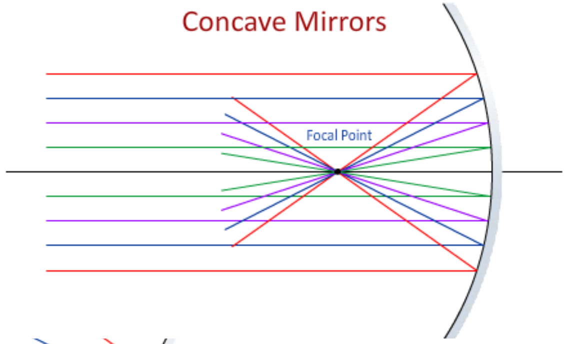
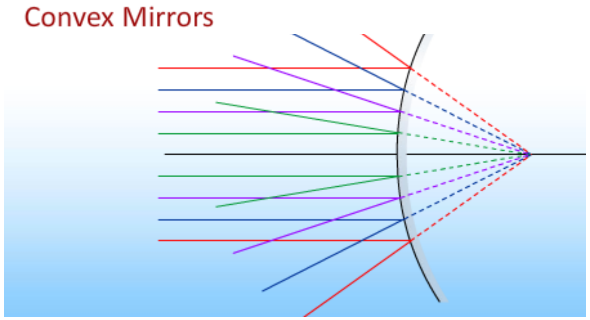
Physics 212
Lecture 27

Today's Concept:

Mirrors





Exam Tomorrow Night at 7:00

- Covers material in Lectures 17 – 25
- Bring your ID: Rooms determined by discussion section (see link)

Your Comments

Triangles everywhere!!! This can only mean one thing... ILLUMINATI CONFIRMED

its nice because mirrors are something we all probably have a lot of experience with. so we can just think about looking into the back or front of a spoon and think about what would happen to the picture if we moved it closer to or farther from our face.

I feel like this pre-lecture didn't give us much to...reflect...on.

I'm not sure I 100% understand what a 'virtual' image is. Does a concave mirror really form some sort of hologram or something in front of it? Or is it just some trick of the light?

Can we go over sign conventions? It's hard to keep track of all of the positives and negatives for mirrors and also for lenses

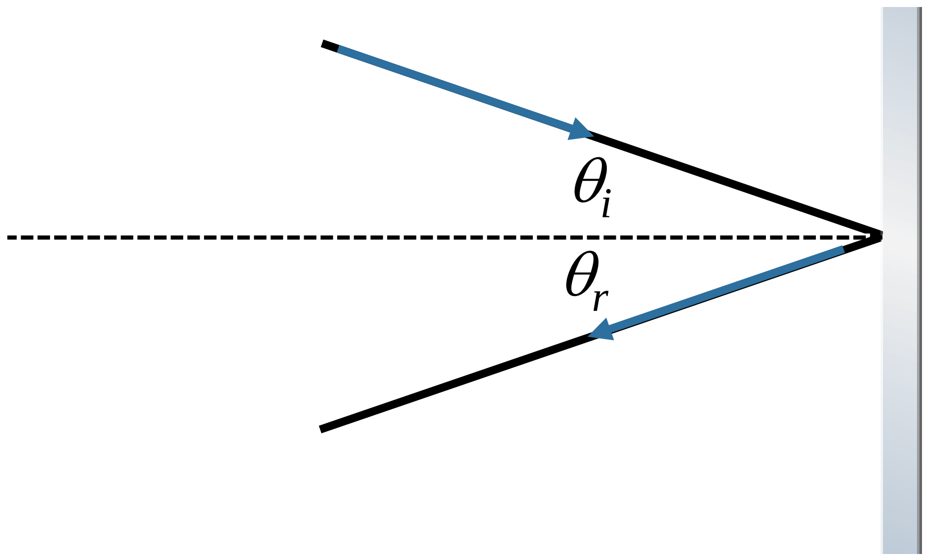
I found this awesome, short video on seeing without glasses. It ties right into optics and lenses, and I think it's really quite interesting.
https://www.youtube.com/watch?v=OydqR_7_DjI

Can you briefly cover how this relates to what we see? We now know where the light rays go, but can you talk about how we can perceive them and what we see from various perspectives with respect to lenses or mirrors?

Reflection

Angle of incidence = Angle of reflection

$$\theta_i = \theta_r$$

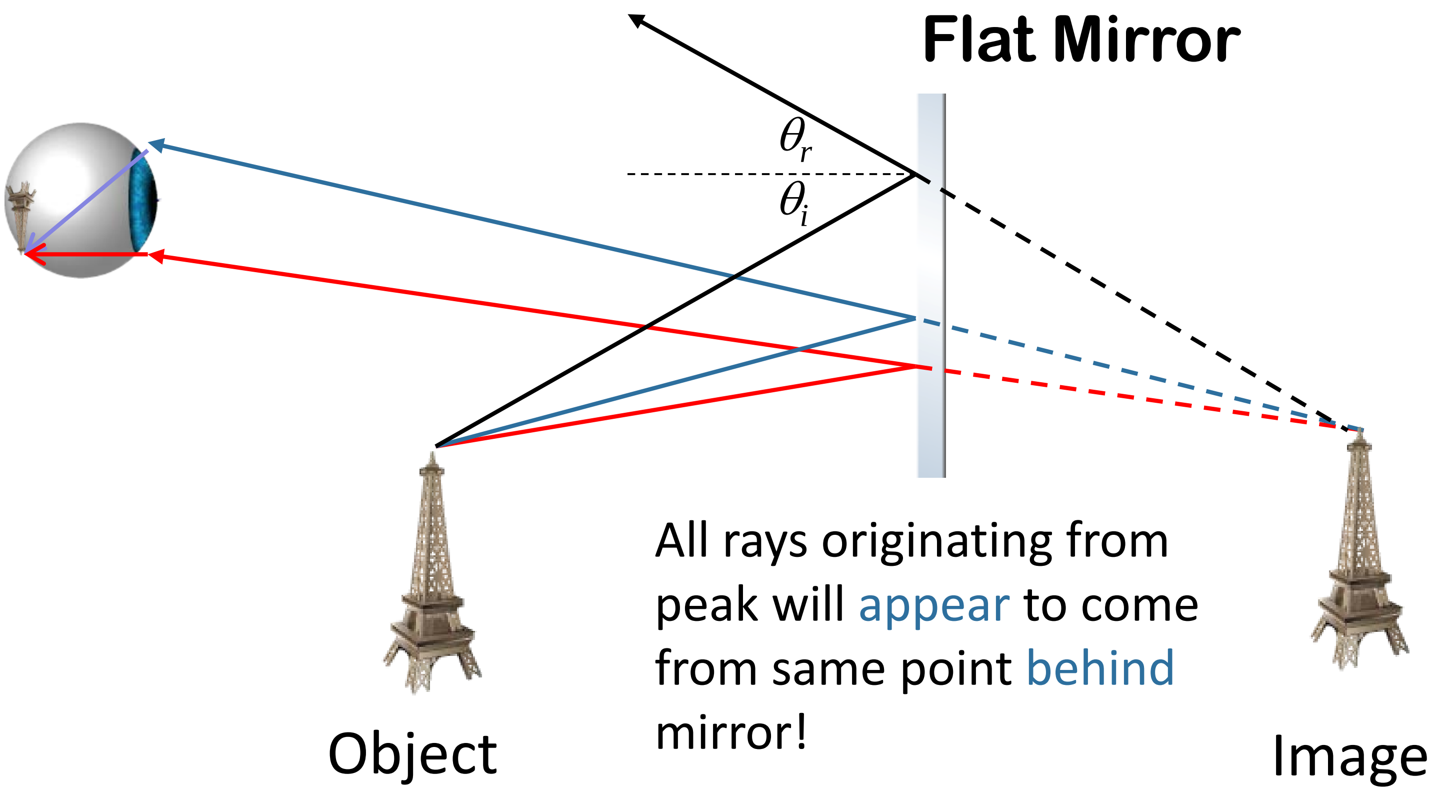


That's all of the physics – everything else is just geometry!

Flat Mirror

All you see is what reaches your eyes

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



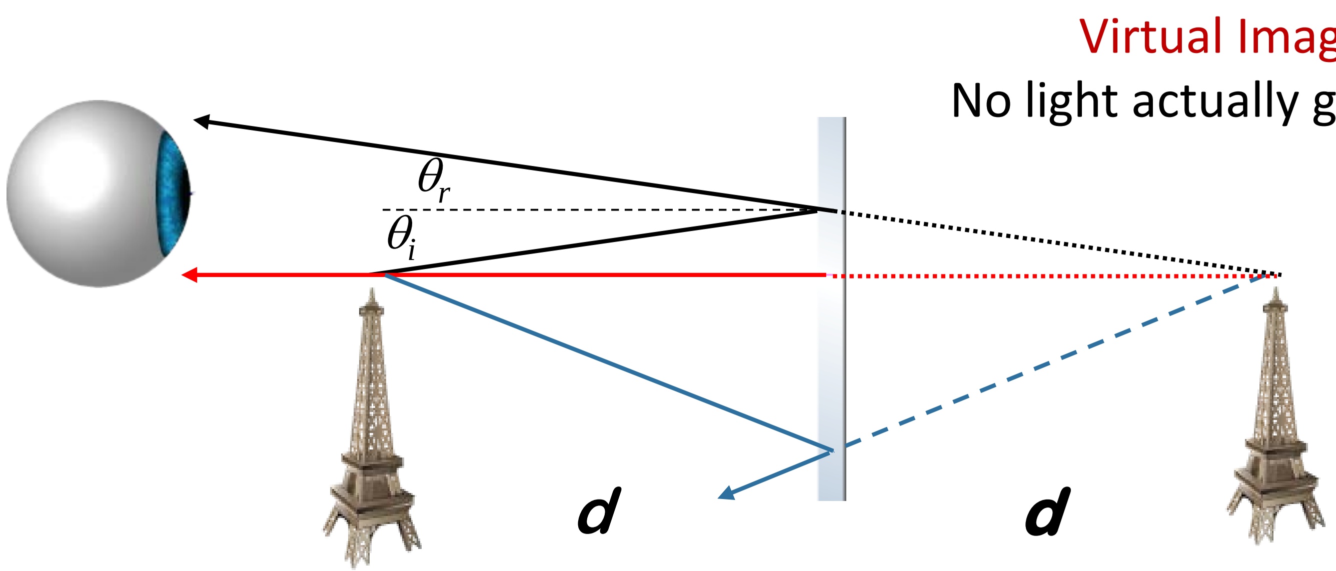
All rays originating from peak will appear to come from same point behind mirror!

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.

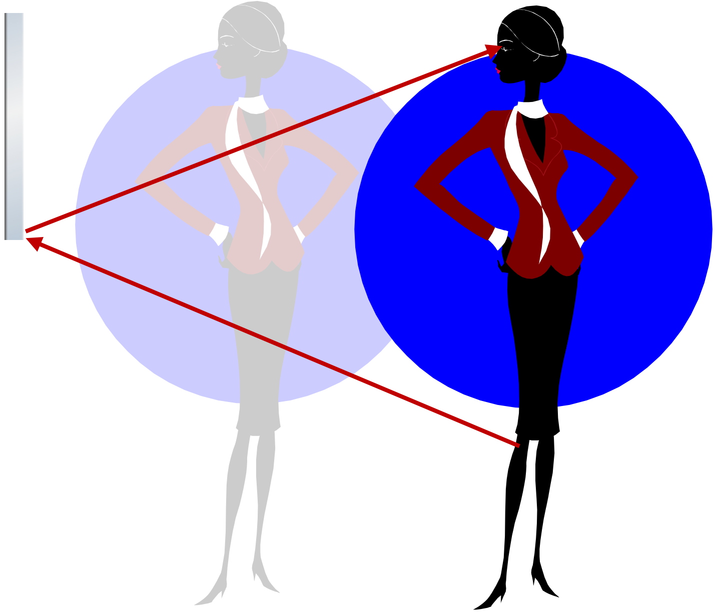


Clicker Question

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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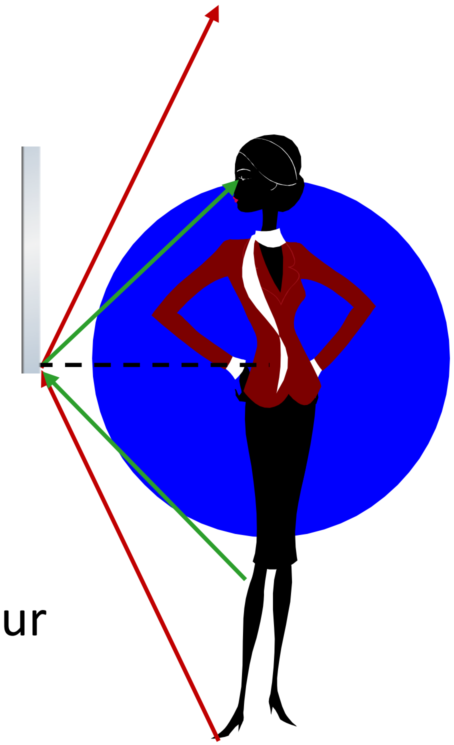
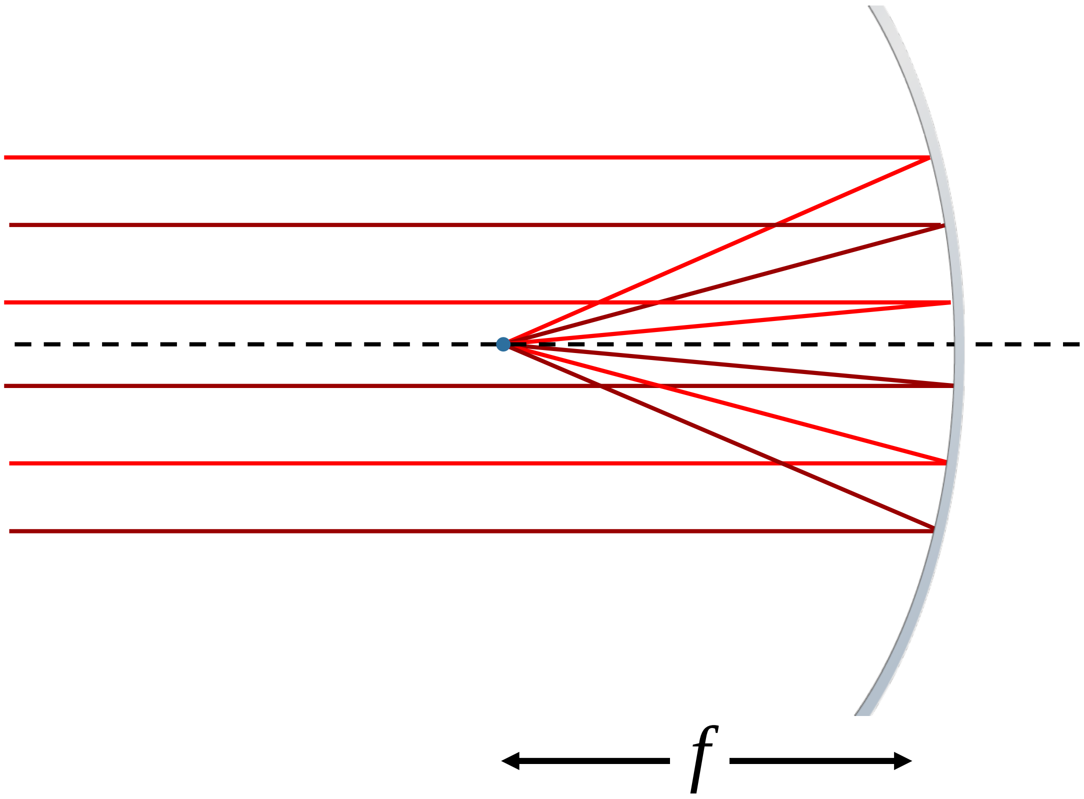


If the light doesn't get to your eye then you can't see it

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

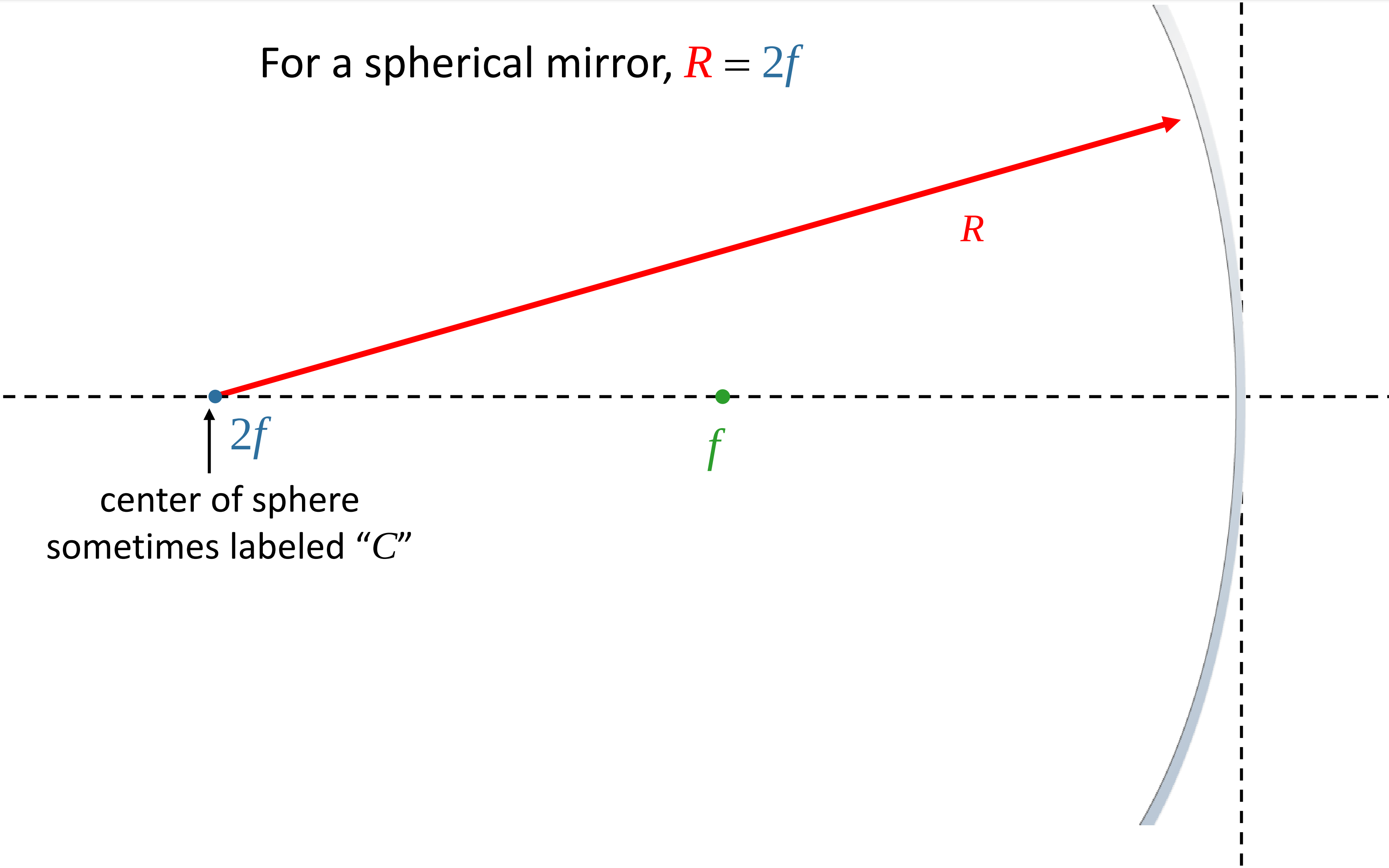


These mirrors are often sections of spheres (assumed in this class).

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

Aside:

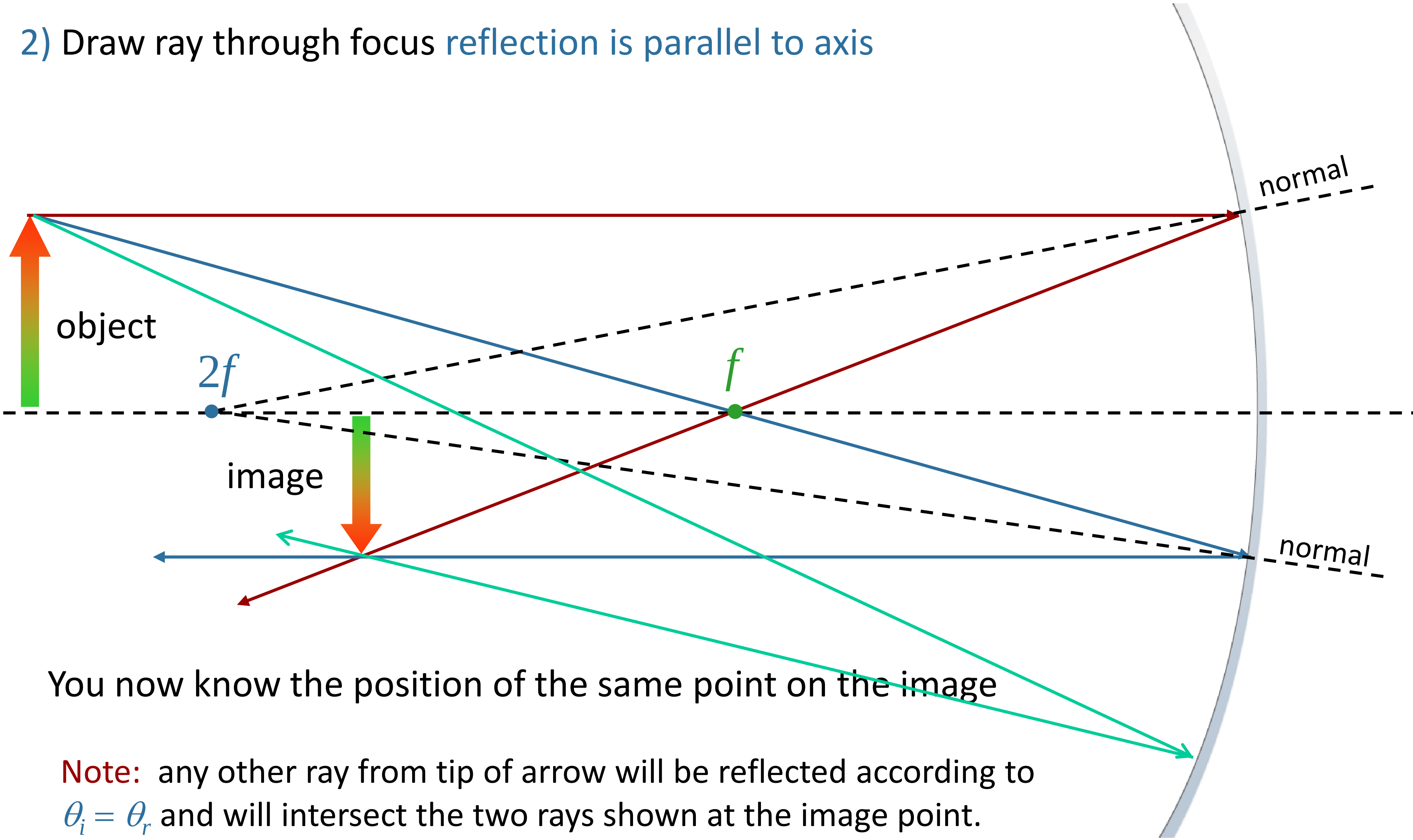
For a spherical mirror, $R = 2f$



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.

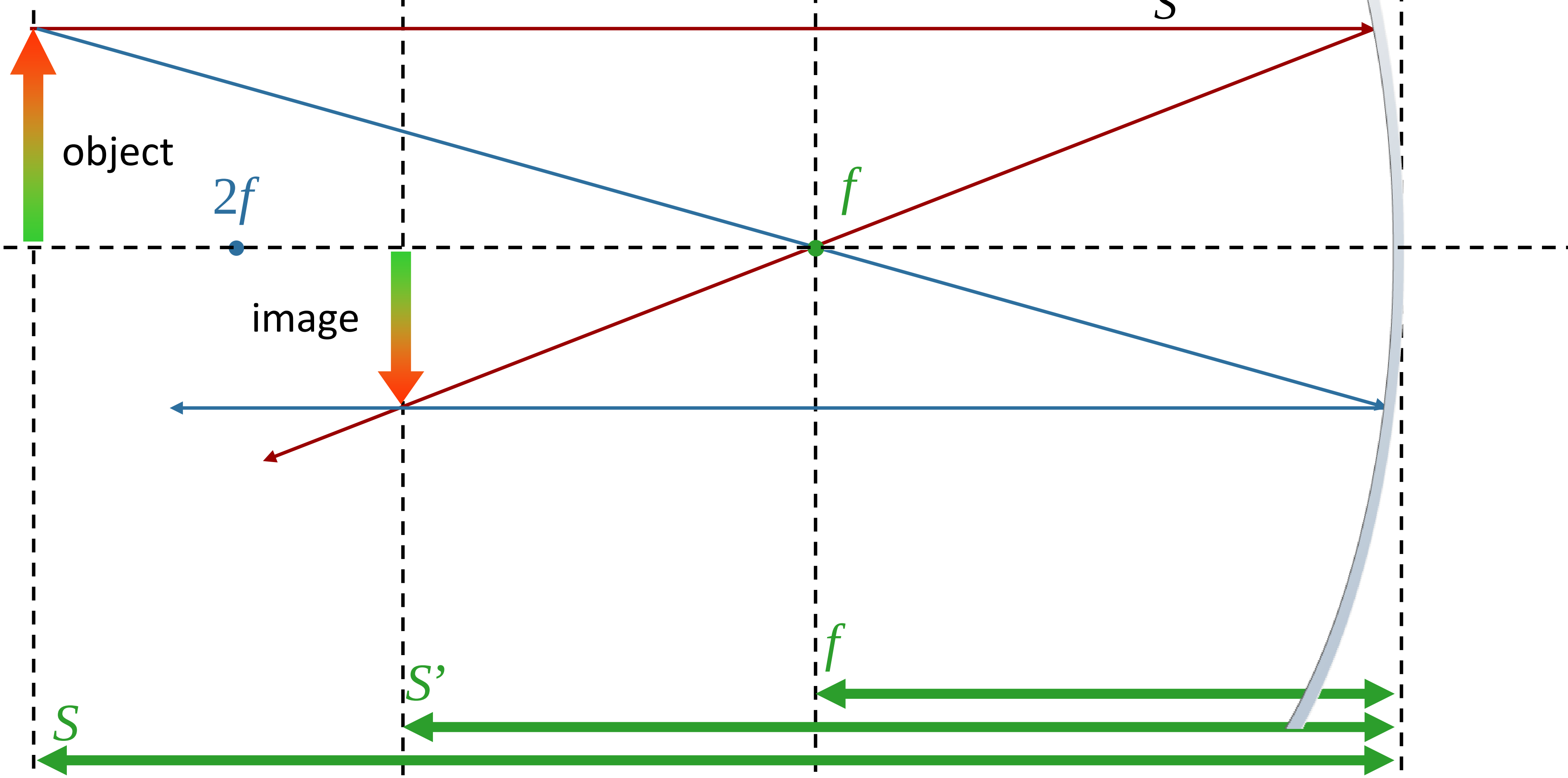
$$S > 2f$$

image is:
real
inverted
smaller

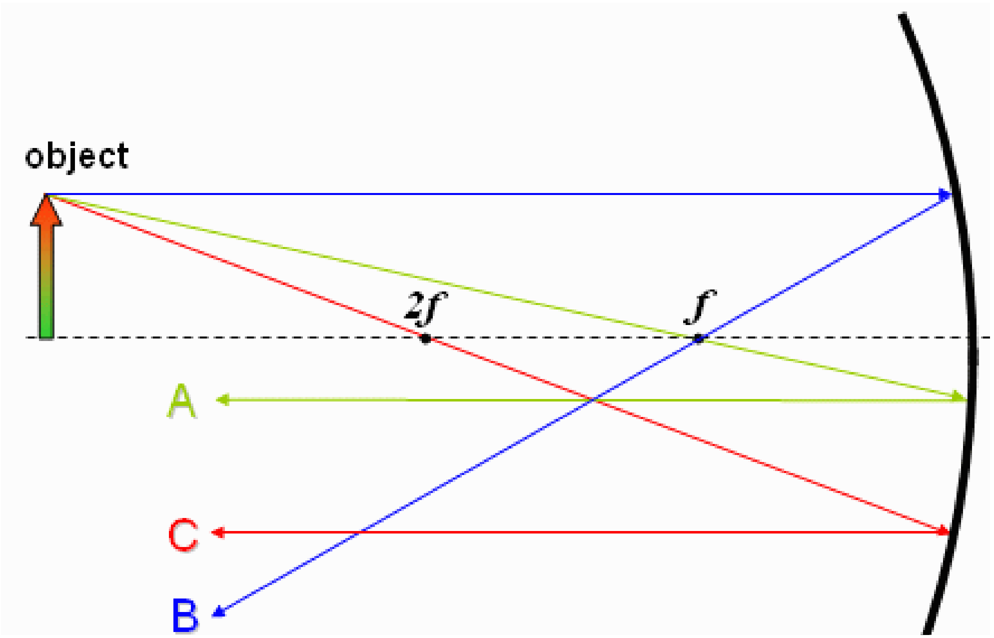
$f > 0$
$s > 0$
$s' > 0$

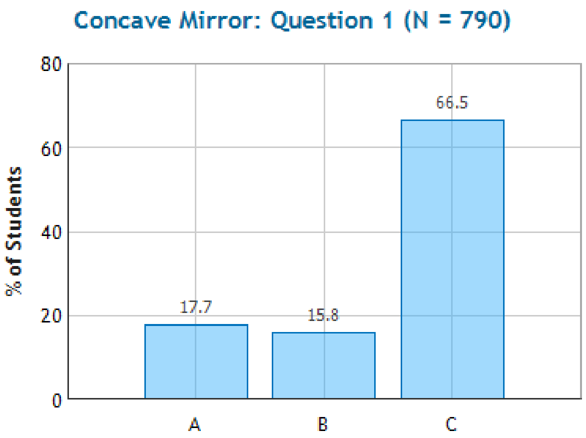
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f}$$

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



CheckPoint 1a



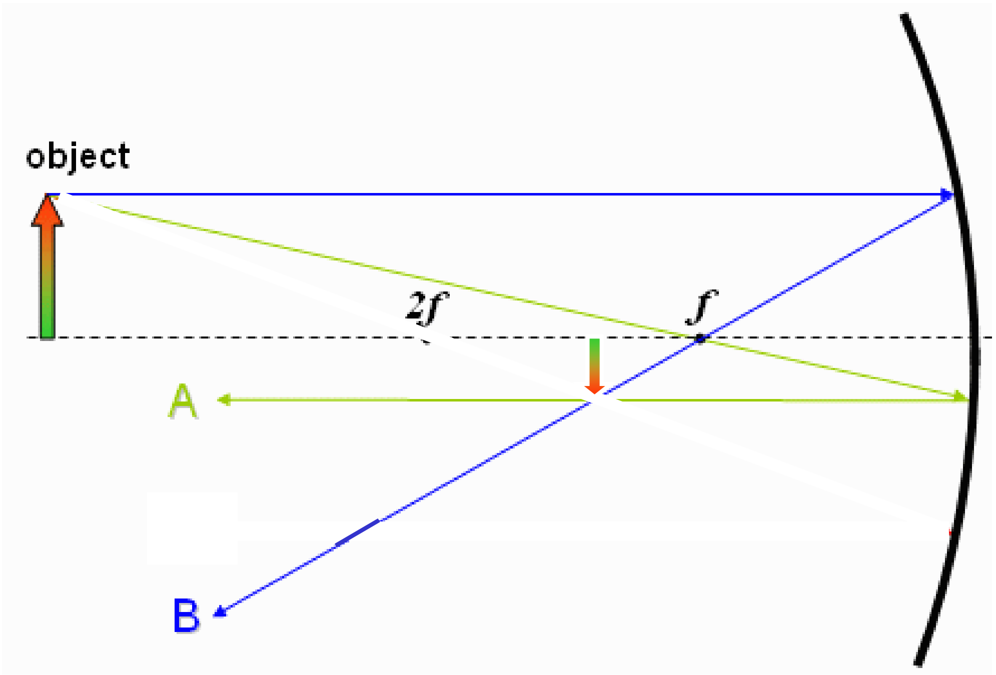


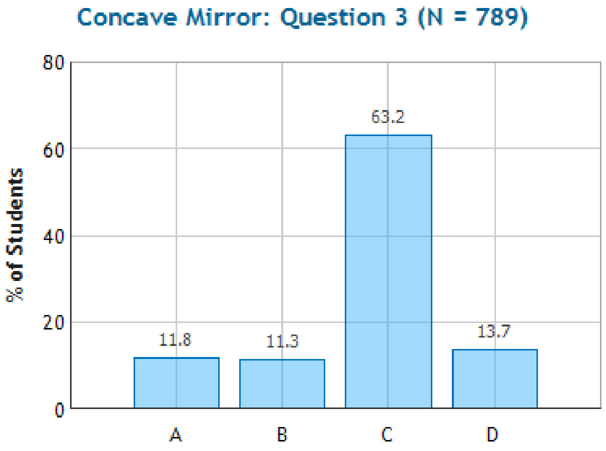
The diagram above shows three light rays reflected off a concave mirror. Which ray is NOT correct?

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





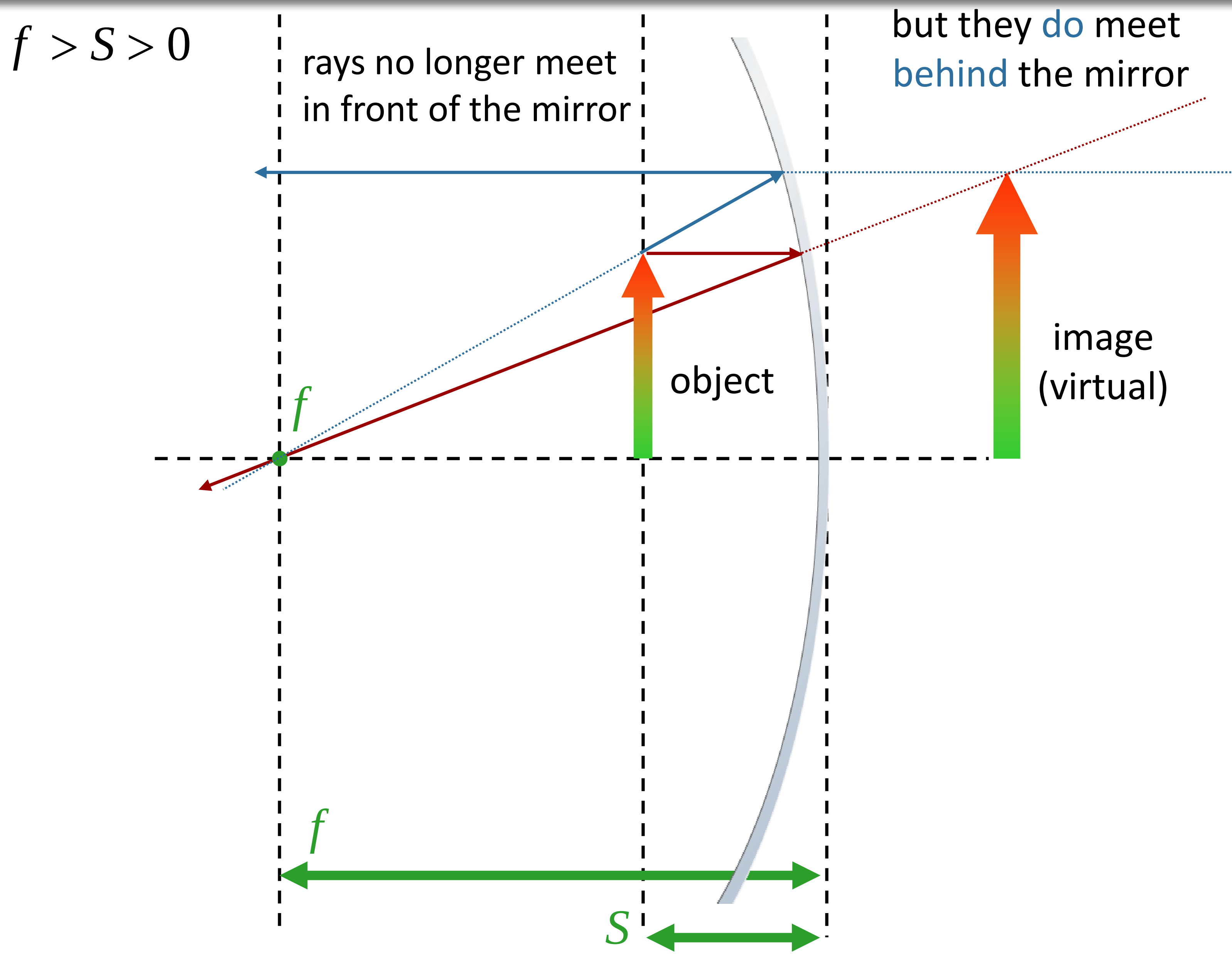
The diagram above shows two light rays reflected off a concave mirror. The image is

A. Upright and reduced

B. Upright and enlarged

C. Inverted and reduced

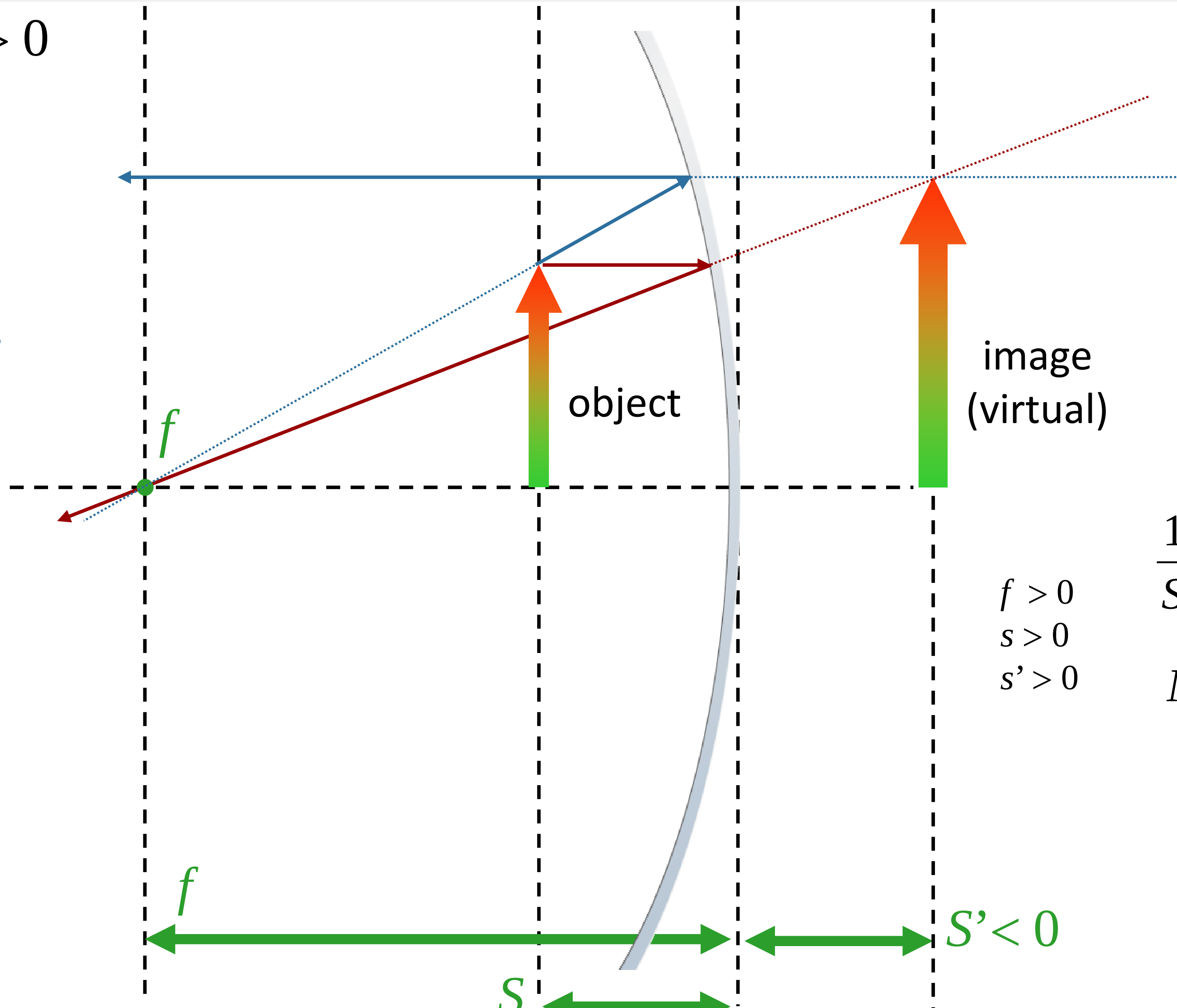
D. Inverted and enlarged



$f > S > 0$
rays no longer meet
in front of the mirror
but they do meet
behind the mirror
object
image
(virtual)
f
f
S

$f > S > 0$

image is:
virtual
upright
bigger



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

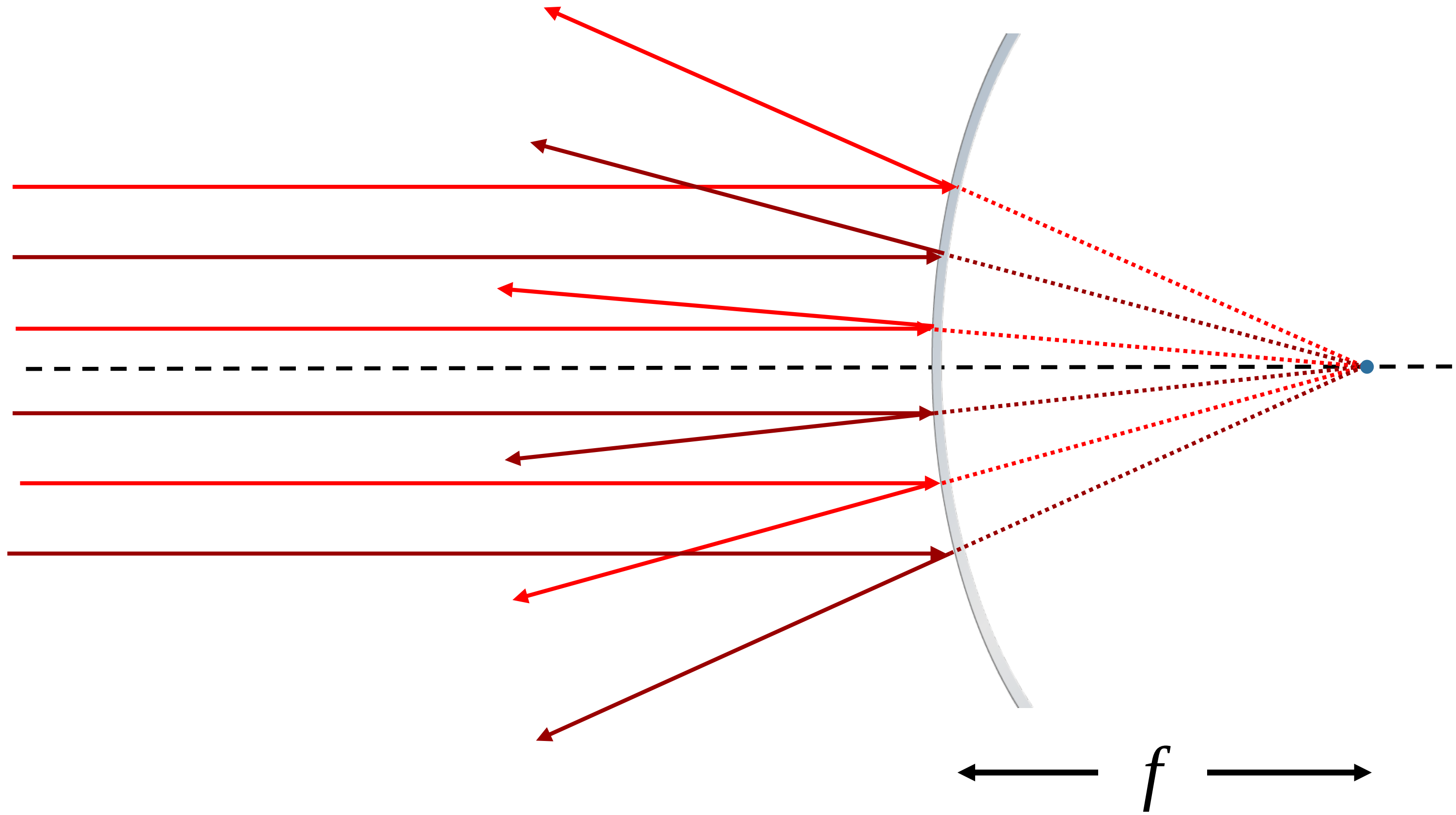
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f}$$

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

Convex 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



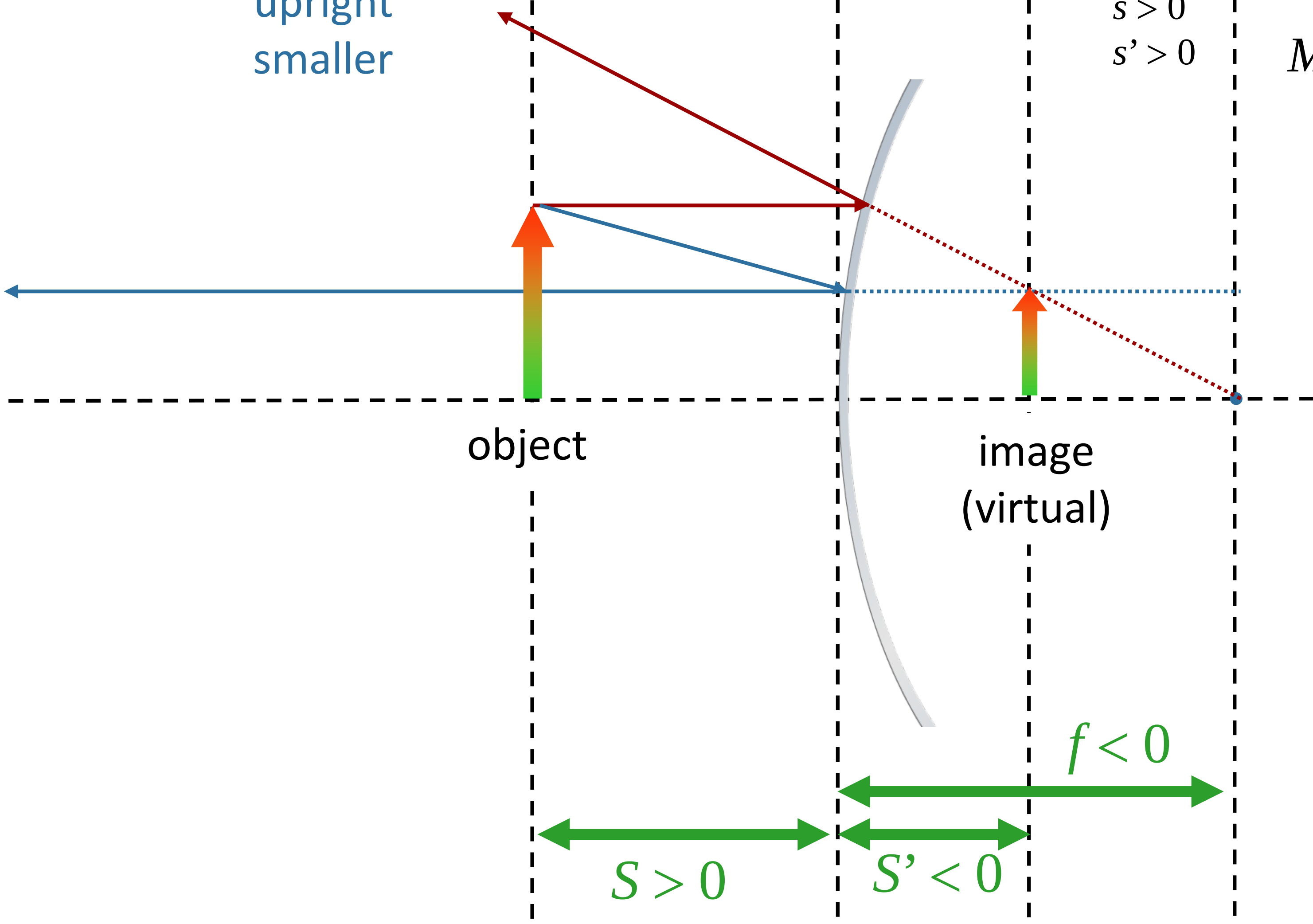
$S > 0$

image is:
virtual
upright
smaller

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

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

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



Executive Summary - Mirrors & Lenses:

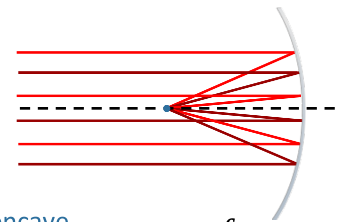
$S > 2f$ — real, inverted, smaller

$2f > S > f$ — real, inverted, bigger

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

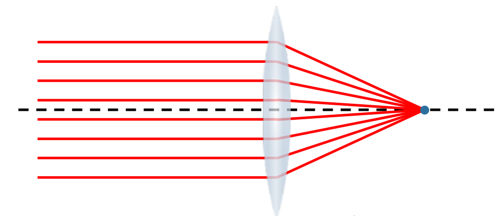
$S > 0$ — virtual, upright, smaller

$f > 0$



Concave (Converging)

$\leftarrow f \rightarrow$

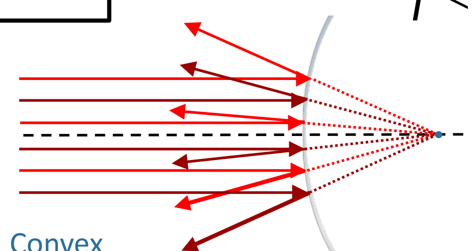


Converging

$\leftarrow f \rightarrow$

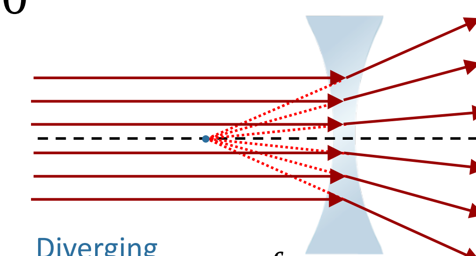
$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M = -\frac{S'}{S}$$

$f < 0$



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)

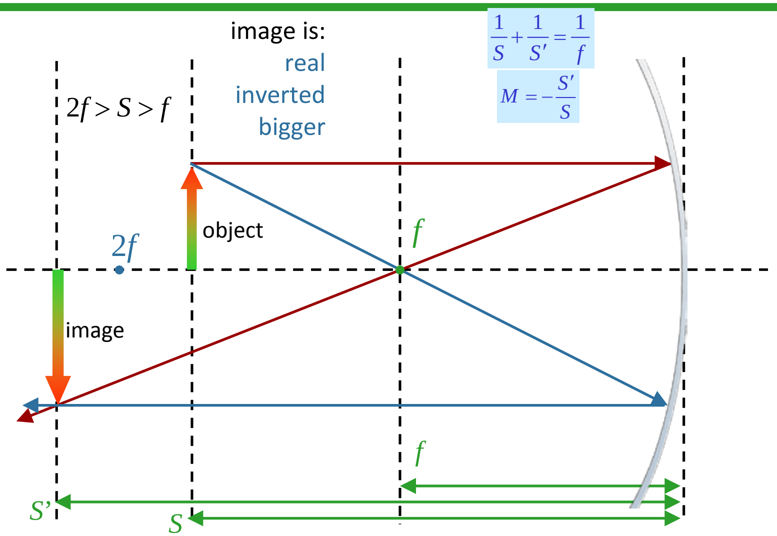
CheckPoint 2a

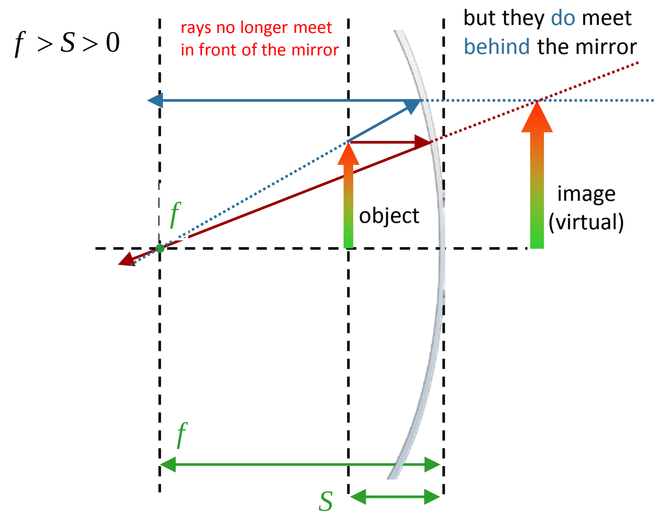
The image produced by a concave mirror of a real object is

A. Always upright

B. Always inverted

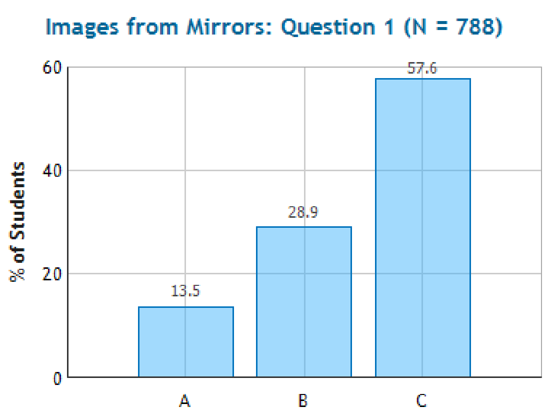
C. Sometimes upright & sometimes inverted





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

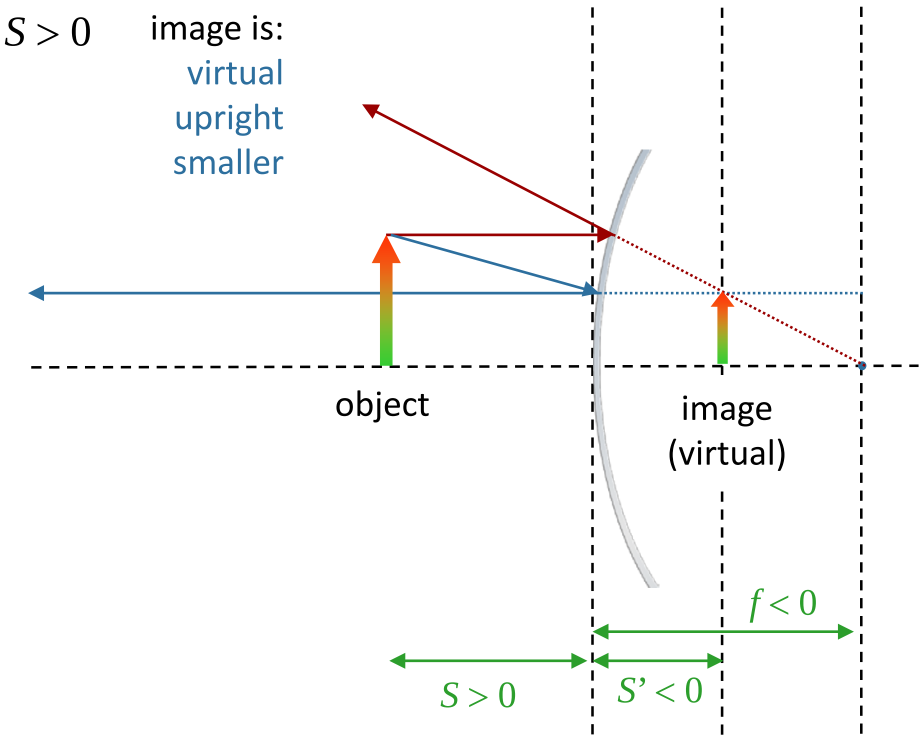
If the object is farther than focal length it will reflect an inverted image.

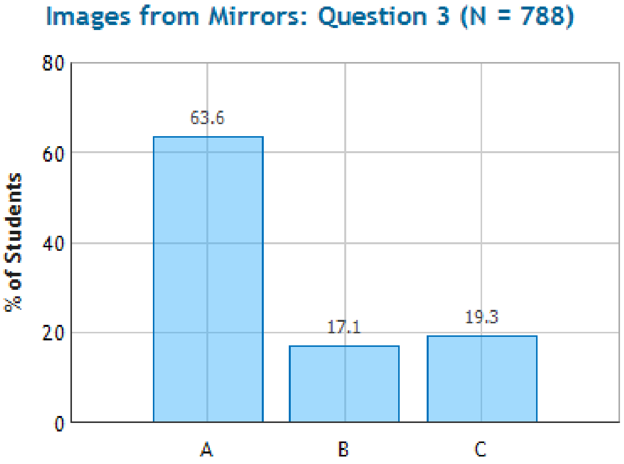


CheckPoint 2b

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

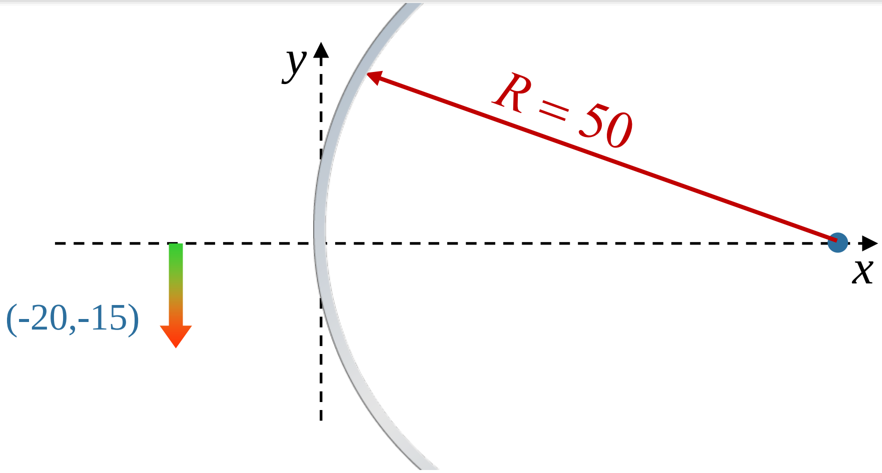
A. Always upright
B. Always inverted
C. Sometimes upright & sometimes inverted





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

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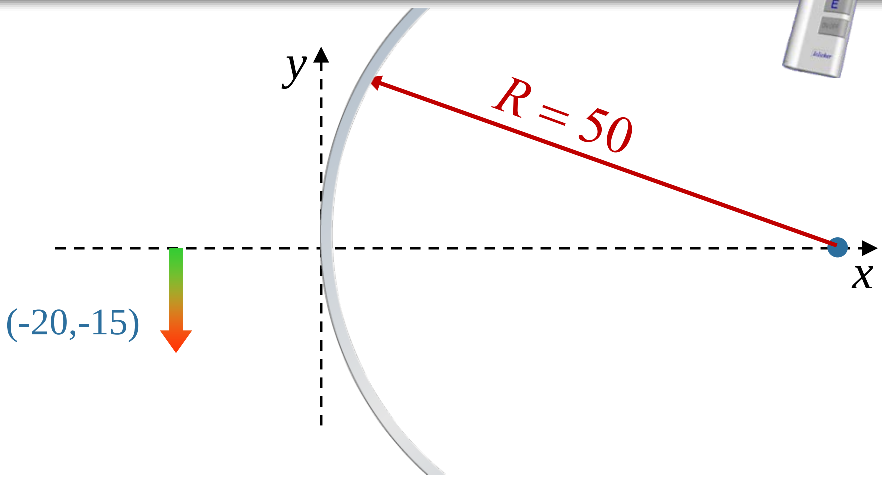
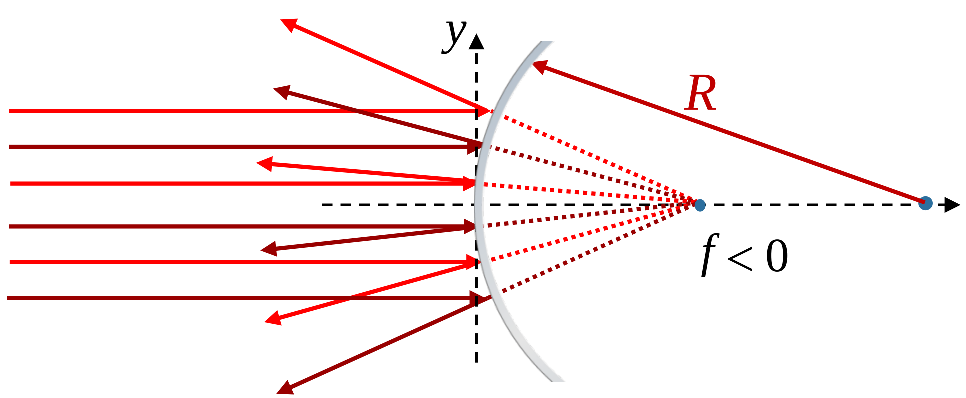


What is the focal length of the mirror?

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

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

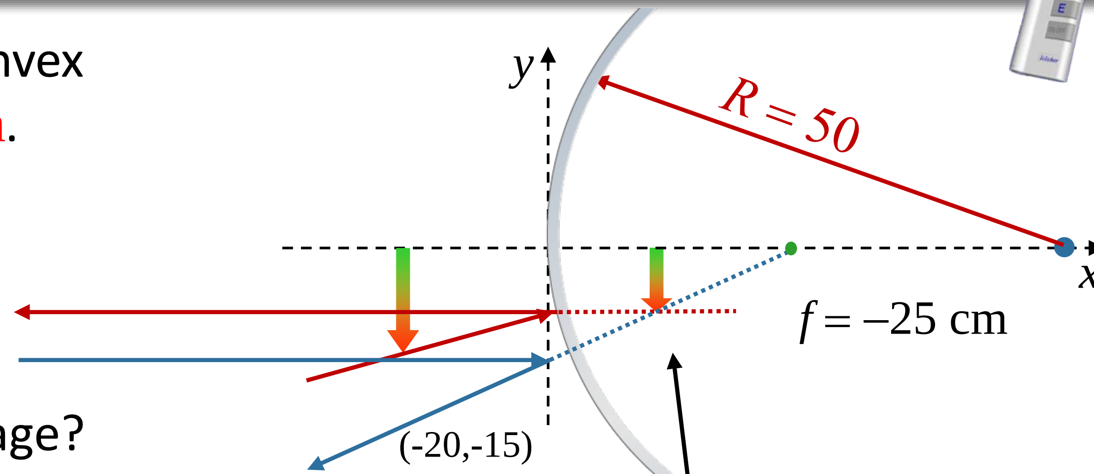
Rule for sign: Positive on side of mirror where light goes after hitting mirror



$f = -25 \text{ cm}$

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?

$\boxed{\text{A) } 11.1 \text{ cm}}$ B) 22.5 cm C) –11.1 cm D) –22.5cm

Mirror equation → $\dfrac{1}{S'} = \dfrac{1}{f} - \dfrac{1}{S}$

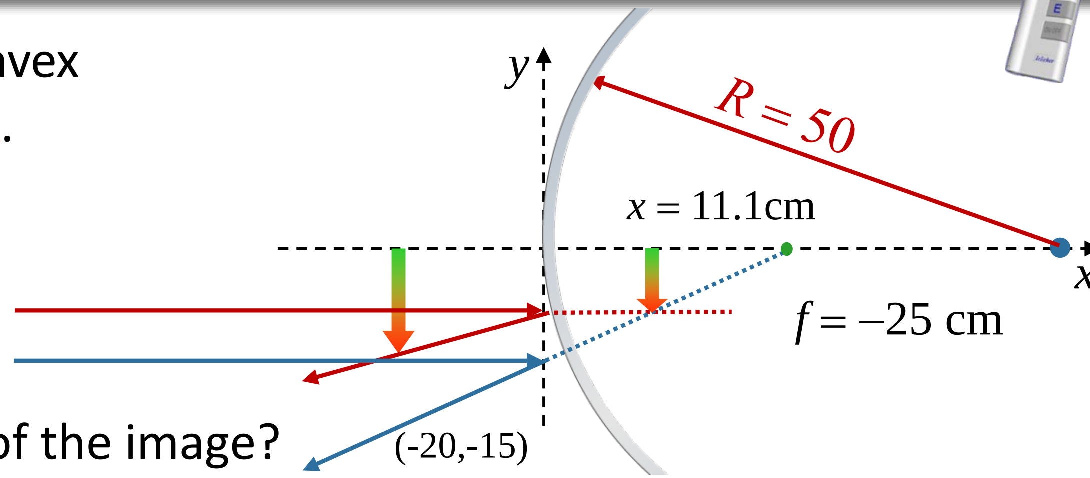
→ $S' = \dfrac{fS}{S - f}$ $s = 20 \text{ cm}$, $f = -25 \text{ cm}$

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

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 $\boxed{\text{D) } -8.3\text{cm}}$

Magnification equation → $M = -\dfrac{S'}{S}$

$s = 20$ cm

$s' = -11.1$ cm

$M = 0.556$

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