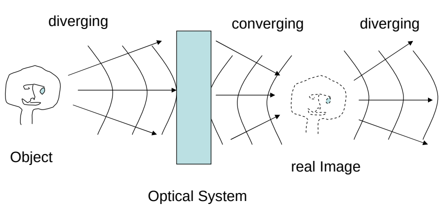
4.1 Mirrors

- Images
- Image formation by mirrors
- Plane mirror
- Curved mirrors.

Object-Image

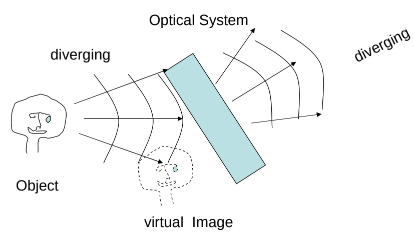
- A physical object is usually observed by reflected light that diverges from the object.
- An optical system (mirrors or lenses) can produce an image of the object by redirecting the light.
  - Real Image
  - Virtual Image

Real Image



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

Virtual Image



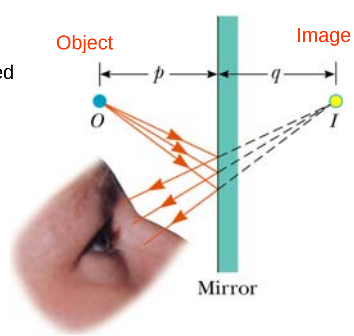
Light appears to come from the virtual image but does not pass through the virtual image

Film at the position of the virtual image is not exposed.

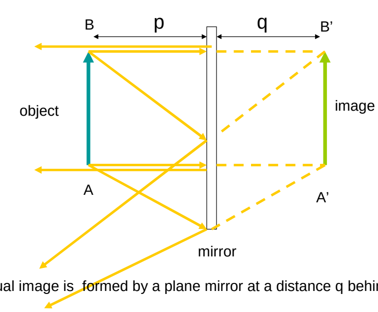
Image formed by a plane mirror.

The image is formed directly behind the mirror.

Light does not pass through the image



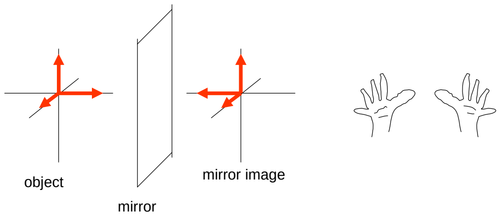
Each point on the image can be determined by tracing 2 rays from the object.



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

$q = -p$

A mirror reverses front and back

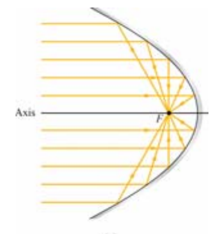


The mirror image is different from the object.

The z direction is reversed in the mirror image.

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 located on the optic axis.

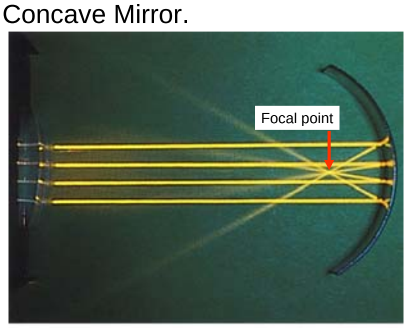
Parabolic Reflector

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

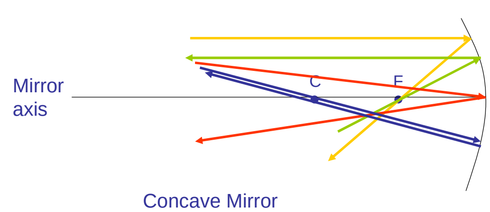
- Spherical mirrors can be used to form images
- Spherical mirrors are much easier to fabricate than parabolic mirrors
- A spherical mirror is an approximation of a parabolic mirror for small curvatures. (i.e. for paraxial rays –close to parallel to the optic axis.
- Spherical mirrors can be convex or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

Parallel beams focus at the focal point of a Concave Mirror.

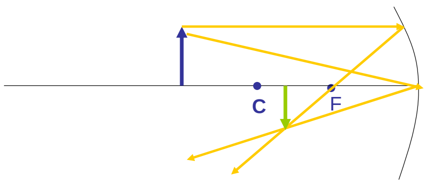


Ray tracing with a concave spherical mirrors

- A ray parallel to the mirror axis reflects through the focal point, **F** which is at a point half the radius distance from the mirror along the optic axis.
  F = R/2
- 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

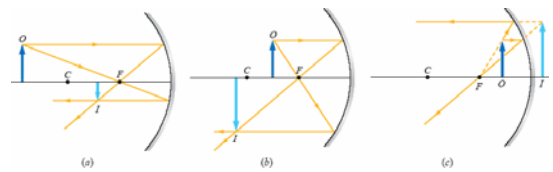


The position of the image can be determined from two rays from the object.



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

Images formed by a concave mirror

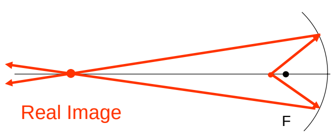


O > C
Real
Inverted
Reduced

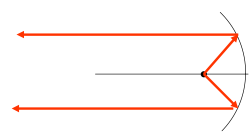
C > O > F
Real
Inverted
Enlarged

F > O
Virtual
Upright
Enlarged

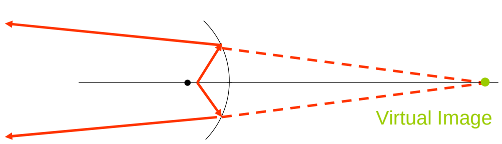
Why does the image goes from a real image to a virtual image when the object passes through the focal point?



Why does the image goes from a real image to a virtual image when the object passes through the focal point?



Why does the image goes from a real image to a virtual image when the object passes through the focal point?



Question

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

Convex Mirror

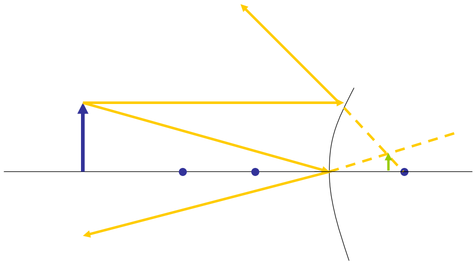
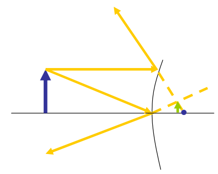
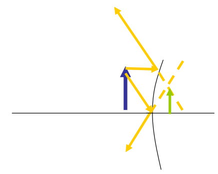


Image is virtual, upright, reduced

Convex Mirror

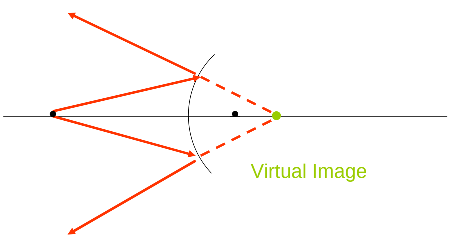


virtual,
upright,
reduced



virtual,
upright,
reduced

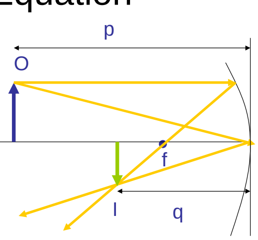
Why does the convex mirror always form a virtual image?



Question

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

Mirror Equation



$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

f is positive if the light from infinity goes through the focal point.
f positive for concave mirrors,
f negative for convex mirrors
q is positive if the light goes through the image – real image
q is negative if light does not go through image – virtual image

Mirror equation. Special cases

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

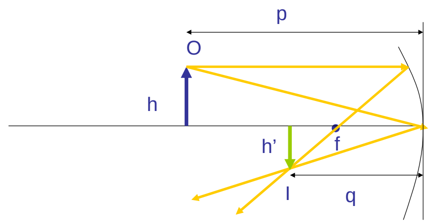
When $f > 0$ concave mirror

$p = \text{infinity}$ $q = f$ Real Image

$p = 2f$ $q = 2f$

$p = f$ $q = \text{infinity}$

Magnification



$$M = \frac{h'}{h} = -\frac{q}{p}$$

M is negative - the image is inverted.
M is positive – the image is upright.

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 real or virtual? Is the image inverted or erect?

Sign Conventions for Mirrors

TABLE 23.1

Sign Conventions for Mirrors

Quantity	Symbol	In Front	In Back	Upright Image	Inverted Image
Object location	p	+	−		
Image location	q	+	−		
Focal Length	f	+	−		
Image height	h'			+	−
Magnification	M			+	−

© 2006 Brooks/Cole - Thomson