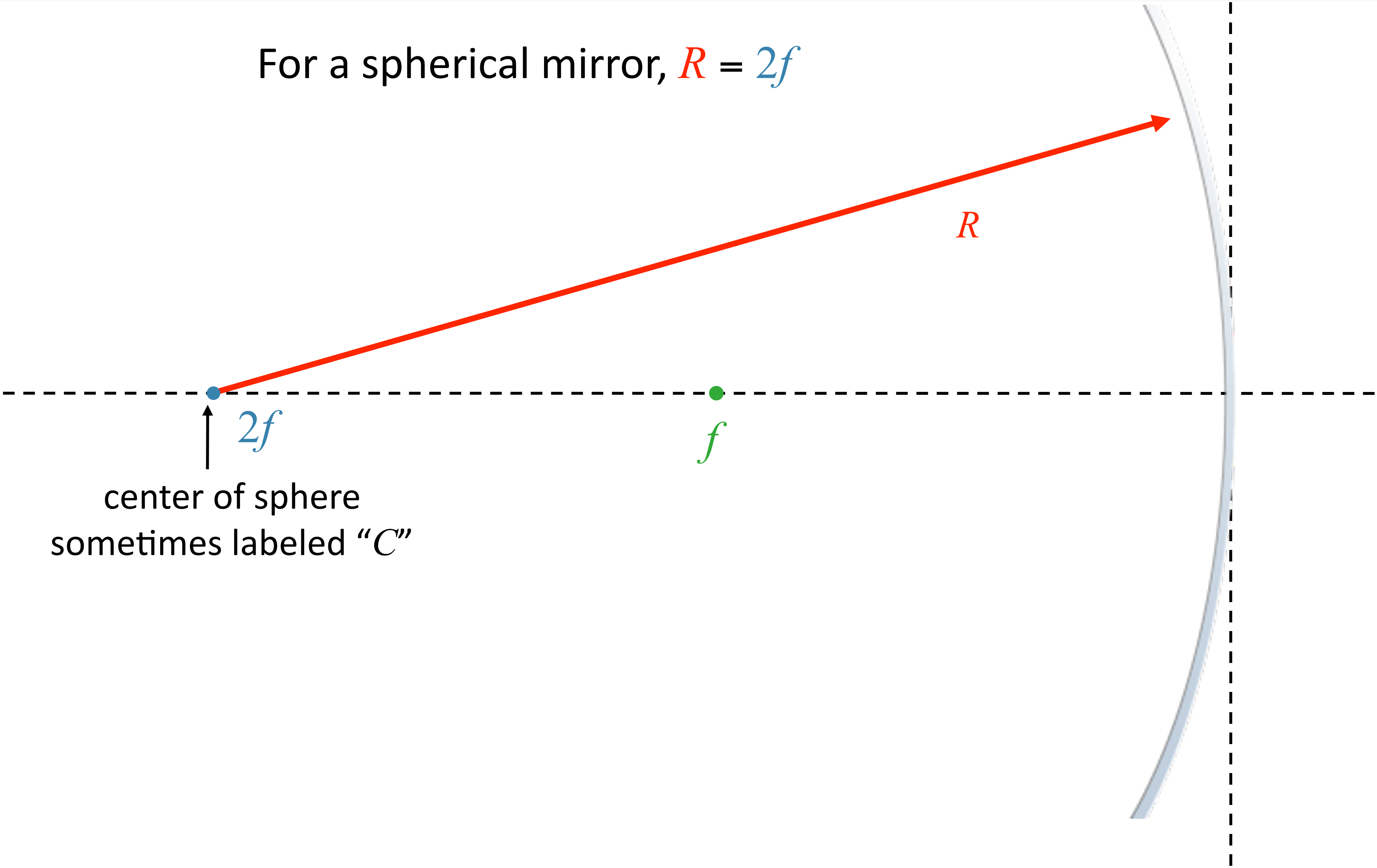


These mirrors are often sections of spheres (assumed in this class).

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

Aside:

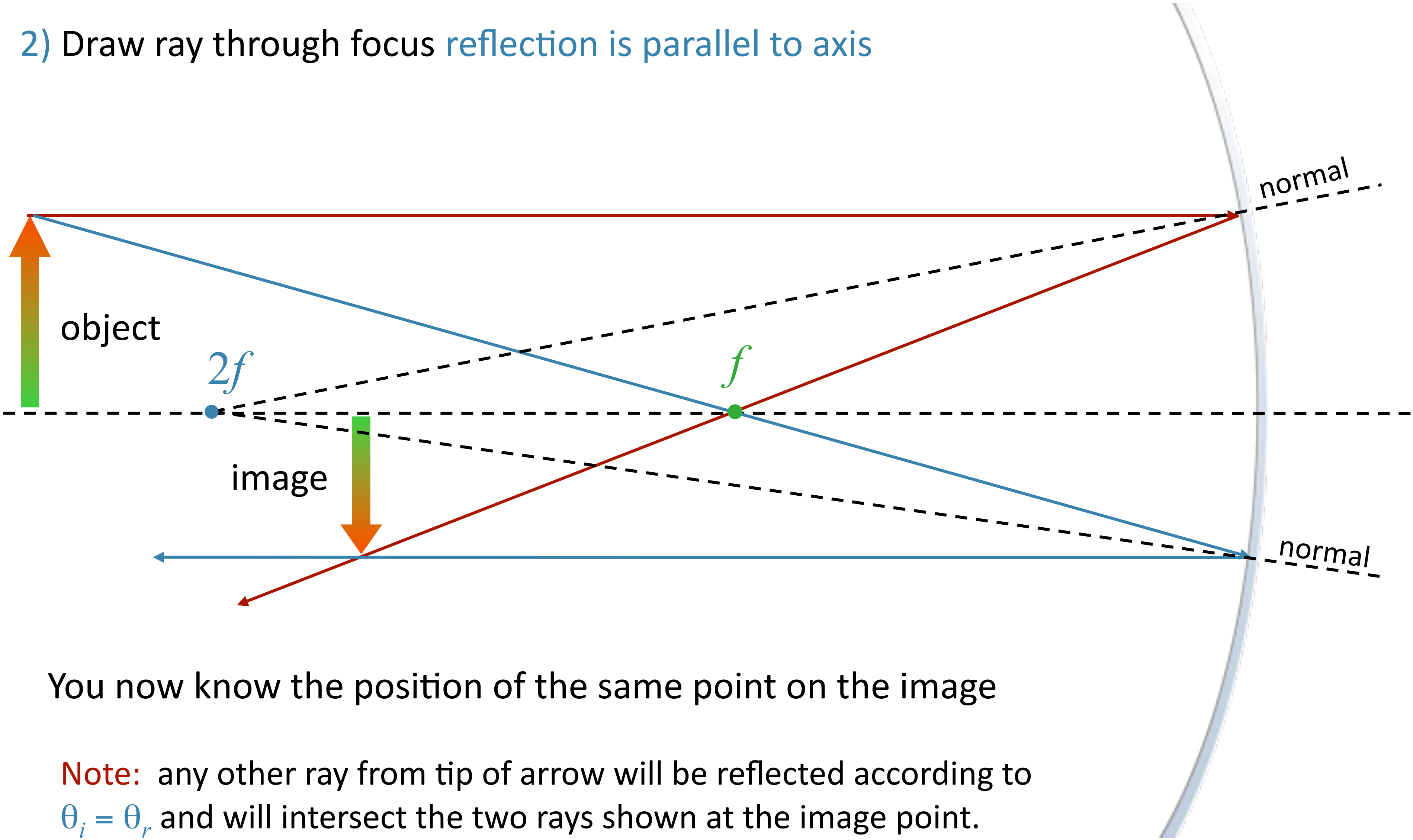
For a spherical mirror, $R = 2f$



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.

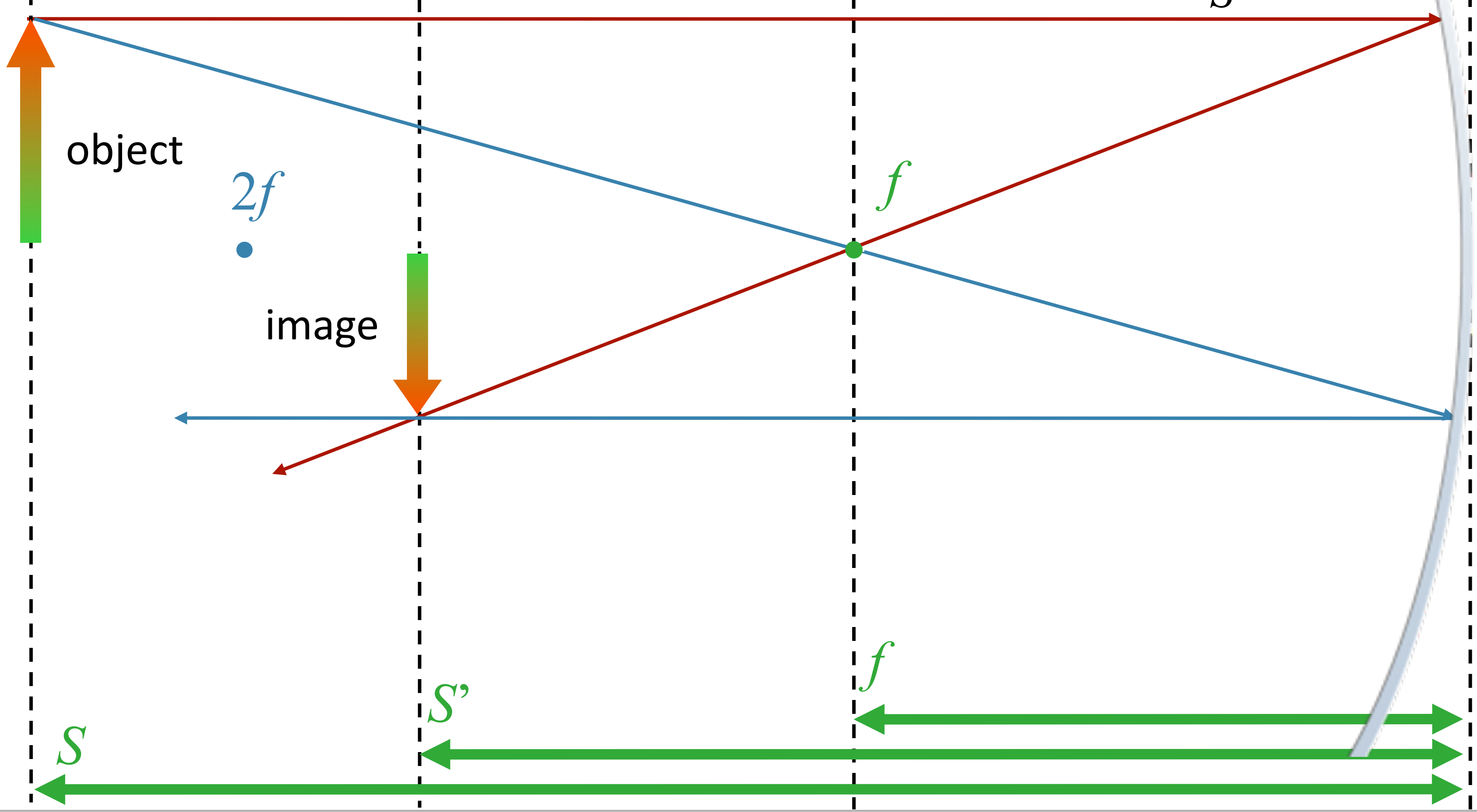
$S > 2f$

image is:
real
inverted
smaller

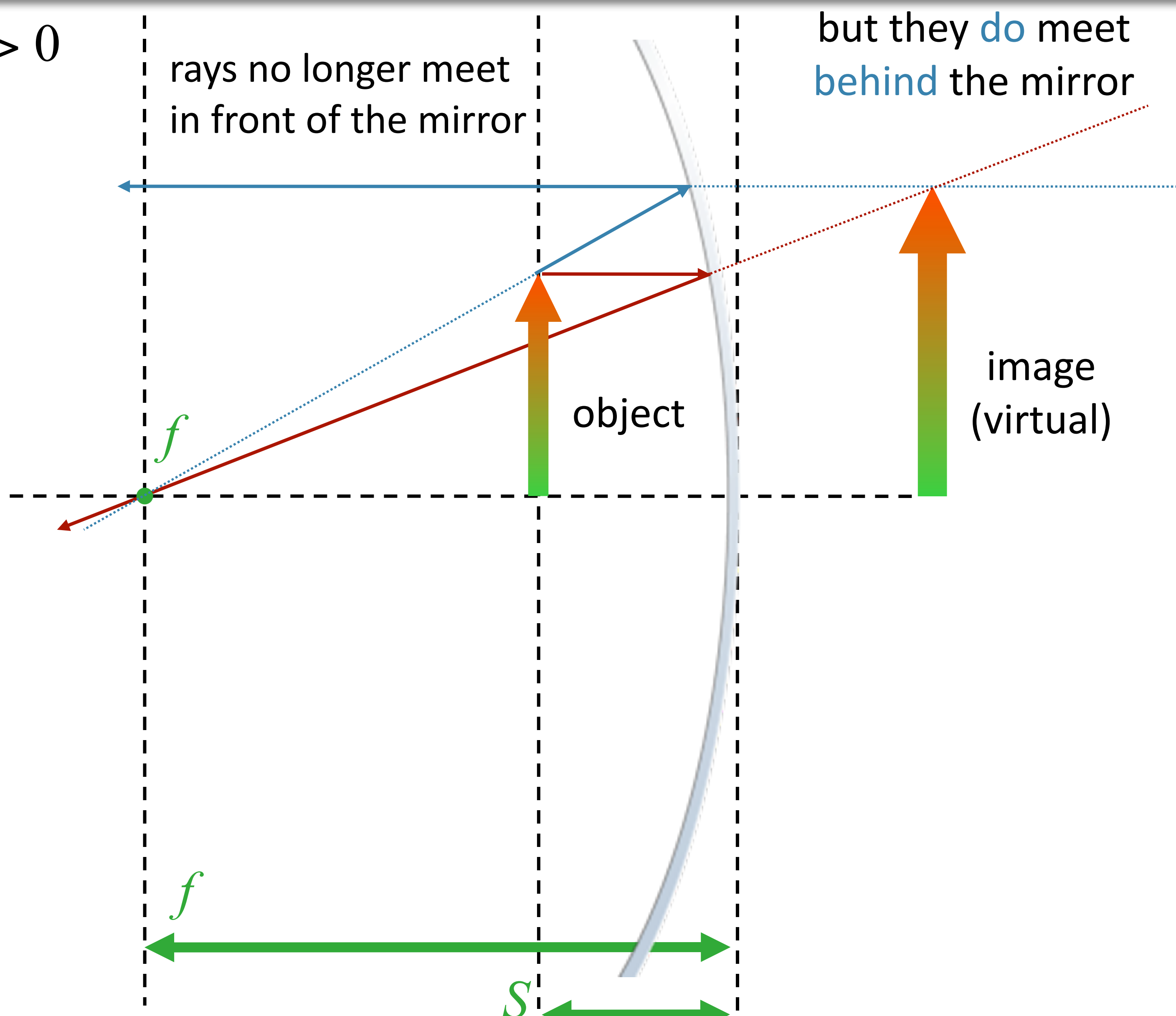
$f > 0$
$s > 0$
$s' > 0$

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

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

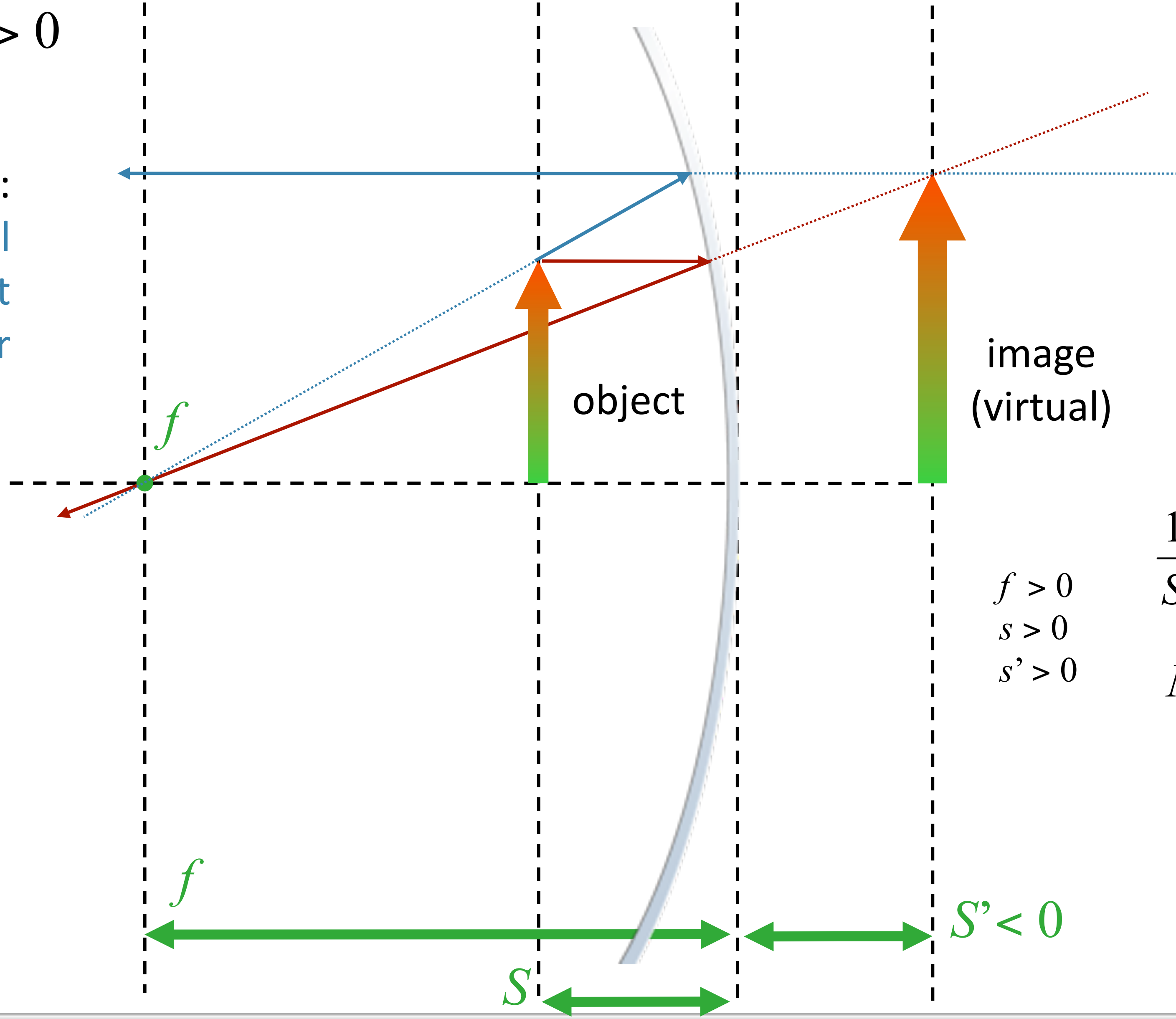


$f > S > 0$


rays no longer meet
in front of the mirror
but they do meet
behind the mirror
f
object
image
(virtual)
f
S

$f > S > 0$

image is:
virtual
upright
bigger



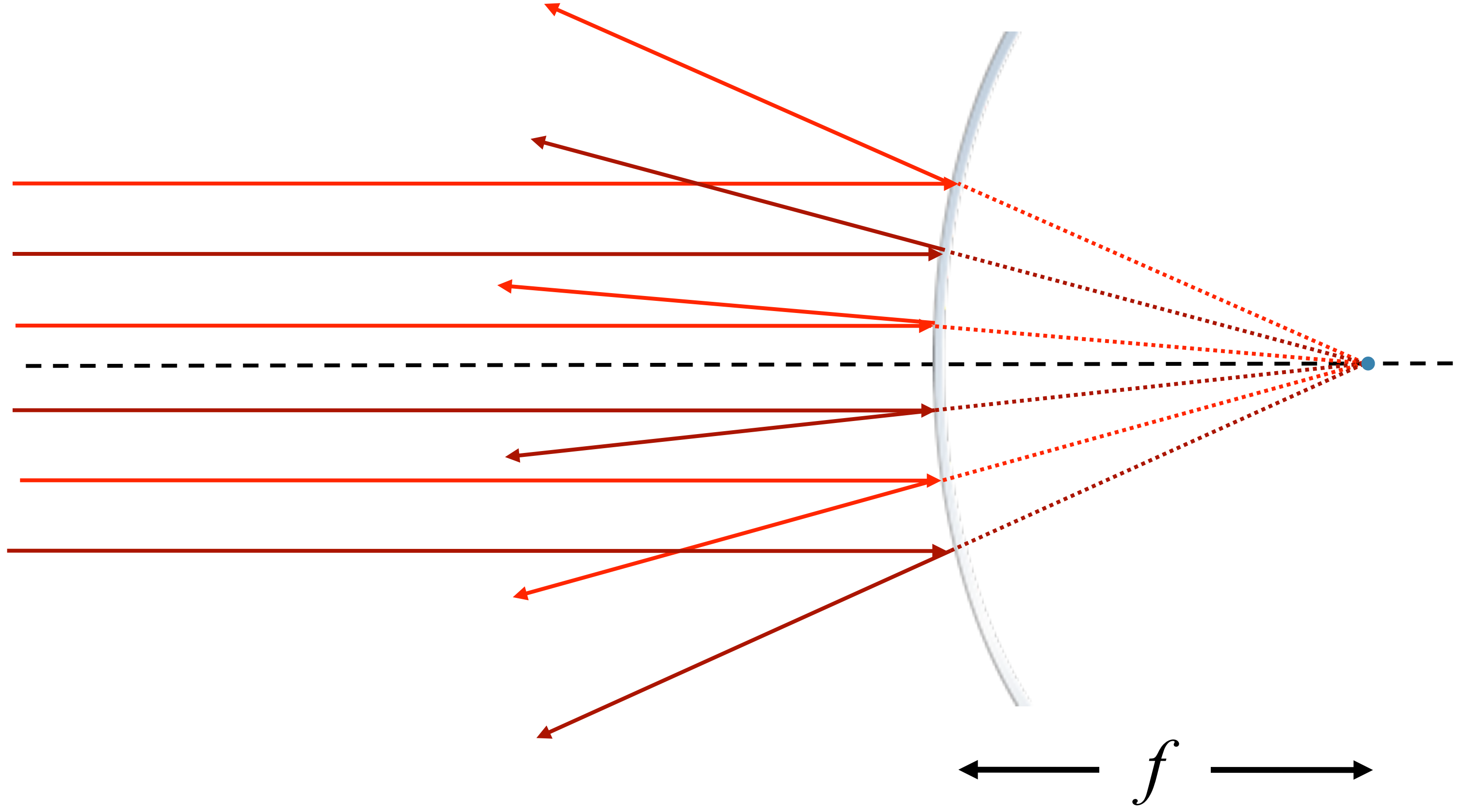
$f > 0$
$s > 0$
$s' > 0$

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

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

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



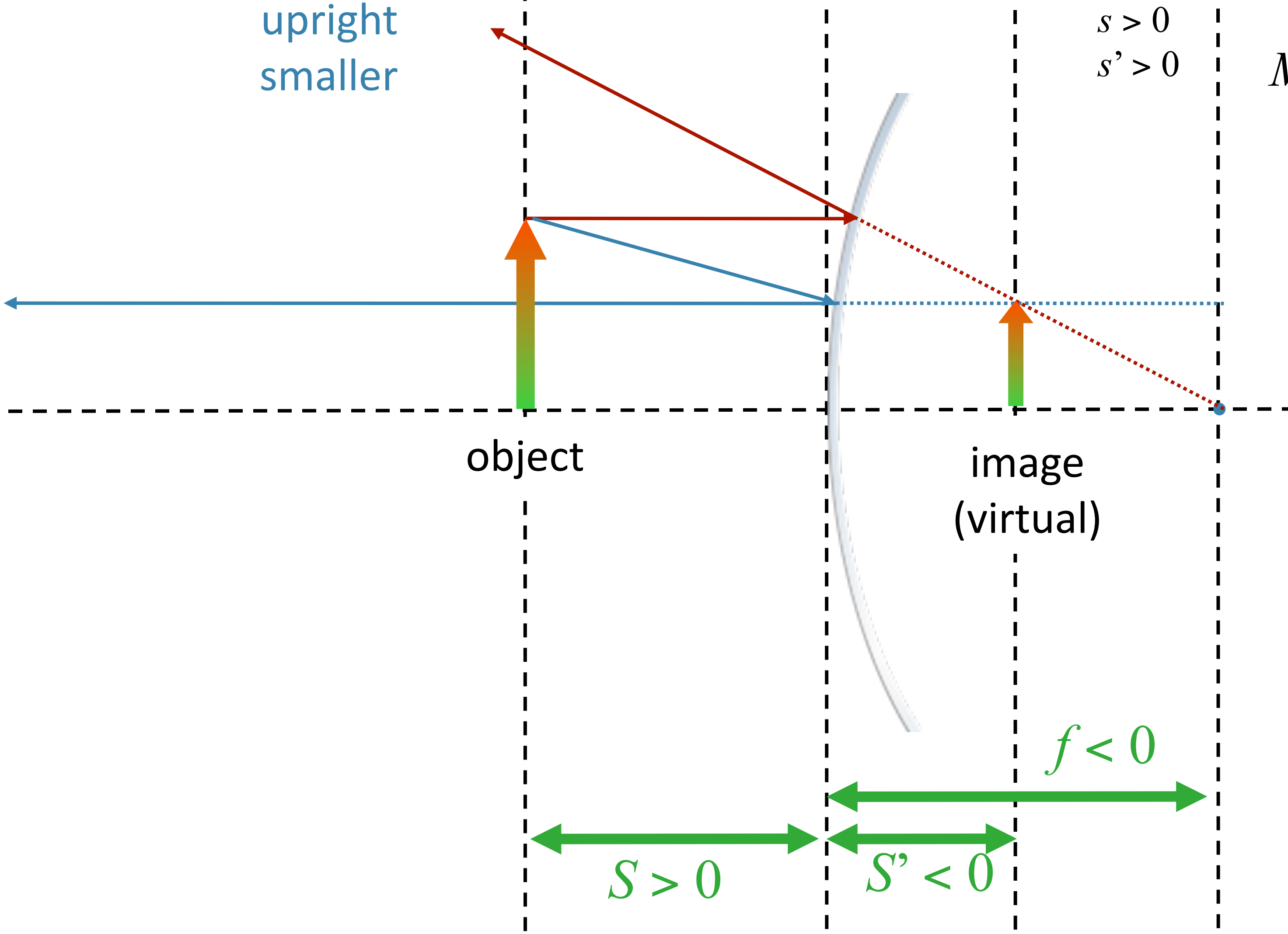
$S > 0$

image is:
virtual
upright
smaller

$f > 0$
$s > 0$
$s' > 0$

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

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



Executive Summary - Mirrors & Lenses:

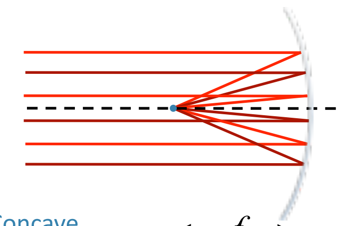
$S > 2f$ — real, inverted, smaller

$2f > S > f$ — real, inverted, bigger

$f > S > 0$ — virtual, upright, bigger

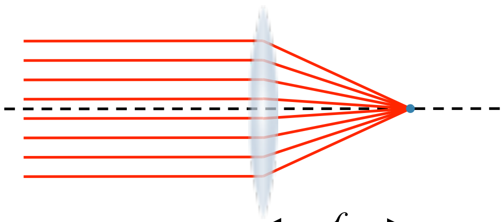
$S > 0$ — virtual, upright, smaller

$f > 0$



Concave (Converging)

$\leftarrow f \rightarrow$

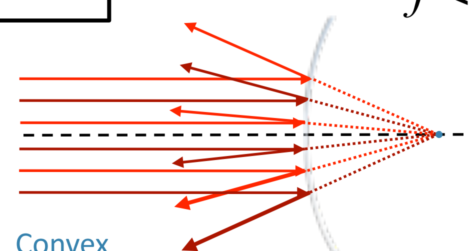


Converging

$\leftarrow f \rightarrow$

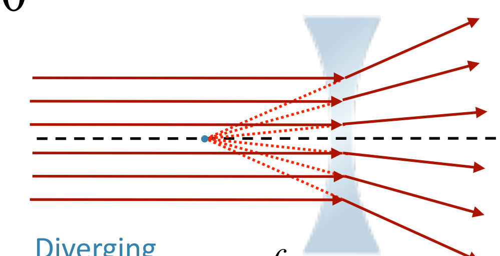
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M = -\frac{S'}{S}$$

$f < 0$



Convex (diverging)

$\leftarrow f \rightarrow$



Diverging

$\leftarrow f \rightarrow$

It's Always the Same:

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

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

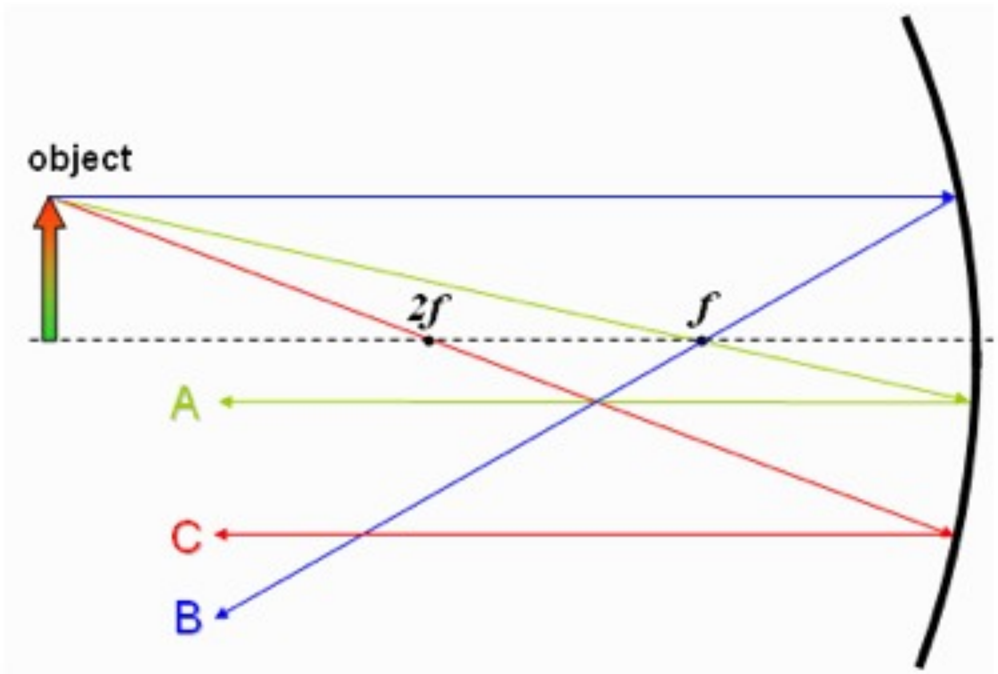
S: positive if object is "upstream" of mirror

S': positive if image is "upstream" of mirror

f: positive if converging mirror (concave)

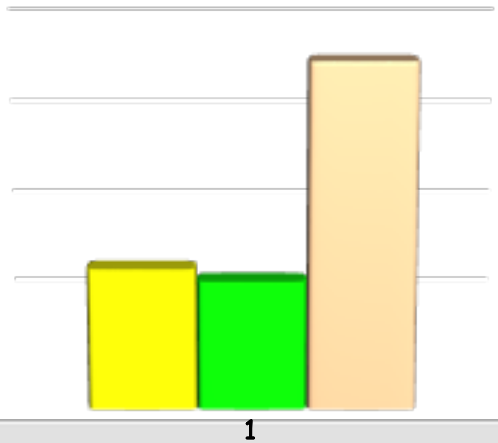
CheckPoint 2

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



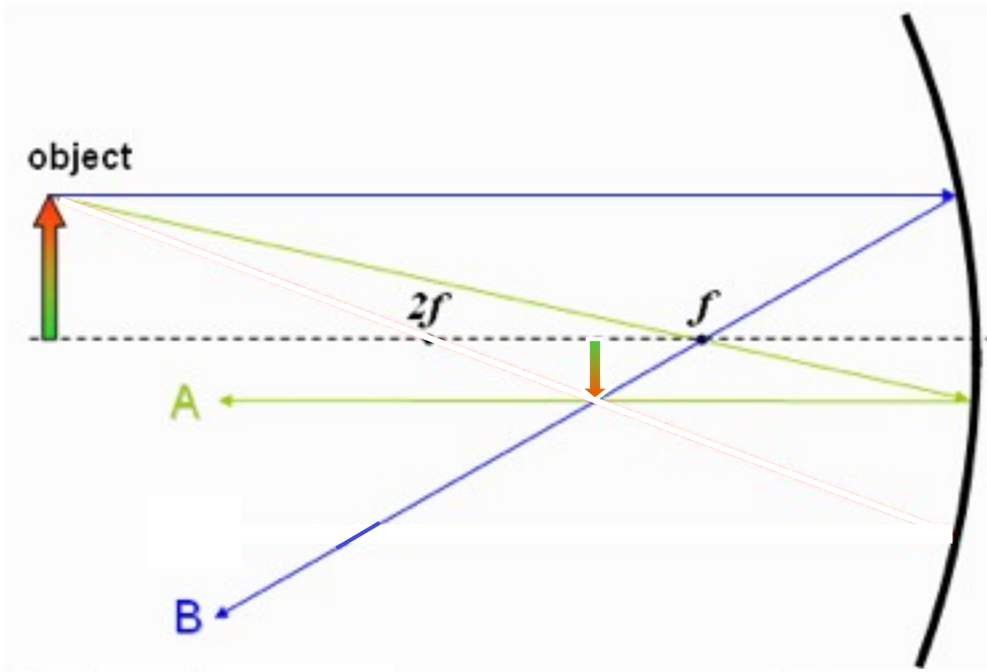
○A ○B ○C

C is not correct as it does not go through the focal point.



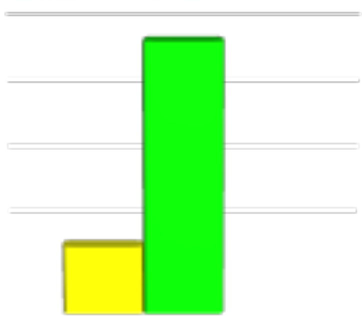
CheckPoints 4 & 5

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



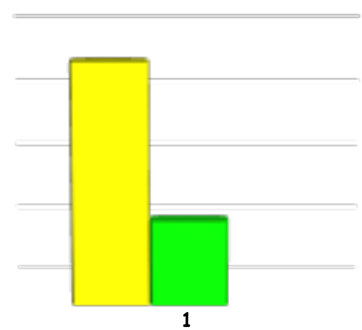
The image is

○ Upright ○ Inverted



The image is

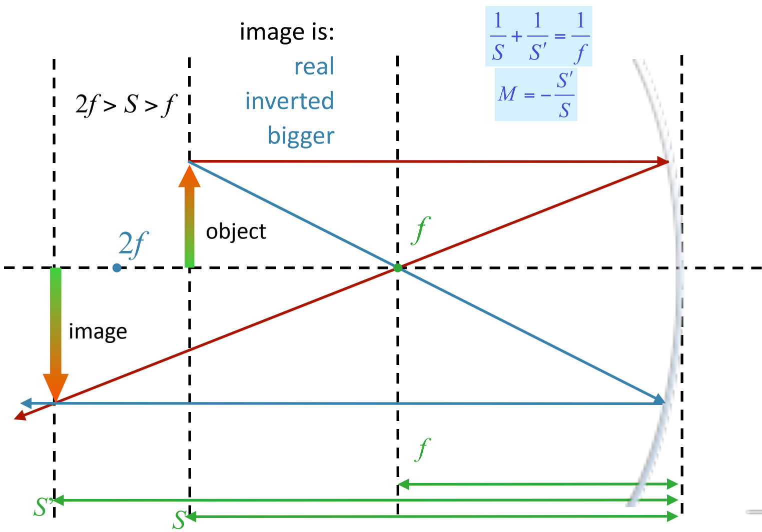
○ Reduced ○ Enlarged

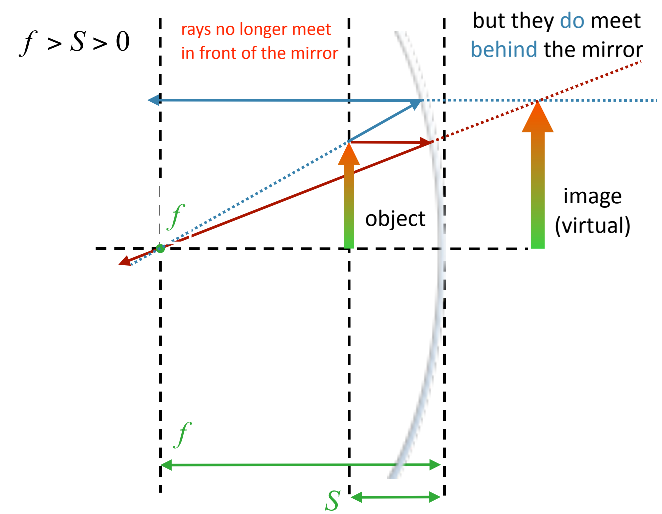


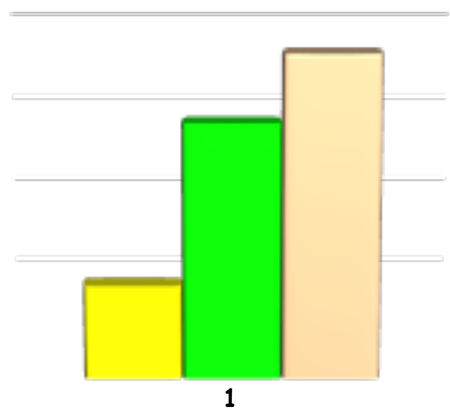
CheckPoint 7

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

- ○ always upright.
- ○ always inverted.
- ○ sometimes upright and sometimes inverted.







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

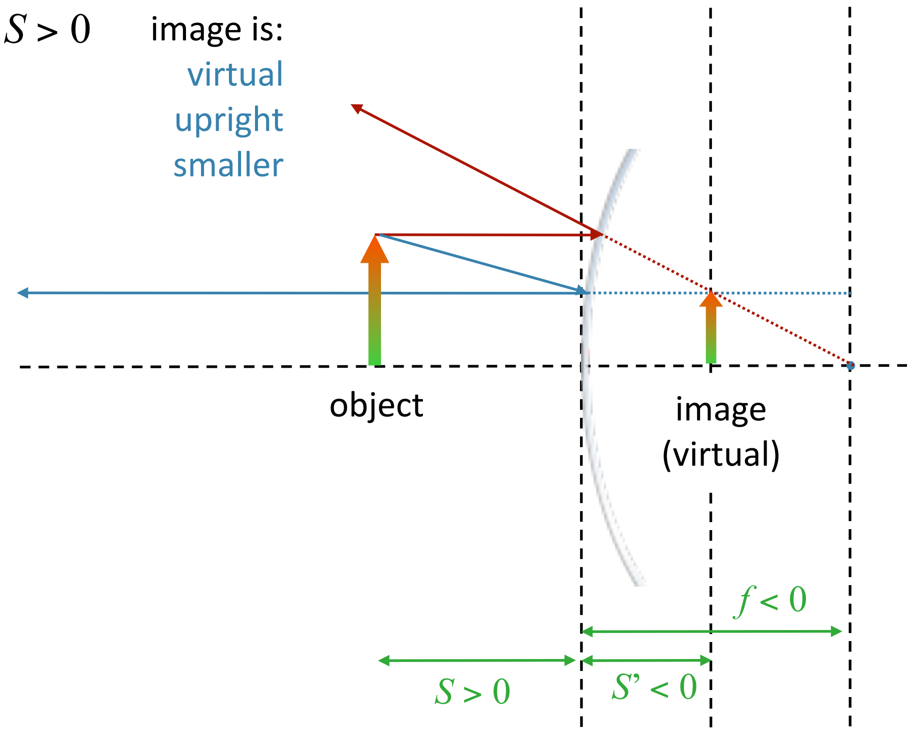
If the object is in front of the focal length it will produce a virtual upright image.

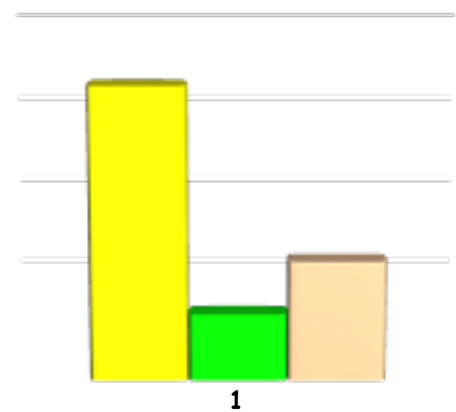
CheckPoint 9

9) **The image produced by a convex mirror of a real object is**

- ○ always upright.
- ○ always inverted.
- ○ sometimes upright and sometimes inverted.

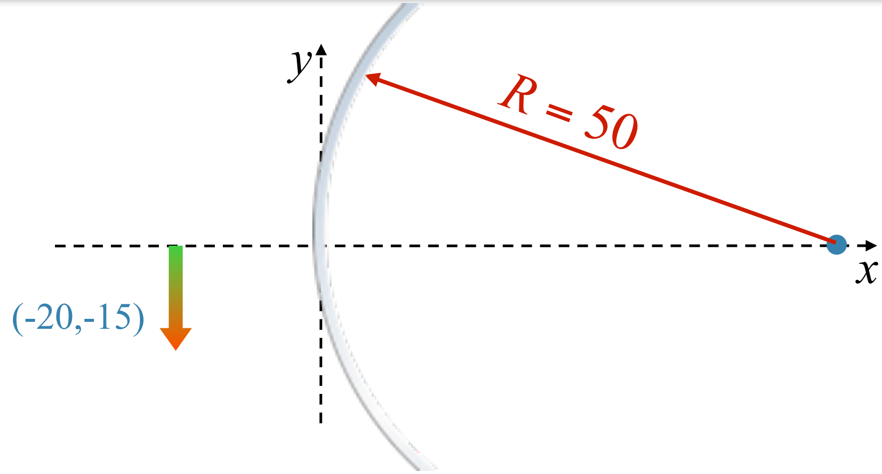
$S > 0$ image is:
virtual
upright
smaller





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: $M = -s'/s$

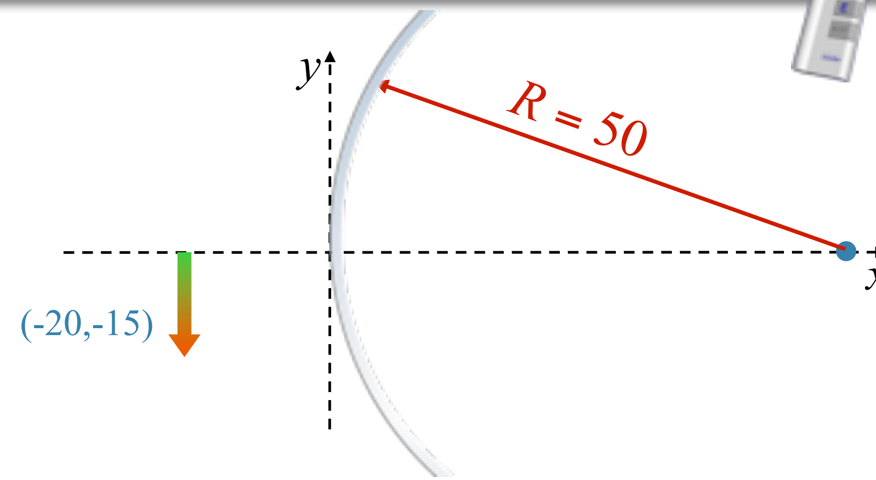
Strategic Analysis

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 $(-20\text{cm}, -15\text{cm})$.

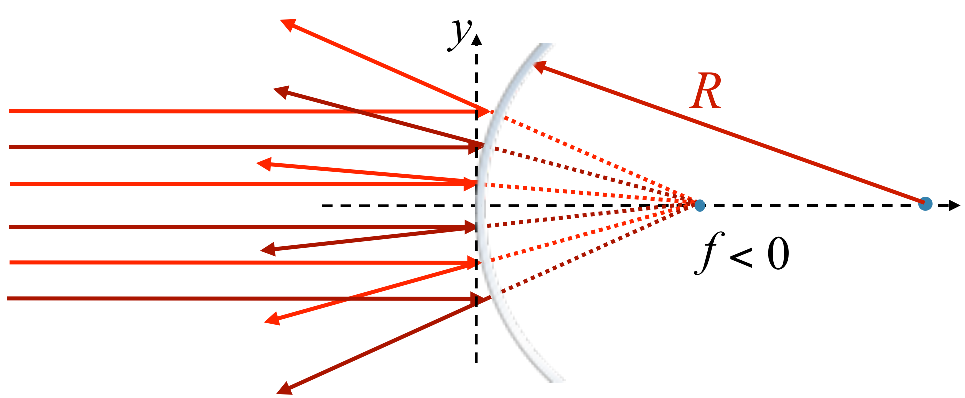


What is the focal length of the mirror?

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

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

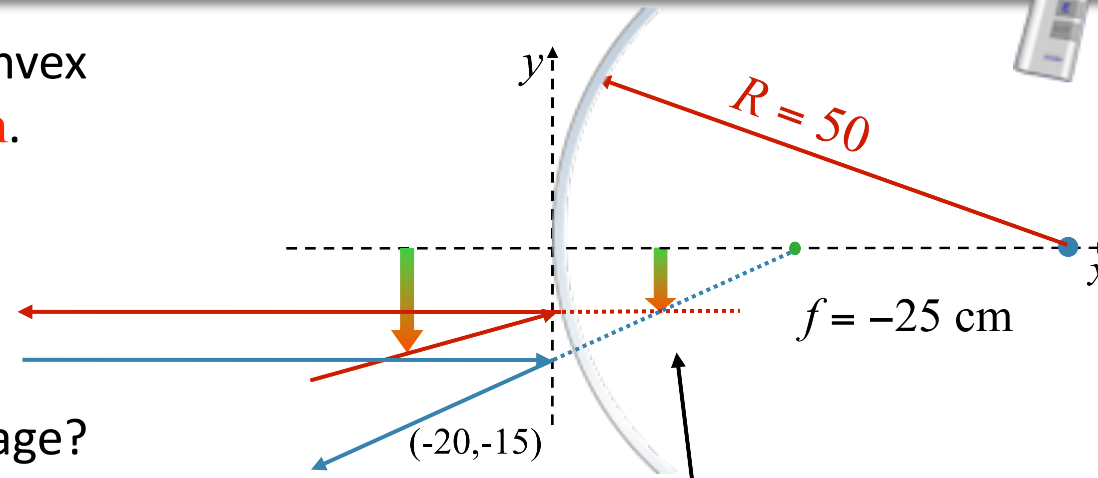
Rule for sign: Positive on side of mirror where light goes after hitting mirror



$f = -25$ cm

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 → $\frac{1}{S'} = \frac{1}{f} - \frac{1}{S}$

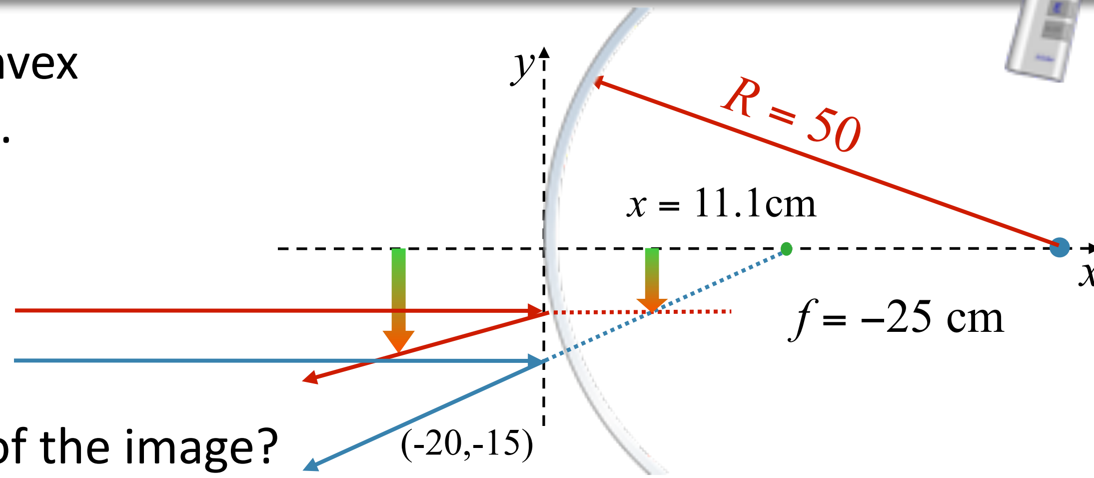
→ $S' = \frac{fS}{S - f}$ $s = 20\text{ cm}$ $f = -25\text{ cm}$

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

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 = 50cm. The tip of the arrow is located at (–20cm,–15cm).



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 → $M = -\frac{S'}{S}$

s = 20 cm

s' = –11.1 cm

} $M = 0.556$

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