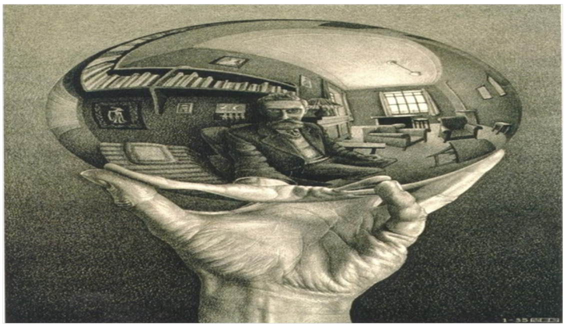
5.B.2 – Spherical Mirrors



1. Mirror Madness!

Approach the convex mirror, what do you observe? Do you appear closer or farther? Upside down?
No

Approach the concave mirror from across the room, what now? Write down your observations.

You start out upside down and small, at focal point you cant see an image, between mirror and focal point you're right side up and magnified.

Spherical Mirrors

Def: Reflecting surface with spherical geometry.

Concave: A recessed surface inside a sphere, such as where your food goes on a spoon.
Think of going into a CAVE.

Convex: A curved surface on the outside of a sphere, such as where your food doesn't go on a spoon.
Think of going into a VEX. Just joking.

Spoon party trick.

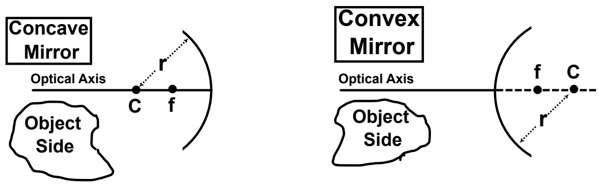
Geometric Considerations

Optical Axis: The center line of a spherical mirror.

Center of Curvature (C): Point on axis corresponding to the sphere's center.

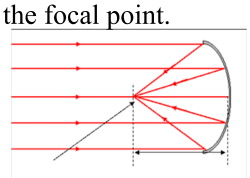
Radius of Curvature (r): Edge to center distance.

Focal Point (f): Intersection point of reflecting parallel light rays.

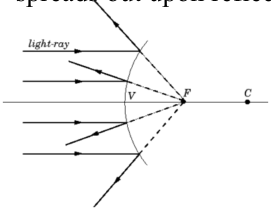


Geometric Considerations

Concave mirrors are converging: light traveling parallel to optic axis intersects at the focal point.



Convex mirrors are diverging: light traveling parallel to optic axis spreads out upon reflection.

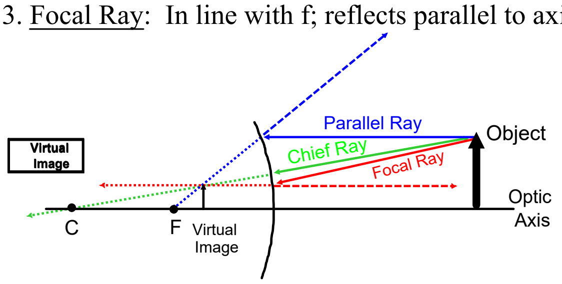


Convex Mirrors:

Objects in Mirror are Closer than they Appear!!

Produce a virtual image, ray diagram pinpoints it:

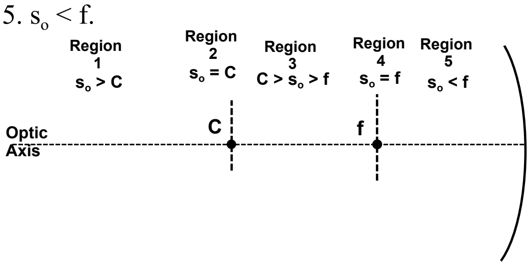
1. Parallel Ray: Follows a path parallel to the optic axis. It reflects in line with focal point.
2. Chief Ray: In line with C.
3. Focal Ray: In line with f; reflects parallel to axis.



Concave Mirror Regions

Distance determines image type & magnification:

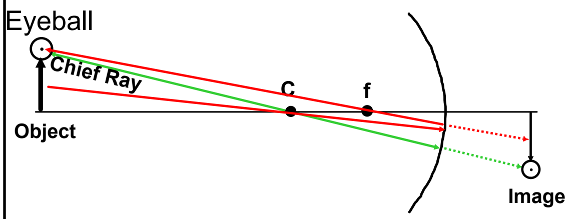
1. $s_o > C$,
2. $s_o = C$,
3. $C > s_o > f$,
4. $s_o = f$,
5. $s_o < f$.



Region 1: Virtual Image

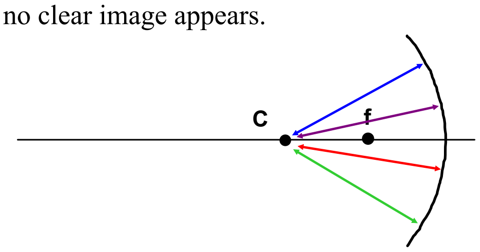
Past C, an inverted, shrunken virtual image appears.

Draw a Chief Ray for orientation.
Draw other rays from the object, such that they reflect back to the viewing point.



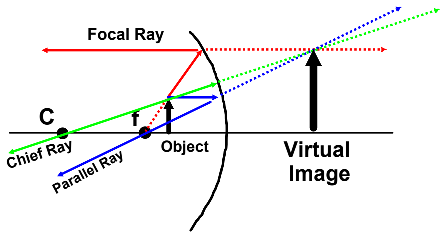
Region 2: No Virtual Image

From C, all light reflects back to C, converging such that no clear image appears.



Regions 3 - 5: Virtual Image

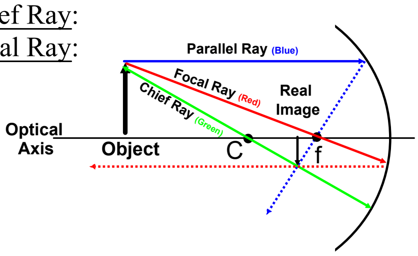
If the object is within C, a magnified upright image appears:



Concave Region 1: Real Image

Three rays pinpoint a <u>real</u> image (glowing globe demo), which requires a screen to see.

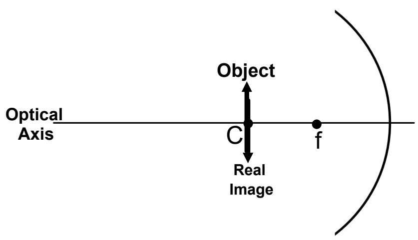
1. <u>Parallel Ray</u>:
2. <u>Chief Ray</u>:
3. <u>Focal Ray</u>:



Concave Region 2: Image Overlap

As an object approaches C, its real image also approaches C.

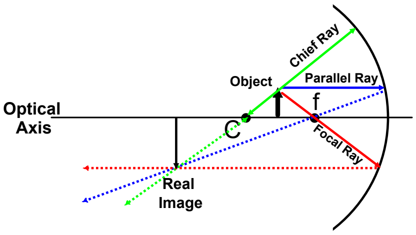
At C, the real image appears upside down, and the same size.



Concave Region 3: Real Image

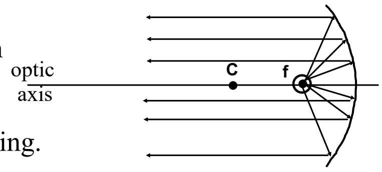
Between C and f, an object's real image is magnified and upside down beyond C.

1. Parallel Ray: 2. Chief Ray: 3. Focal Ray:

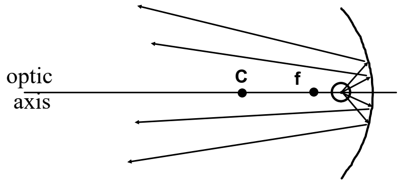


Regions 4-5: No Real Image

At the focal point, reflecting rays from an object reflect parallel to the optic axis, never converging.



Between f and the mirror, reflected rays diverge.



Spherical Mirror Equation

For all spherical mirrors,

$$\frac{1}{s_i}+\frac{1}{s_o}=\frac{1}{f}=\frac{2}{r}$$

AP Equation

s_o = object distance,
s_i = image distance,
f = focal point
r = radius of curvature.

Useful alternative form: $f=\left(s_i^{-1}+s_o^{-1}\right)^{-1}$

Two convenient derivations:

$$s_i=\frac{s_o f}{s_o-f} \qquad s_o=\frac{s_i f}{s_i-f}$$

Magnification of Spherical Mirrors

Magnification is same as plane mirrors:

$$|M|=\left|\frac{h_i}{h_o}\right|=\left|\frac{s_i}{s_o}\right|$$

AP Equation

s_o = object distance
s_i = image distance
h_o = object height
h_i = image height

In this class, we often use:

$$M=\frac{h_i}{h_o} \qquad M=-\frac{s_i}{s_o}$$

1. If image is upside down, h_i is negative.
2. For s_i: virtual image is negative, real is positive.

Sign Conventions - Resources 8

Focal Length, Radius of Curvature	Concave Mirror	f & r = positive
	Convex Mirror	f & r = negative
	Converging (convex) Lens	f & r = positive
	Diverging (concave) Lens	f & r = negative
	Planar Surface	f & r = infinity
Object Distance	Object in front of mirror	s_o = positive
	Object behind lens (virtual object in lens combinations)	s_o = negative
Image Distance (and type)	Mirrors: Real image on screen	s_o = positive
	Mirrors: virtual image inside mirror	s_o = negative
	Lenses: real image on screen opposite object	s_o = positive
	Lenses: virtual image same side as object	s_o = negative
Orientation (M) (mirrors/lenses)	Upright W. R. T. object	M = positive
	Inverted W. R. T. object	M = negative

Examples

A 3.0 cm object is 7.0 cm in front of a concave mirror. A virtual image forms 18.0 cm behind the mirror (remember conventions for virtual images).

2. What is the focal length of the mirror?

$$f=\left(s_i^{-1}+s_o^{-1}\right)^{-1}=\left(-18.0cm^{-1}+7.0cm^{-1}\right)^{-1}=11.5cm$$

3. What's the magnification?

$$M=-\frac{s_i}{s_o}=-\frac{-18.0cm}{7.0cm}=2.6$$

4. How tall is the object's image?

$$M=\frac{h_i}{h_o} \rightarrow h_i=M\bullet h_o=2.6\bullet 3.0cm=7.7cm$$

Homework
5.B.2 Problems
Due: Next Class.