Reflection from Plane Mirrors

Normal – perpendicular to the surface

Incident Light – Light that is striking a surface

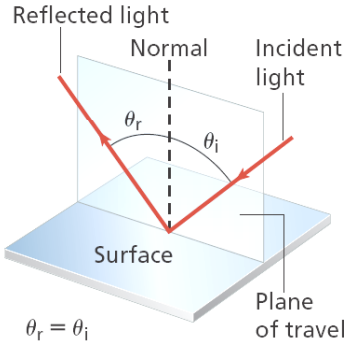
Reflected Light – Light that is reflected

Angle of Incidence (θ_i) – the angle between incident light ray and the normal

Angle of Reflection (θ_r) – the angle between reflected light ray and the normal

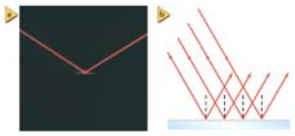
Law of Reflection

Angle of Reflection θ_r = Angle of Incidence θ_i



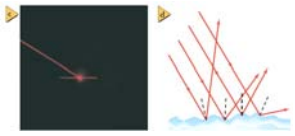
Types of Reflection

Specular Reflection– Reflection from a smooth surface



ex. a mirror

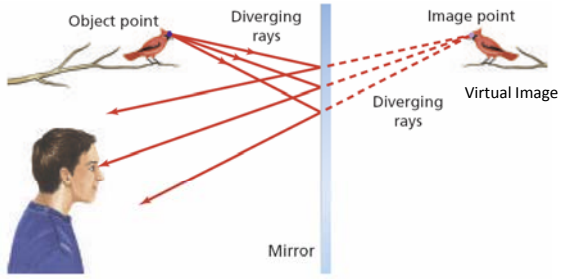
Diffuse Reflection– Reflection from a rough surface



ex. a sheet of paper

Normals are at different angles

Plane – Mirror Reflection



Plane-Mirrors always create a virtual image

Virtual Image- Image formed by light rays that only appear to intersect but do not really intersect. It is formed on the other side of a mirror.

Plane – Mirror Reflection

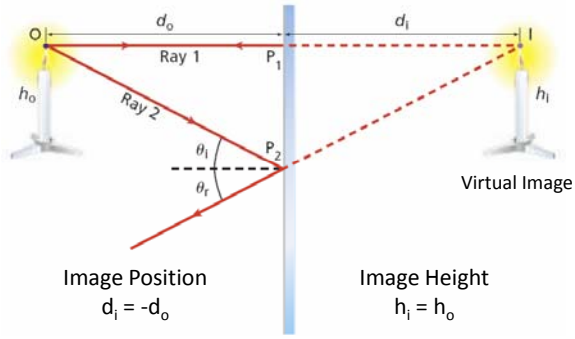
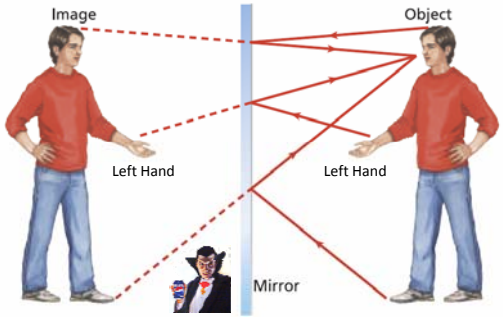


Image Position
$d_i = -d_o$

Image Height
$h_i = h_o$

The negative indicates it is a virtual image behind the mirror.

Image reversal



Vampires don't reflect

Curved Mirrors

Concave Mirror–edges curve toward the observer
Convex Mirror–edges curve away from the observer

Principle Axis – straight line perpendicular to the surface of the mirror that divides the mirror in half

Focal Point (F) – Point where incident rays that are parallel to the principle axis converge after reflecting from the mirror

Focal Length (f) – the position of the focal point with respect to the mirror along the principle axis
f = half the radius of curvature

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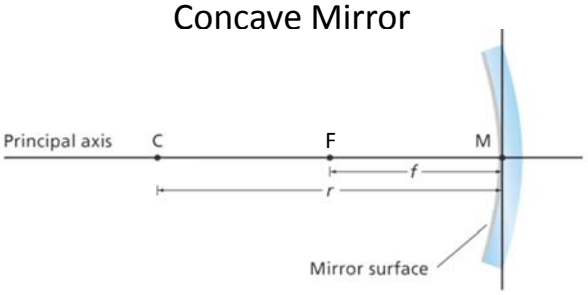
Concave Mirror



C = center of curvature
(if the mirror was a full circle, this would be the center)

r = radius of curvature (radius of full sphere)

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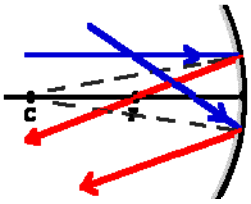
Concave Mirror Properties

- Focal Length is always positive and half of the radius $f = \frac{r}{2}$
- Incident rays parallel to the principal axis will pass through the focal point upon reflection.
- Incident ray passing through the focal point on the way to the mirror will travel parallel to the principal axis upon reflection.
- The Normal Lines always go through the C



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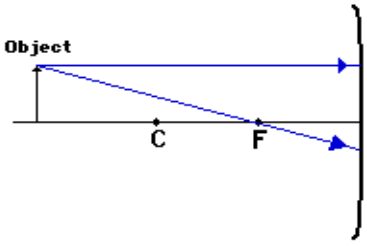
Rules for Concave Ray Diagrams

1. Pick a point on the top of the object and draw two incident rays traveling towards the mirror.
   - Draw one ray through the focal point, F, and to the mirror.
   - The Second should be drawn parallel to the principle axis



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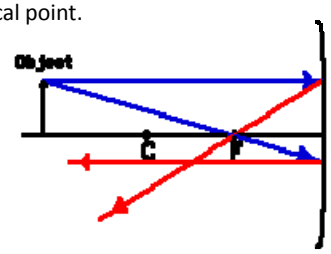
Rules for Concave Ray Diagrams

2. Next, Follow the rules of reflection for concave mirrors.
   - The ray that went through the focal point then reflects parallel to the principle axis
   - The ray that moved parallel will then reflect through the focal point.



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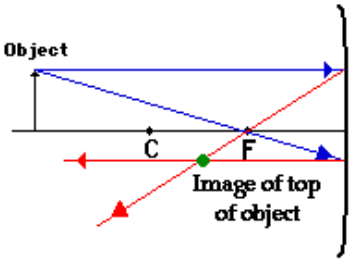
Rules for Concave Ray Diagrams

3. Mark the image of the top of the object.
   - This is the point where all light from the top of the object would intersect upon reflecting off the mirror.
4. Repeat steps for all points of the image.



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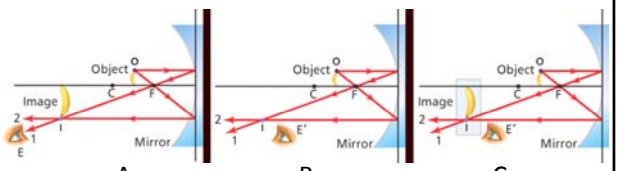
Viewing the Image

Real Image– image that is formed by the converging of light rays



A B C

A. Image seen by eye
B. Image cannot be seen
C. Real image appears on opaque screen

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Mirror Equation and Magnification

This image size and location can be found mathematically as well

- Mirror Equation : $\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$
- Magnification : $m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$

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Objects Locations

- Between F and C → a larger inverted image found past C
- At C → inverted image that is the same size
- Past C → smaller inverted image found between F and C
- Between F → larger erect virtual image behind mirror

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Object in front of F

1. Draw a line from F, through the tip of the object, to the mirror
2. Draw a line parallel to the optical axis from where this line hits the mirror and draw the line out past the back of the mirror.
3. Draw a line from the tip of the object straight to the mirror.
4. Draw a line from the F, through the point where the last line hit the mirror, and out past the mirror.

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Object in front of F

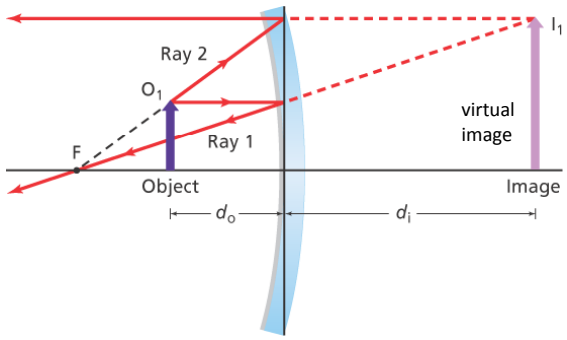

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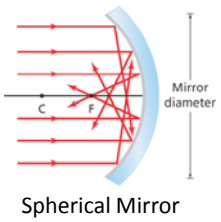
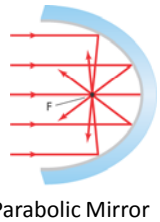
Image Defects

- **Spherical aberration** – a large spherical mirror with a small radius will look fuzzy, not sharp



Spherical Mirror



Parabolic Mirror

Parabolic mirrors can fix this

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Rules for Convex Ray Diagrams

1. Draw a line from F, through the tip of the object.
2. Draw a line parallel to the optical axis from where this line hits the mirror.
3. Draw a line from the tip of the object straight to the mirror.
4. Draw a line from the F, through the point where the last line hit the mirror

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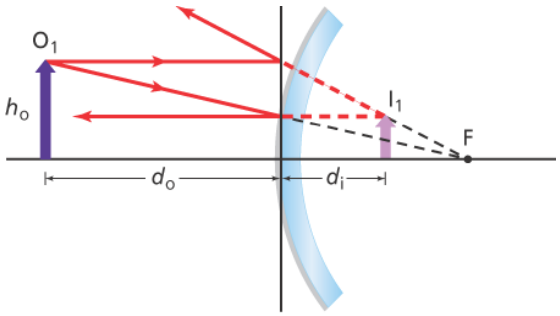
Convex Mirror



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Single Mirror Properties

Mirror Type	f	d_o	d_i	m	Image
Plane	N/A	$d_o > 0$	$\lvert d_i \rvert = d_o$ (negative)	Same size	Virtual
Concave	+	$d_o > r$	$r > d_i > f$	Reduced, inverted	Real
		$r > d_o > f$	$d_i > r$	Enlarged, inverted	Real
		$f > d_o > 0$	$\lvert d_i \rvert > d_o$ (negative)	Enlarged	Virtual
Convex	–	$d_o > 0$	$\lvert r \rvert > \lvert d_i \rvert > 0$ (negative)	Reduced	Virtual

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