

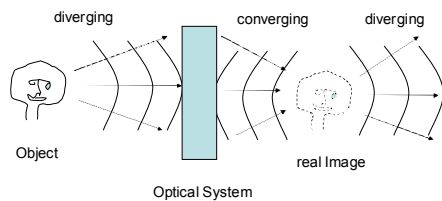
Image formation 4.3

- Images
 - real image
 - virtual image
- Image formation by mirrors, ray tracing
 - plane mirror
 - convex mirror
 - concave mirror
- Mirror equation

Object-Image

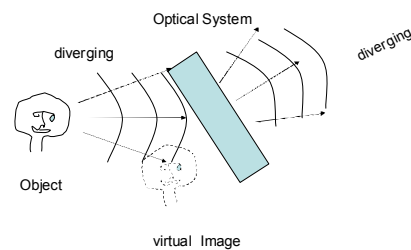
- A physical object is usually observed by reflected light that diverges from the object.
- An optical system (mirrors or lenses) can produce an image of the object by redirecting the light.
 - Real Image
 - Virtual Image

Real Image



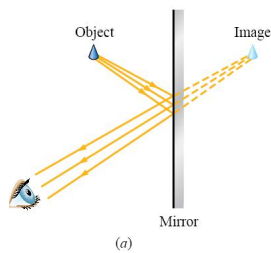
Light passes through the real image
Film at the position of the real image is exposed.

Virtual Image



Light does not pass through the virtual image
Film at the position of the virtual image is not exposed.

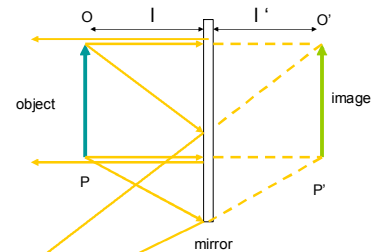
Image formed by a plane mirror.



Ray tracing – Trace the light rays coming from the object reflecting off the mirror (angle of incidence equal the angle of reflection)

The reflected rays appear to come from a virtual image.

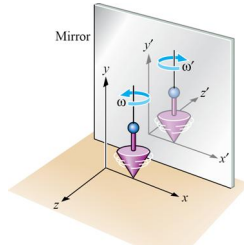
Each point on the image can be determined by tracing 2 rays from the object.



A virtual image is formed by a plane mirror at a distance l' behind the mirror.

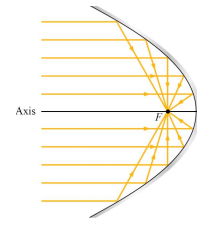
$$l' = -l$$

A mirror reverses front and back



- The z direction is reversed in the mirror image.
- The direction of rotation of a spinning top is reversed.
- Your right hand is the mirror image of your left hand.

Parabolic Mirrors



Parallel rays reflected by a parabolic mirror are focused at a point, called the Focal Point

Parabolic Reflector



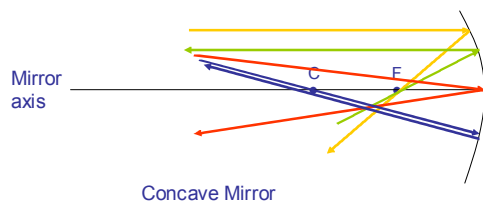
Parabolic mirrors can be used to focus incoming parallel rays to a small area or to direct rays diverging from a small area into parallel rays.

Spherical mirrors

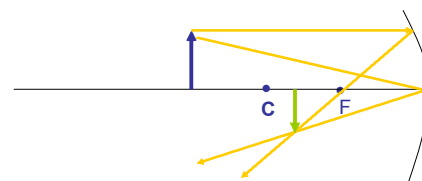
- Spherical mirrors can be used to form images
- Spherical mirrors are much easier to fabricate than parabolic mirrors
- A spherical mirror is an approximation of a parabolic mirror for small curvatures. (i.e. for paraxial rays –close to parallel to the optic axis.
- Spherical mirrors can be convex or concave

Ray tracing with spherical mirrors

- A ray parallel to the mirror axis reflects through the focal point, F.
- A ray passing through the focal point reflects parallel to the mirror axis
- A ray striking the center of the mirror reflects symmetrically around the mirror axis
- A ray that passes through the center of curvature C reflects and passes back through itself

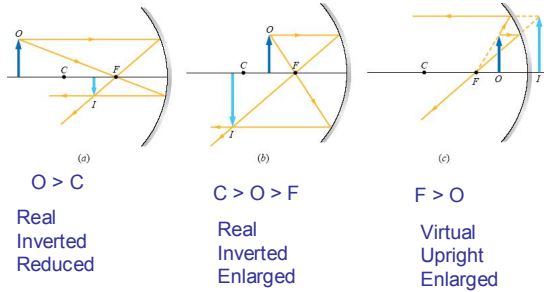


The position of the image can be determined from two rays from the object.



When object distance $>$ C, F
The image is real, inverted, reduced

Images formed by a concave mirror



Concave mirrors

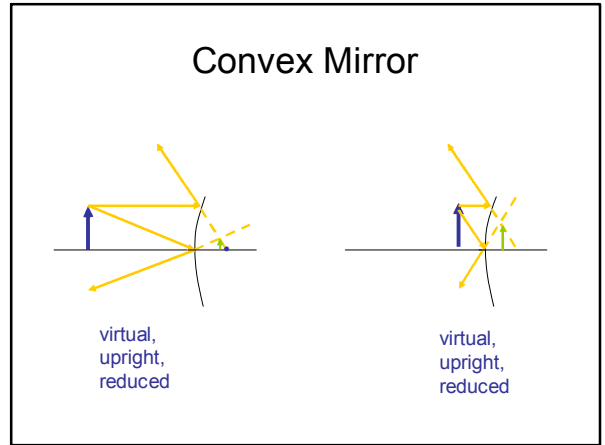
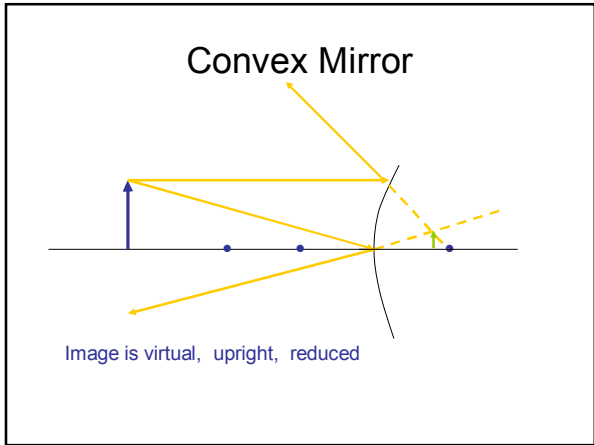
Simulation of image formation with concave mirrors

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/mirrors/concave.html>

Question

What image of yourself do you see when you move toward a concave mirror?





Convex mirror

Simulation of image formation with convex mirrors

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/mirrors/convex.html>

Question

Describe how your image would appear as you approach a convex mirror?



Mirror Equation

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

f is positive if the light from infinity goes through the focal point.
 f positive for concave mirrors, f negative for convex mirrors

The image distance l' is positive if the light goes through the image
 l' positive - real image l' negative - virtual image

Mirror equation. Special cases

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

When $f > 0$ concave mirror

$l = \text{infinity}$ $l' = f$ Real Image

$l = 2f$ $l' = 2f$

$l = f$ $l' = \text{infinity}$

Magnification

$$M = \frac{h'}{h} = -\frac{l'}{l}$$

M is negative if the image is inverted.

Question

A boy stands 2.0 m in front of a concave mirror with a focal length of 0.50 m. Find the position of the image. Find the magnification. Is the image upright or inverted?

Question

At what two distances could you place an object from a 10 cm focal length concave mirror in order to get an image 2 times the size of the object?

Question

When viewed from the earth the moon subtends an angle of 0.5 degrees. How large an image of the moon will be formed by the 3.6 m diameter Hawaiian telescope which has a focal length of 8.5 m.