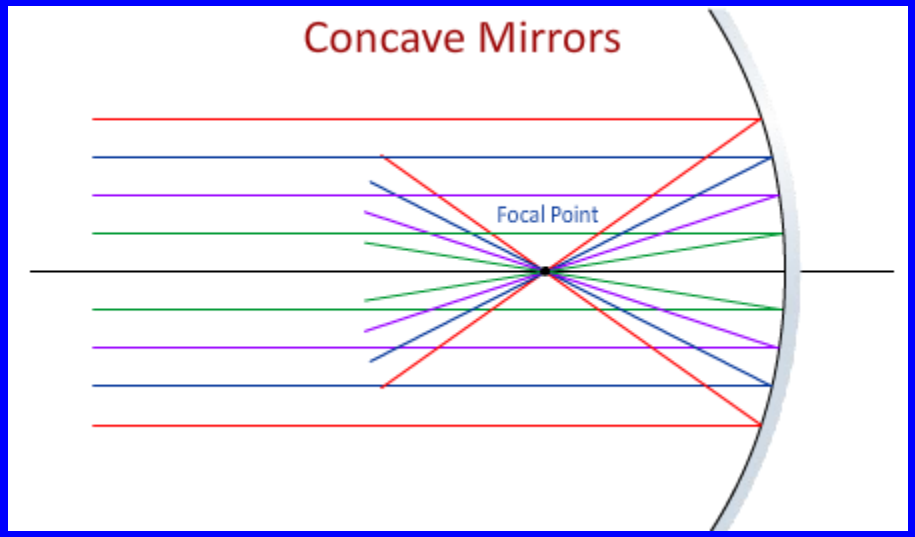
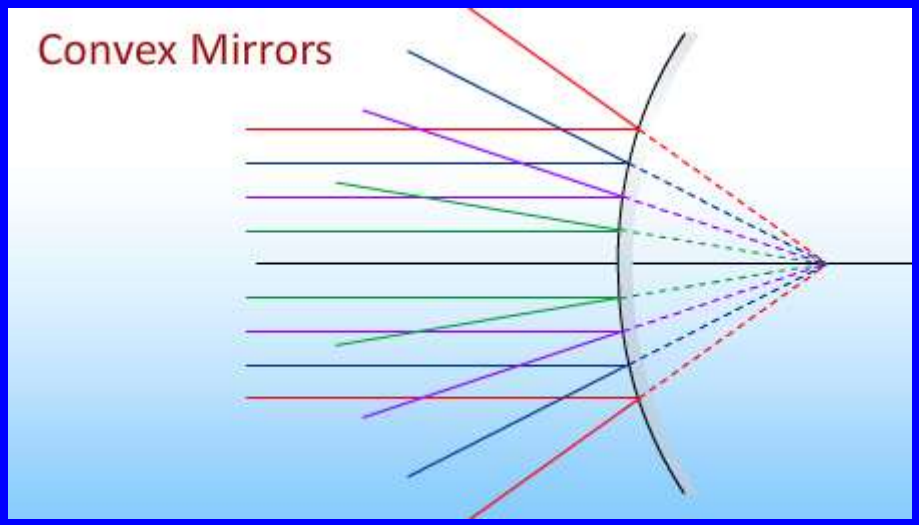
Physics 212
Lecture 27: Mirrors





Music

Who is the Artist?

A) Soul Rebels Brass Band
B) John Boutte
C) New Orleans Nightcrawlers
D) Paul Sanchez & Shammar Allen
E) Alex McMurray and Matt Perrine

Why?

Threadhead Records Beats Shazam !!
Fan-funded and volunteer run record company

Wonderful music from New Orleans

Hint: Thursday's artists also did a great set at Lagniappe stage last Jazzfest

Your Comments

"Since the extended rays intersect behind the convex mirror, where there is no light, is the image produced virtual or real? wouldn't the image just be magnified? I'm so confused."

"When are images real and when are they inverted in mirrors?"

"Not too bad. Just a recap of all the sign conventions including lenses would be nice"

"How can you have a real image with a mirror? It always looks like we're looking at something behind the mirror. I don't understand how a mirror can produce a real image."

"Go over drawing the lines for convex mirrors again"

We will
Do Examples
Clarify Sign Conventions

Note How Similar This Lecture is to the Lenses Lecture !!

Even better – the calculation

"When you look at a shiny spoon, you can see yourself upside down on the concave part, and right side up on the convex part. When I was little I always wondered how that worked. Now I do. ;D"

"Spoons. I use them a lot to justify my answer. Thanksgiving was so good to me."

"spoons and beans!"

Some Exam Stuff

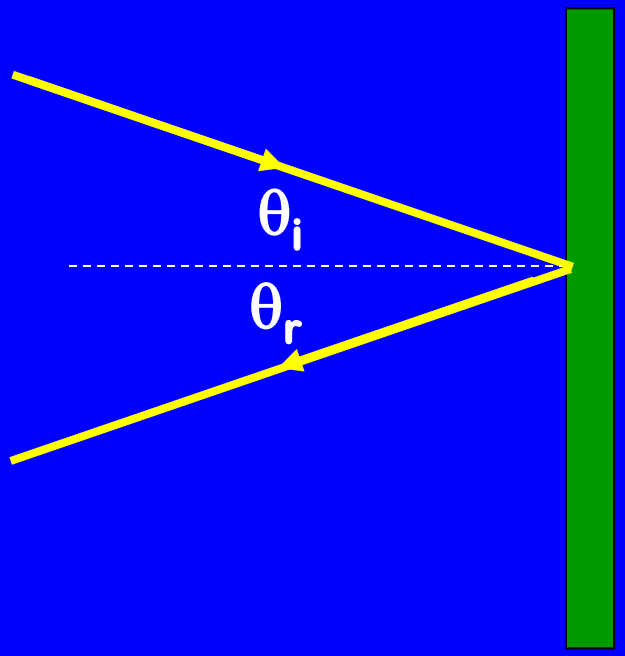
- Exam tomorrow night at 7:00
  - Covers material in Lectures 19 – 26: LC circuits to lenses (not mirrors)
  - Bring your ID: Rooms determined by discussion section (see link)
  - Conflict exam at 5:15 – Loomis 151
  - If you have conflicts with both of these, you should have heard from Prof. Park about scheduling

- Final EXAM
  - "Combined": Wed, Dec. 14, 7:00 – 10:00 p.m.
  - "Conflict": Thurs, Dec. 15, 1:30 – 4:30 p.m.
  - Bring your ID: Rooms to be announced by next week
  - Brief review next Tues.
  - Questions on final ~ uniformly divided over all course material

Reflection

Angle of incidence = Angle of reflection

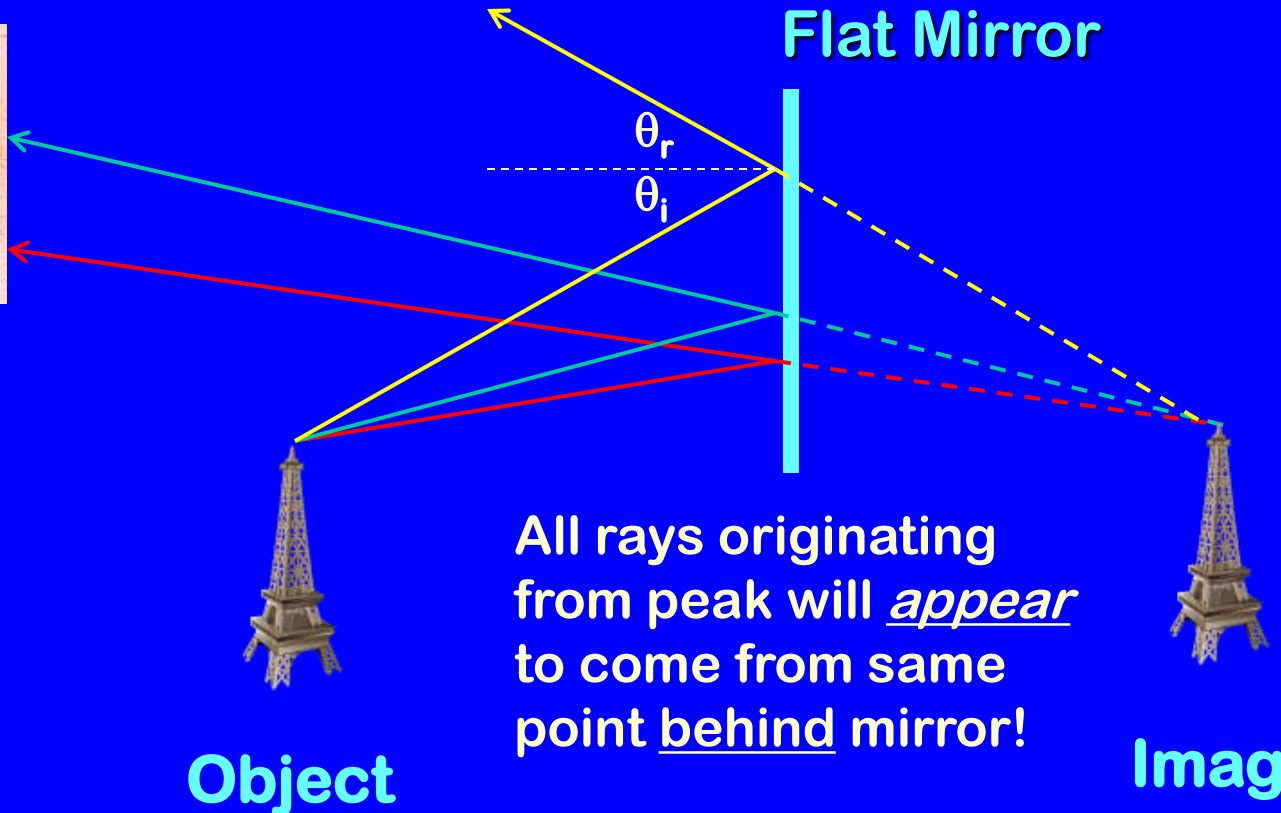
$$\theta_i = \theta_r$$



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.



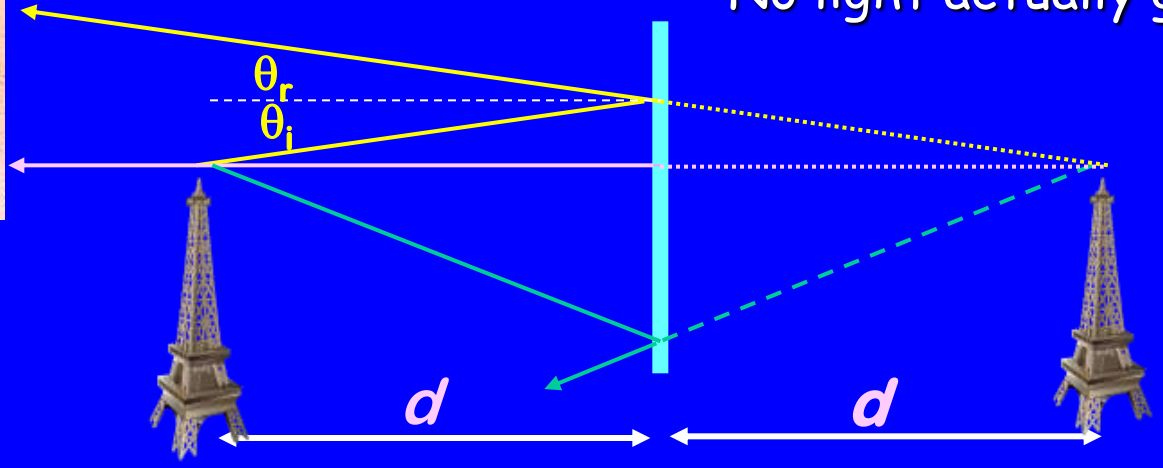
Flat Mirror

(1) Draw first ray perpendicular to mirror 0 = $\theta_i = \theta_r$

(2) Draw second ray at angle. $\theta_i = \theta_r$

(3) Extend the reflected rays behind the mirror

(4) Lines appear to intersect a distance *d* behind mirror. This is the image location.

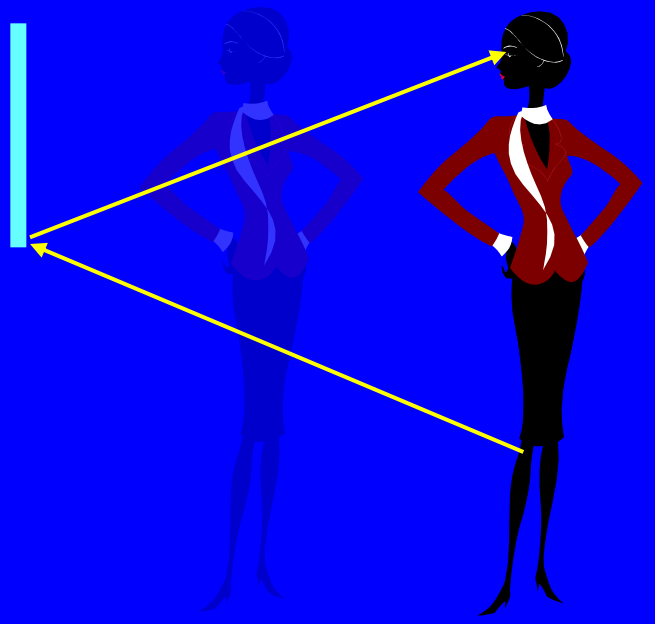


ACT

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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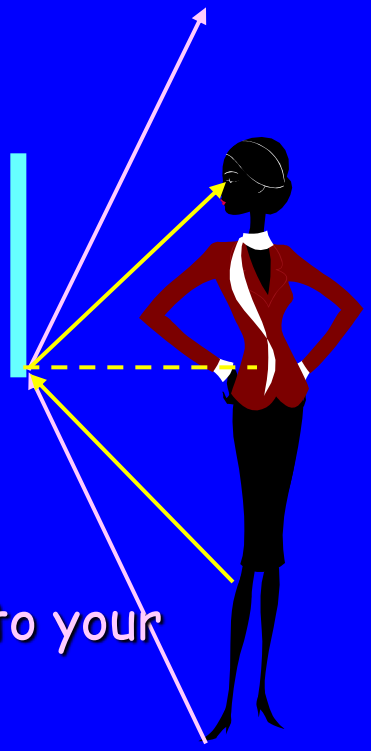
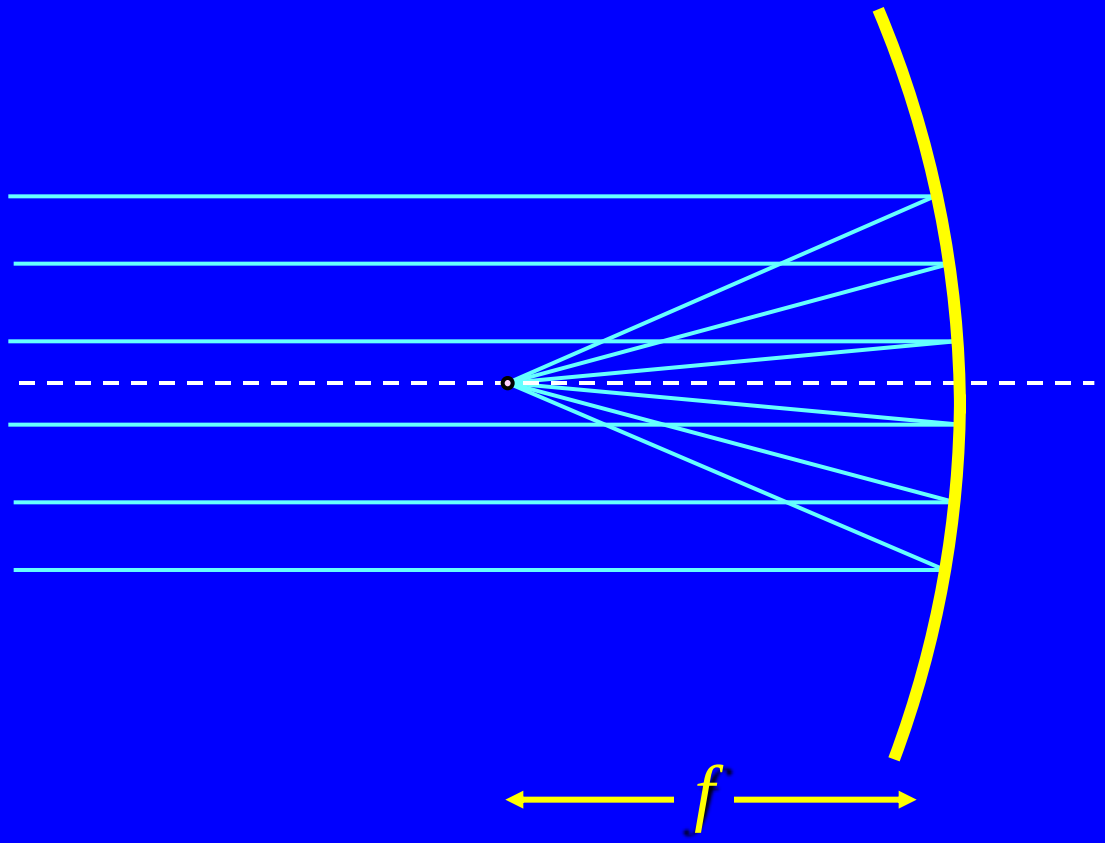


If the light doesn't get to your eye then you can't see it

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

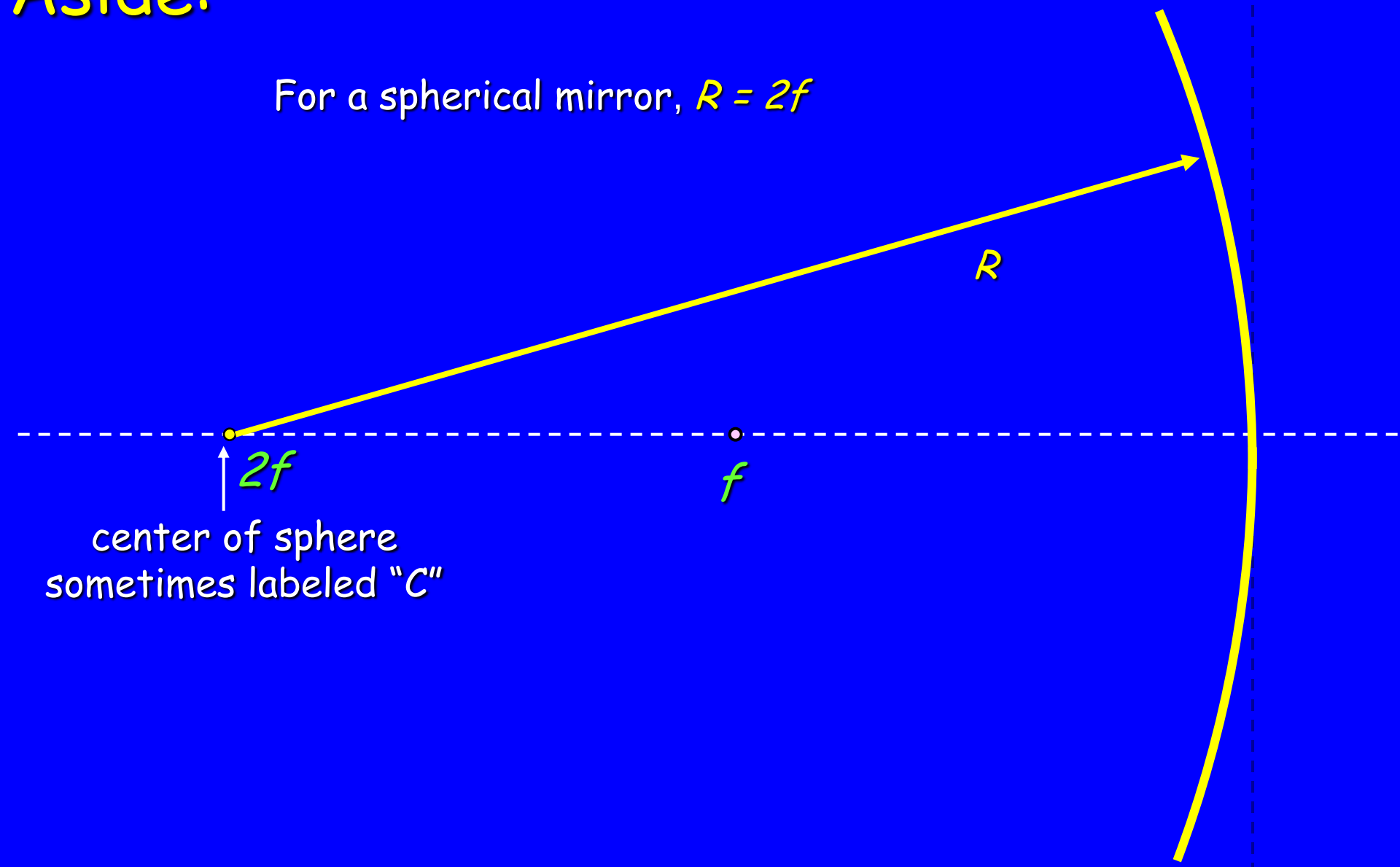


These mirrors are often sections of spheres (assumed in this class).

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

Aside:

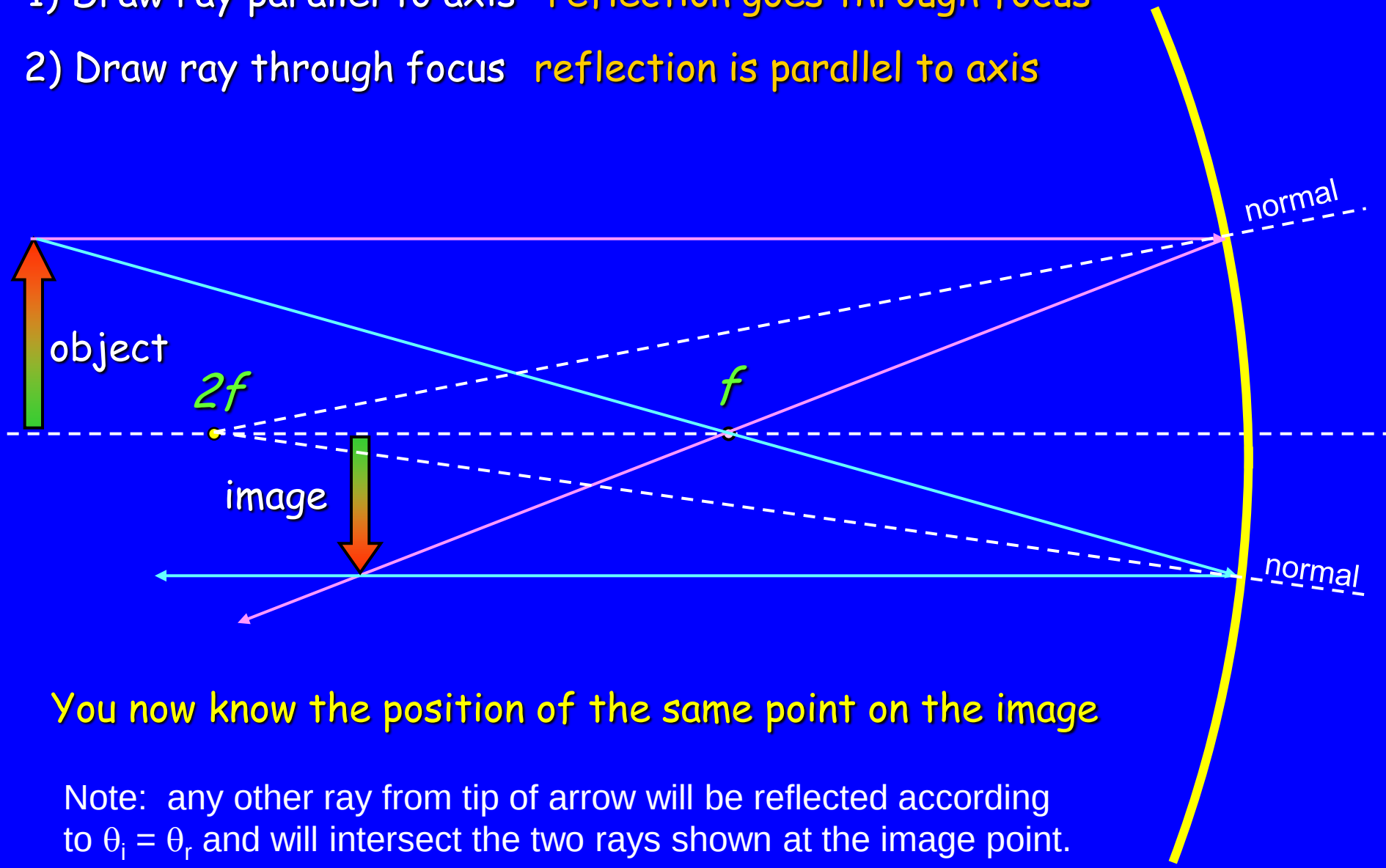
For a spherical mirror, $R = 2f$



Recipe for finding image:

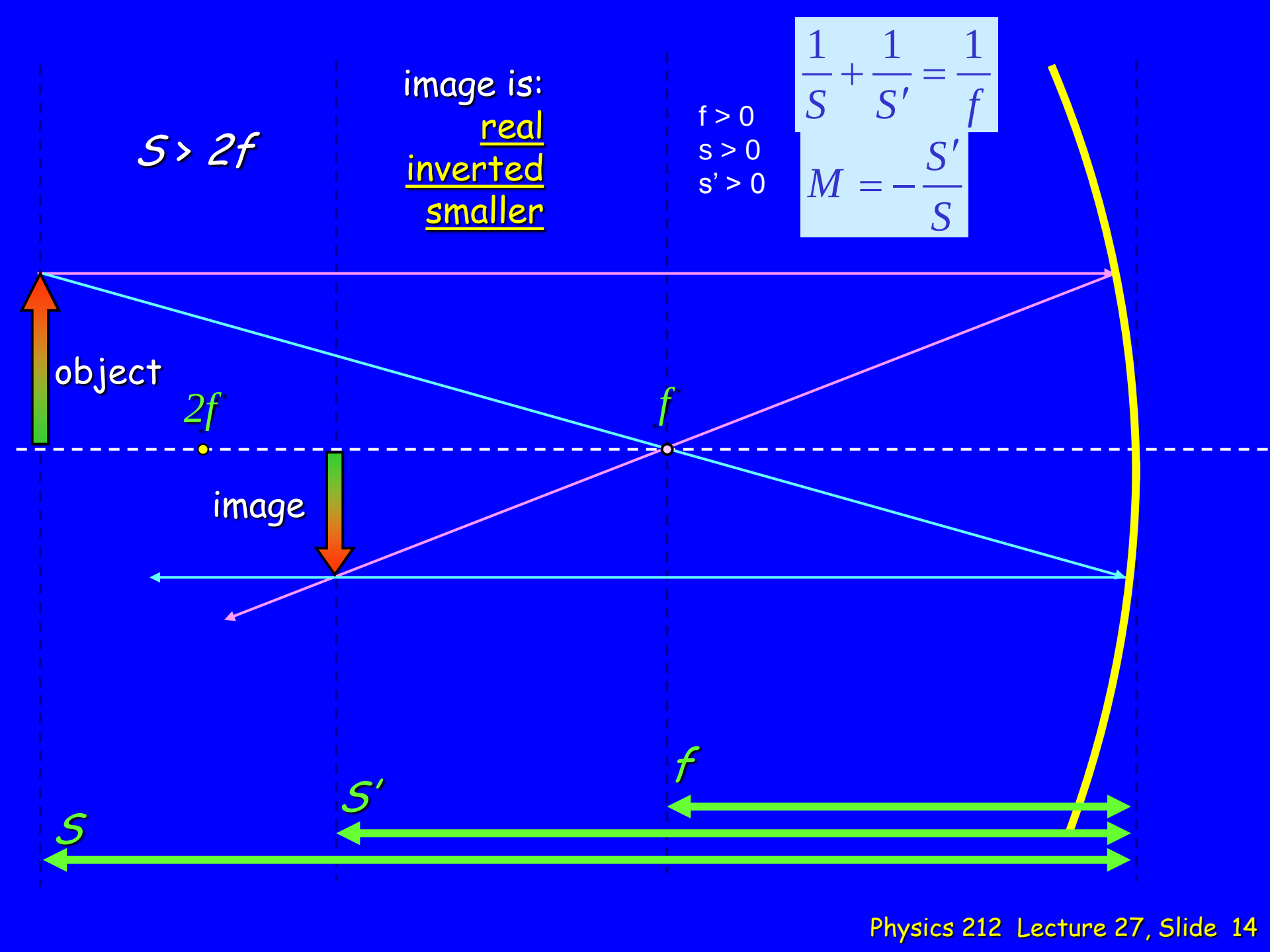
1) Draw ray parallel to axis reflection goes through focus

2) Draw ray through focus reflection is parallel to axis

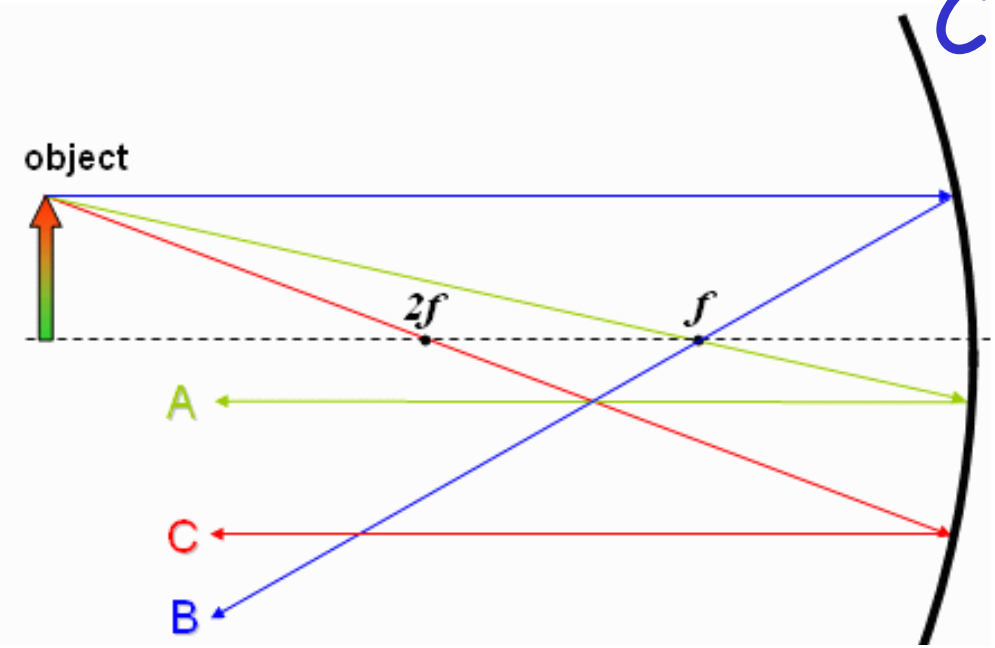


You now know the position of the same point on the image

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
$\frac{1}{S}+\frac{1}{S'}=\frac{1}{f}$
$M=-\frac{S'}{S}$
object
2f
f
image
f
S'
S

Checkpoint 1a



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

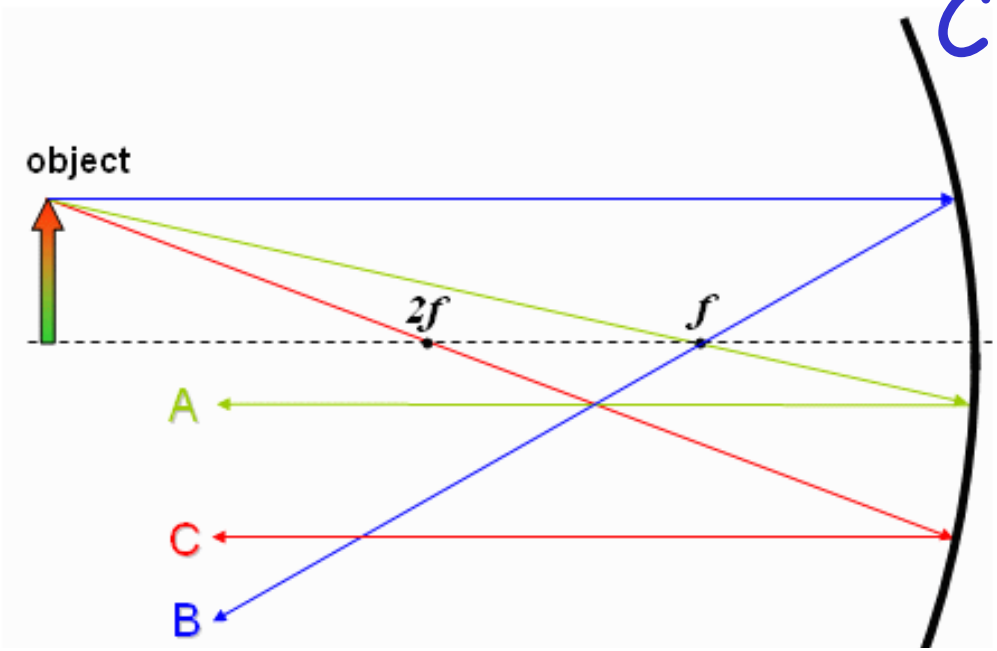
A ***B*** ***C***

"all the rays need to intersect in the same place, and A's reflection does not follow the law that angle of incidence equals angle of reflection."

"B does not go through the focal point"

"C goes back towards top of object"

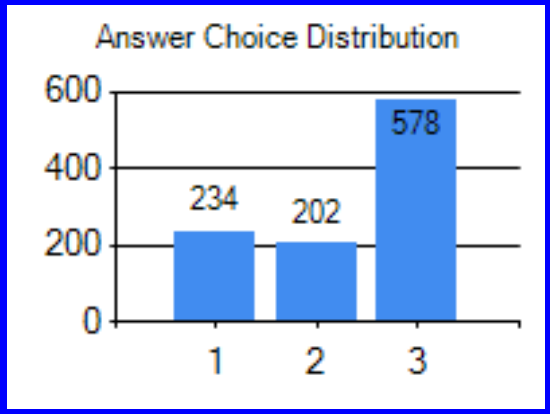
Checkpoint 1a



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

A ***B*** ***C***

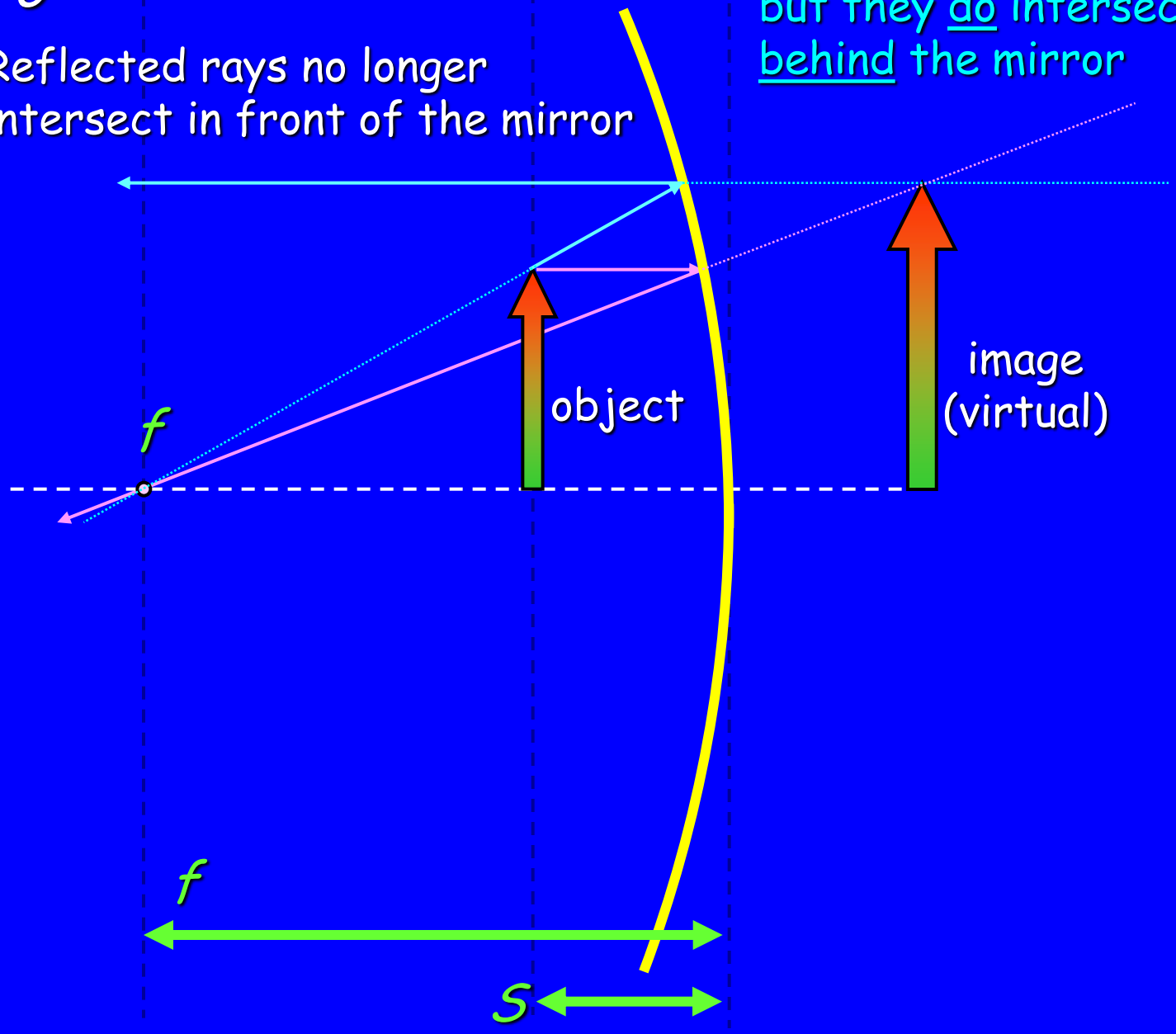
C is not correct as it does not go through the focal point.



$f > S > 0$

Reflected rays no longer intersect in front of the mirror

but they do intersect behind the mirror



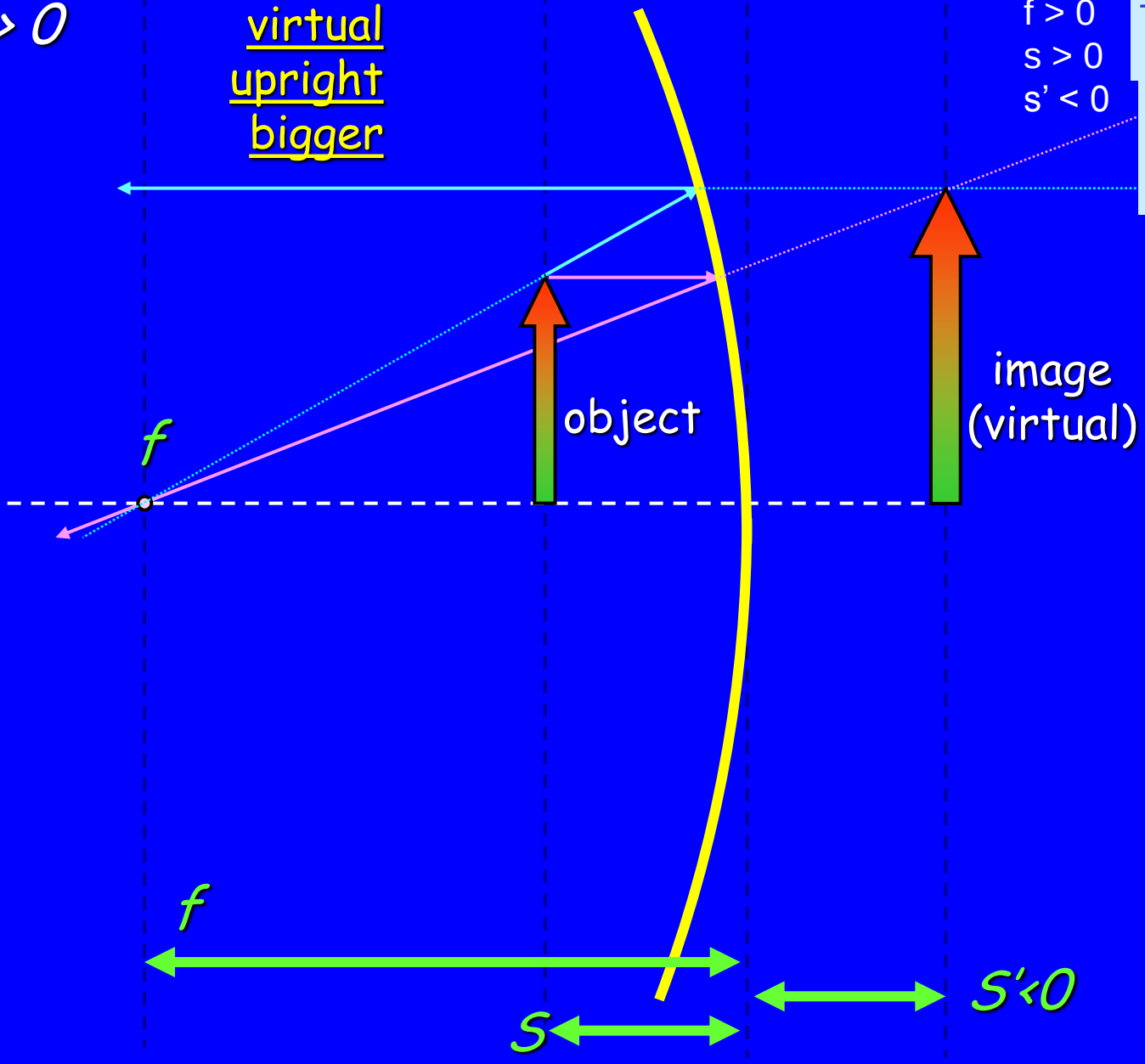
$f > S > 0$

image is:
virtual
upright
bigger

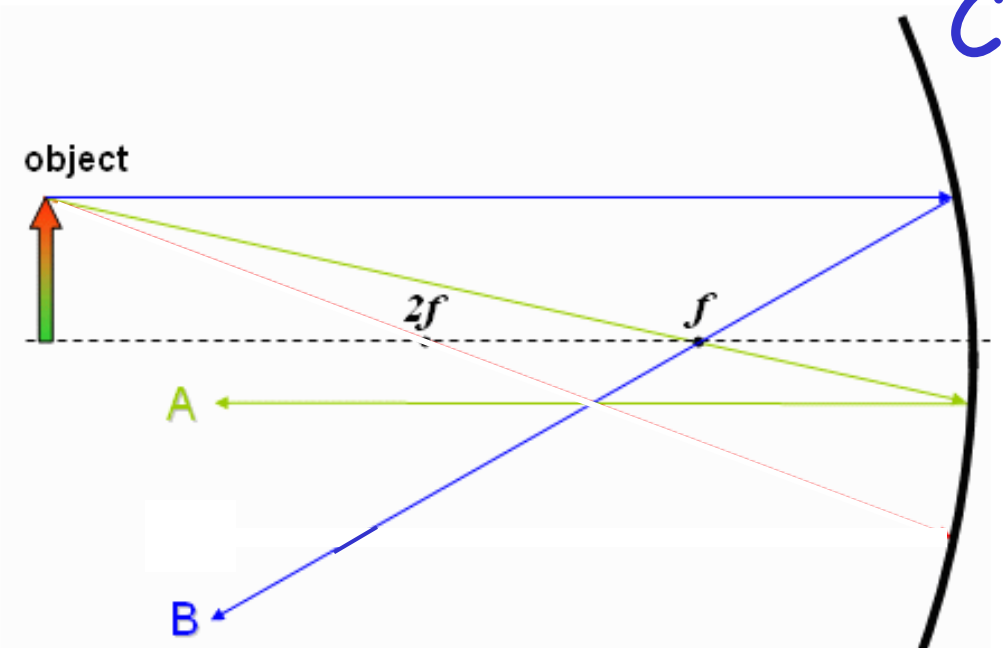
f > 0
s > 0
s' < 0

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

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



Checkpoint 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

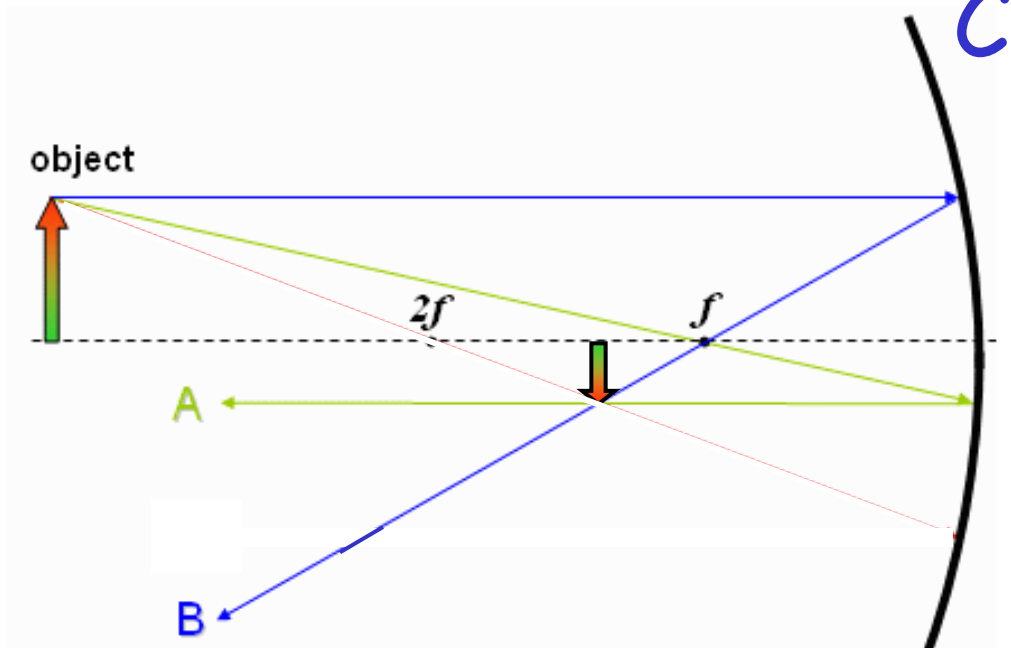
"The image would be upright since it is before the lens and reduced in order to reach the focal point."

"M is greater than zero which means it is upright. it is magnified so it is enlarged."

"LInes cross at an area that sees the image being inverted and reduced."

"s>f thus a real enlarged inverted image is produced"

Checkpoint 1b



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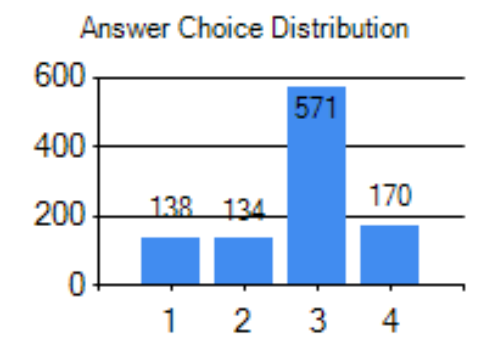
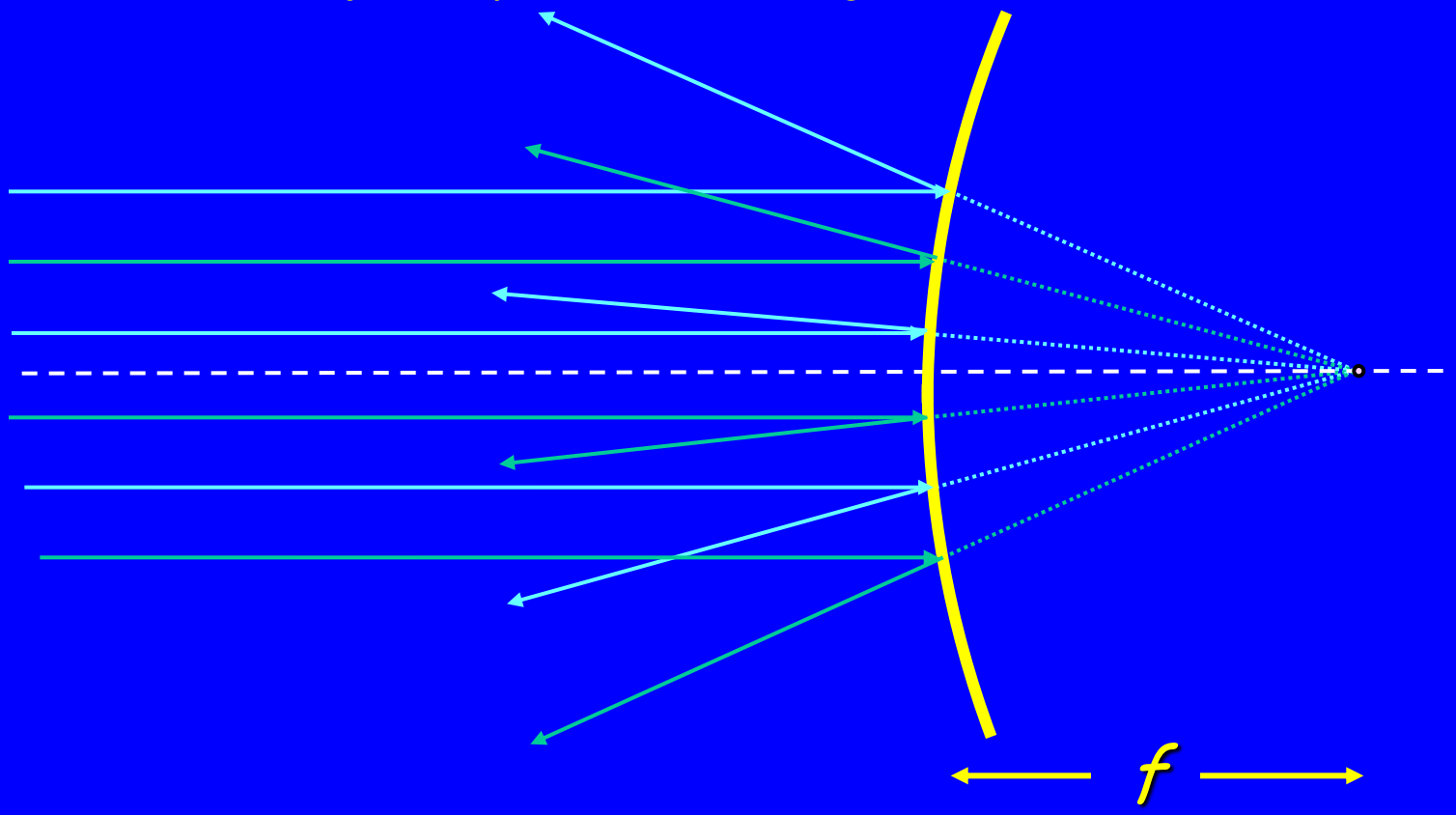


Convex: Consider the case where the shape of the mirror is such that light rays parallel to the axis of the mirror are all "focused" to a common spot a distance *f behind* the mirror:

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

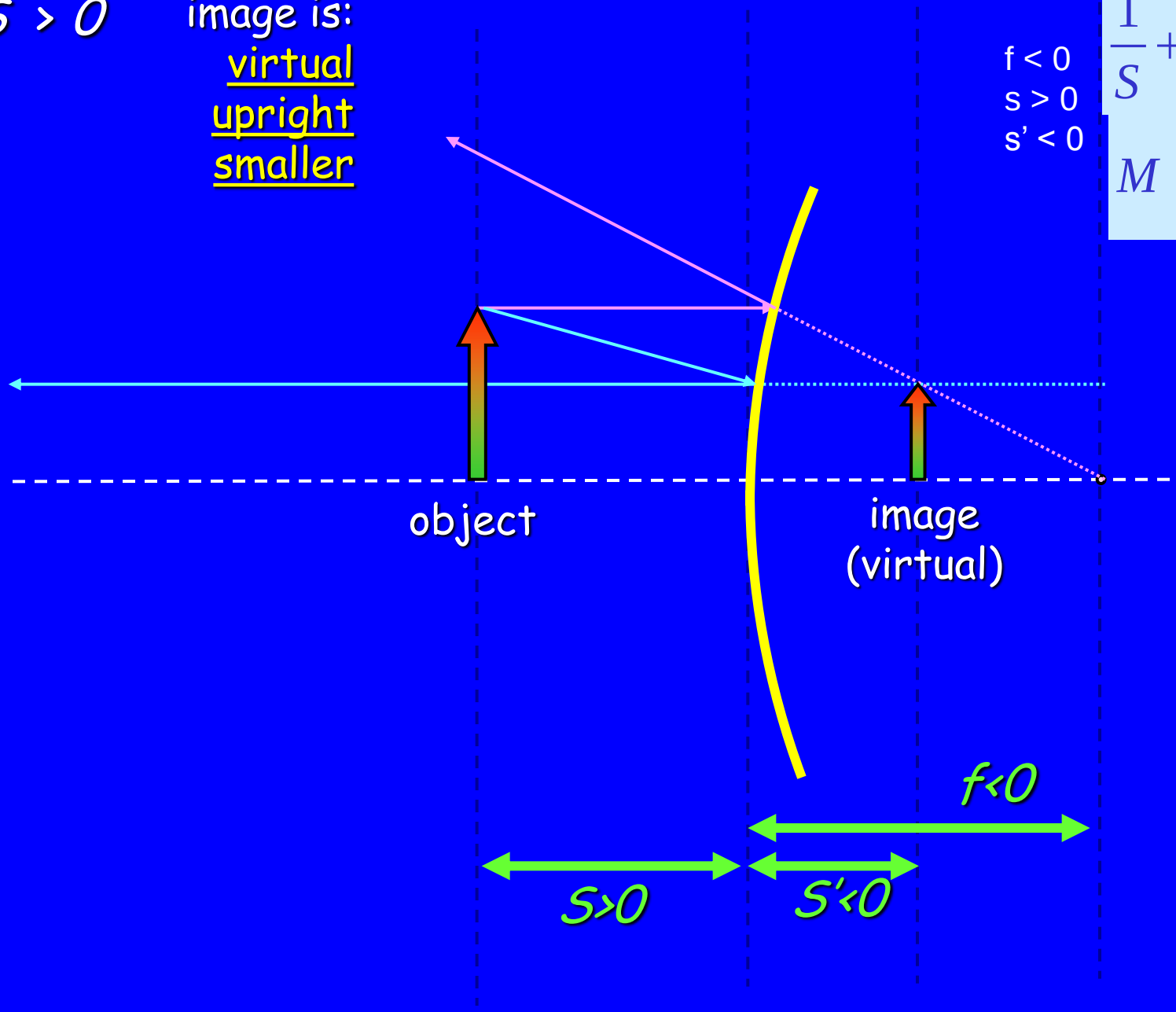


$S > 0$ image is: virtual upright smaller

f < 0
s > 0
s' < 0

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

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



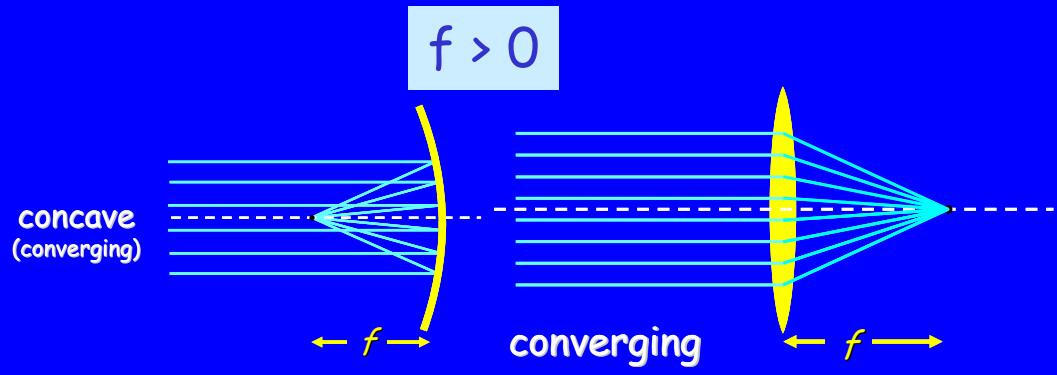
Executive Summary – Mirrors & Lenses:

$S > 2f$ — real, inverted, smaller

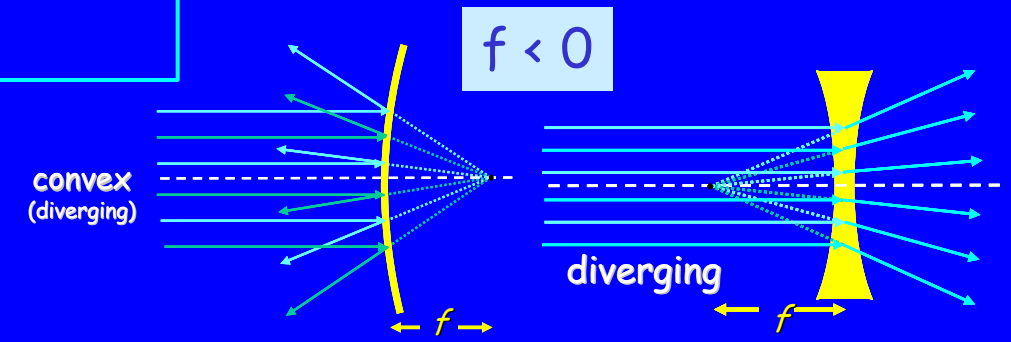
$2f > S > f$ — real, inverted, bigger

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

$S > 0$ — virtual, upright, smaller



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



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 and sometimes inverted

"It will always be upright since the rays do now flip sides."

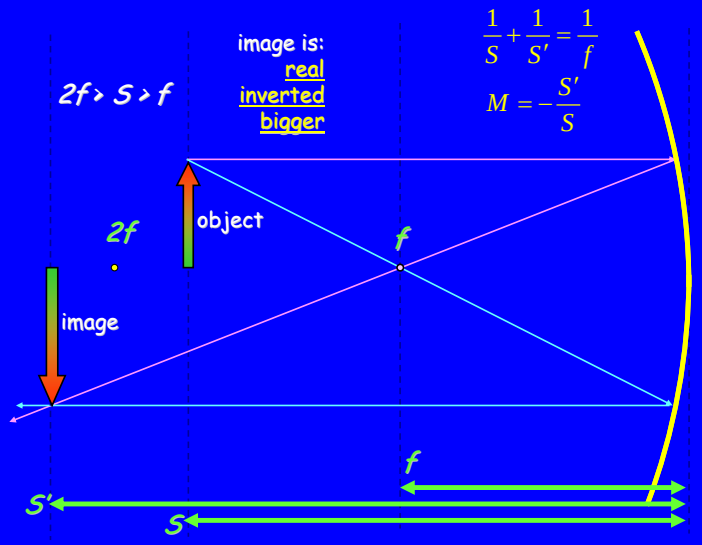
"You look upside down in a spoon."

"depends if the object is inside or outside the focal length."

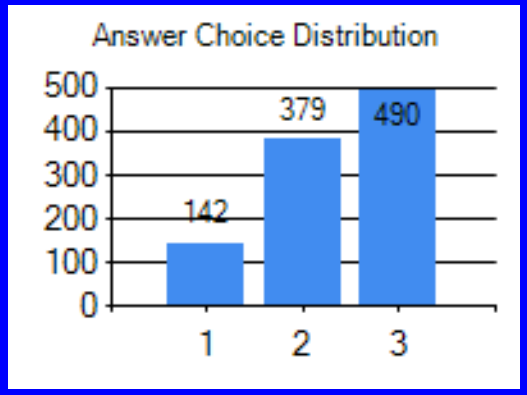
Checkpoint 2a

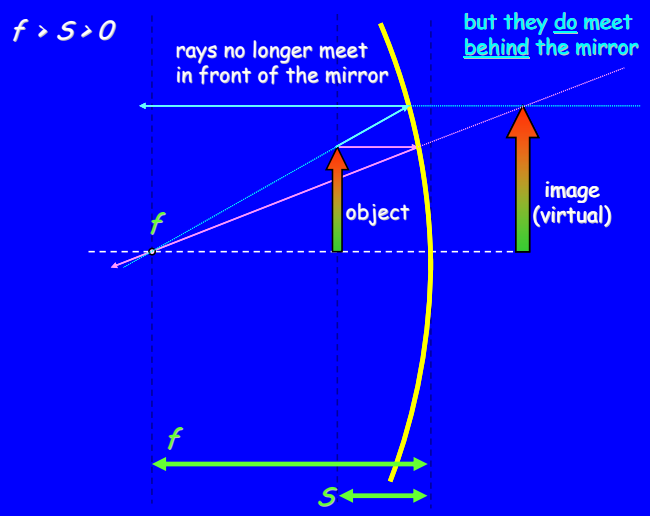
The image produced by a concave mirror of a real object is

A. Always upright ***B.*** Always inverted ***C.*** 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 2b

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

A. Always upright ***B.*** Always inverted ***C.*** Sometimes upright and sometimes inverted

"can only produce virtual image, which is upright."

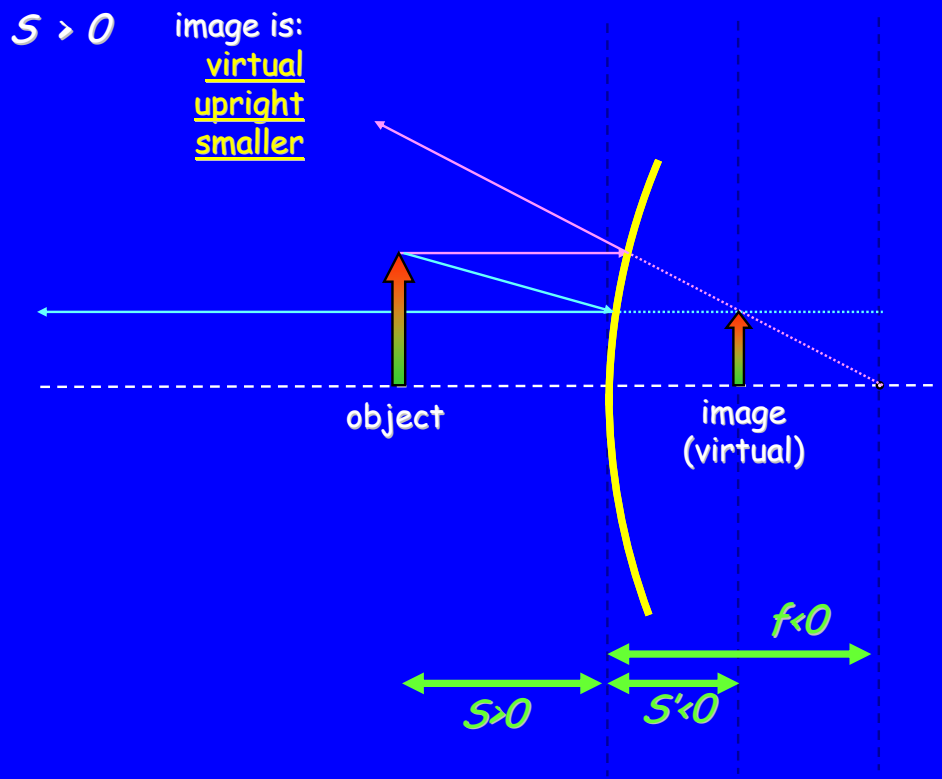
"Opposite of concave mirror"

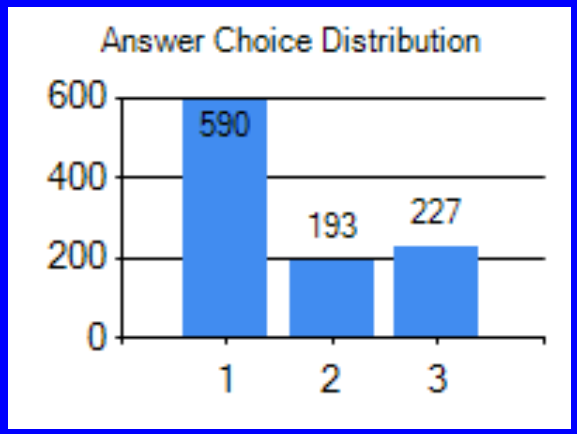
"if the object is farther than the focal point, the image is real and inverted, but if the object is within the focal length, the image is imaginary and upright."

Checkpoint 2b

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

A. Always upright **B.** Always inverted **C.** Sometimes upright and sometimes inverted

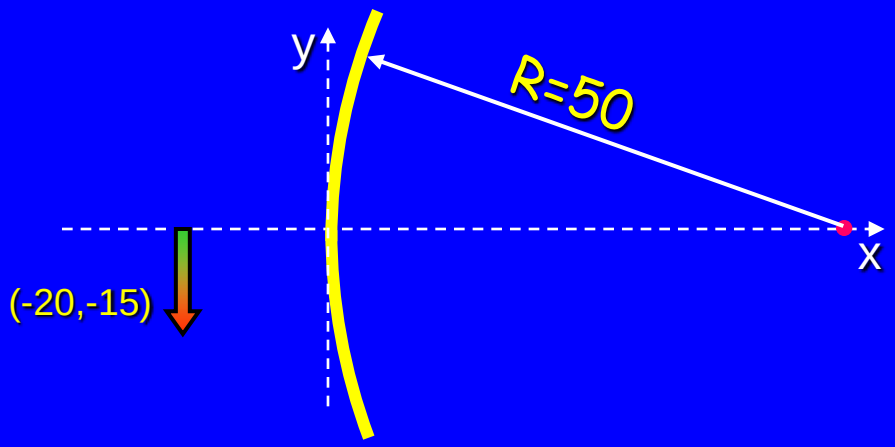




It's like the back of a spoon, or one of those mirrors in the corner of a convenience store.

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).



Where is the tip of the arrow's image?

- **Conceptual Analysis**
  - Mirror/Lens 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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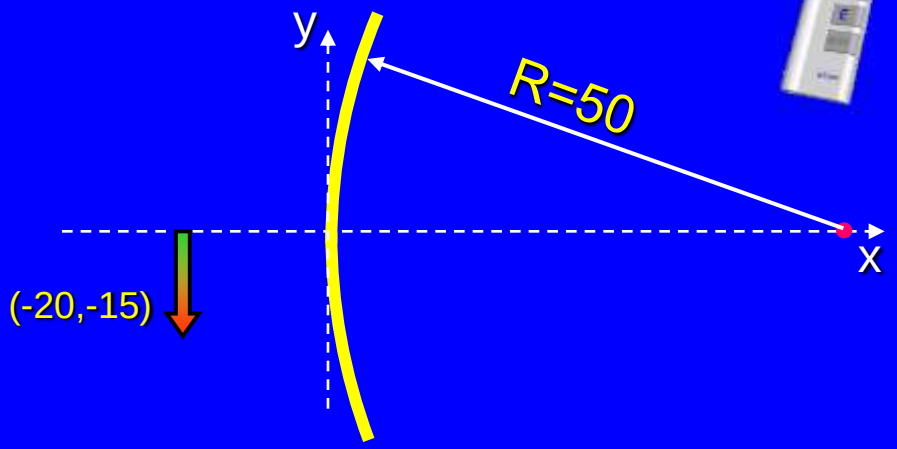
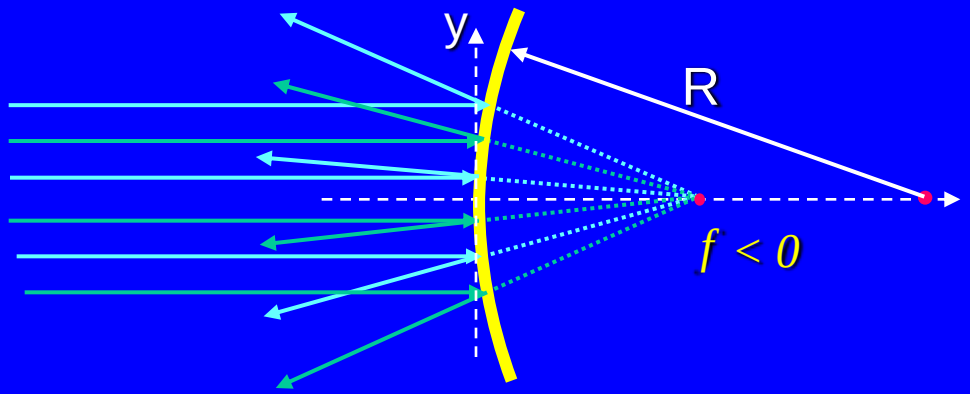


What is the focal length of the mirror?

A) f =50cm B) f = 25cm C) f = -50cm **D) f = -25cm**

For a spherical mirror $|f| = R/2 = 25$cm.

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



$f = -25$ cm

Calculation

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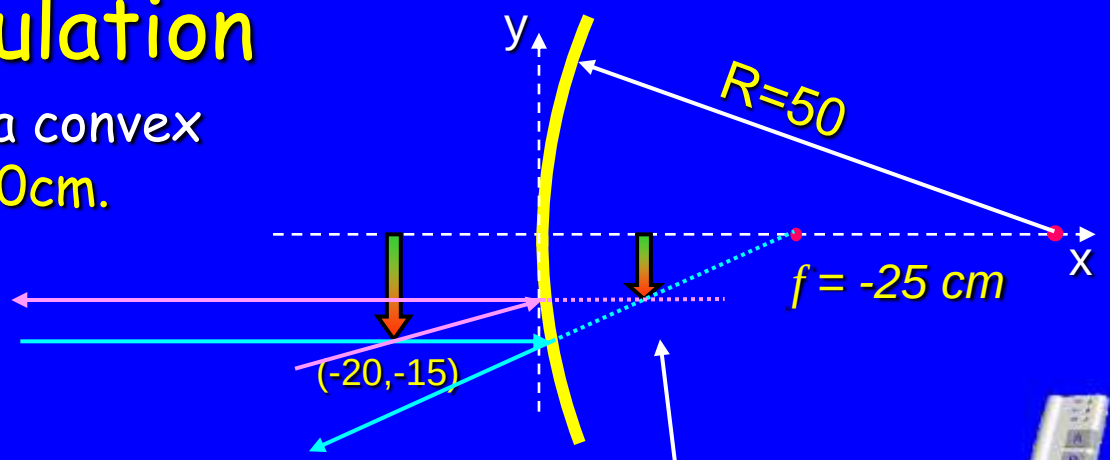


What is the x coordinate of the image?

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

Mirror equation

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

$$s' = \frac{fs}{s - f}$$

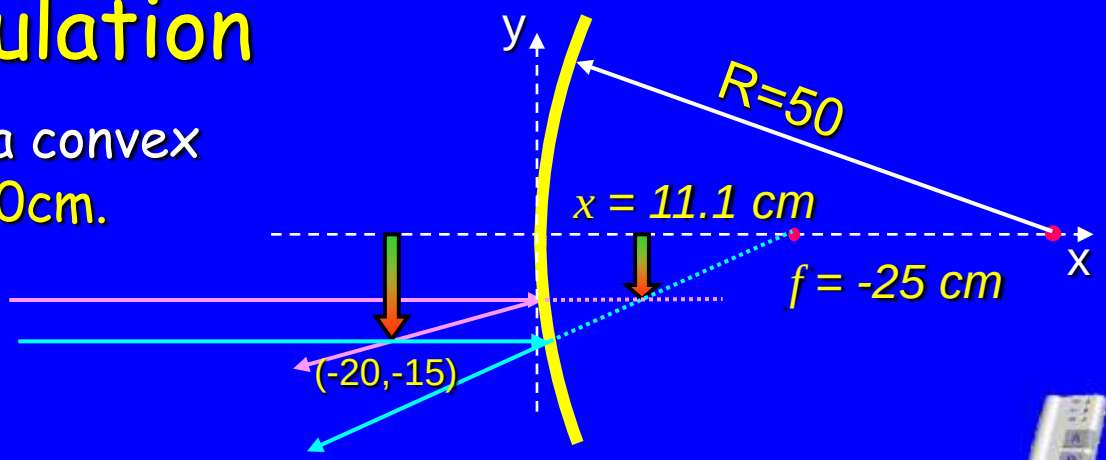
s = 20 cm
f = -25 cm

$$s' = \frac{(-25)(20)}{20 + 25}$$ *= -11.1 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

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