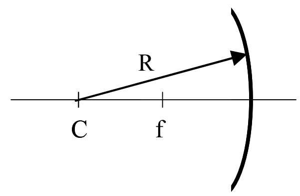
Geometrical Optics Review
Phys 375

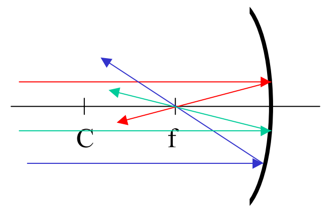
Mirrors

Spherical mirror – a section of a sphere

Principal Axis – A line drawn from the center of the sphere (C) to the center of the spherical segment. Note that C is a distance R from the spherical segment.



Rays from infinity parallel to the principal axis all go through the focal point, f.



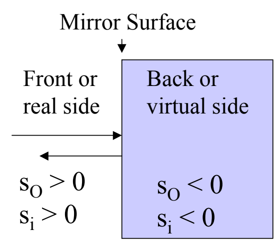
An object a distance s_O in front of the mirror will create an image a distance s_i from the mirror according to:

$$\frac{1}{s_O} + \frac{1}{s_i} = \frac{1}{f}$$

where f is the focal length of the mirror: $f = R/2$, where R is the radius of curvature of the spherical mirror. The lateral magnification is $M = -s_i/s_O$. $M < 0$ means that the image is inverted, $M > 0$ means that the image is upright.

Whenever light actually passes through a point, the image formed there is real. Otherwise the image is virtual (that is virtual images are formed by rays of light that appear to diverge from a point, even if they did not originate there – see below.)

Sign Convention for Mirrors:



For a concave mirror:

If the object is in front with $s_O > f$, the image is also in front (real) but is inverted.

If the object is in front with $s_O < f$, the image is behind (virtual) and upright.

$f < 0$ for convex mirror

$f > 0$ for concave mirror

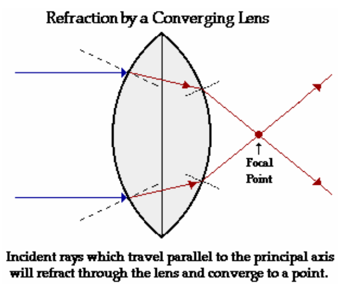
Ray-tracing rules for mirrors are summarized on page 32 of P^3.

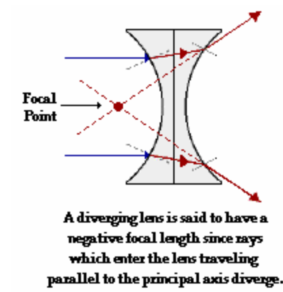
Lenses

Lenses are made up of refracting spherical surfaces or flat (R → ∞ spherical) surfaces. A principal axis can also be defined for lenses, as above. The lens equation is identical to the mirror equation above!

$$\frac{1}{s_O} + \frac{1}{s_i} = \frac{1}{f}$$

A group of rays approaching parallel to the optic axis will converge at the focal point of the lens. This defines the focal length f for the lens.

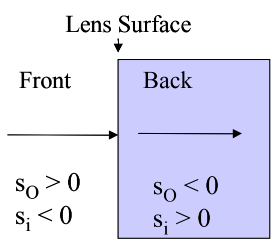




Sign Conventions:

$s_i > 0$ when the image is on the opposite side of the lens from the object.
$s_i < 0$ when the image is on the same side of the lens as the object.

$f > 0$ for a converging lens (Thicker in the middle than at the edges)
$f < 0$ for a diverging lens (Thinner in the middle than at the edges)



$$\frac{1}{s_O} + \frac{1}{s_i} = \frac{1}{f}$$

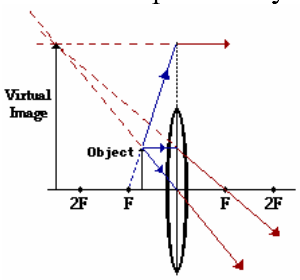
The lens-maker's equation is:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

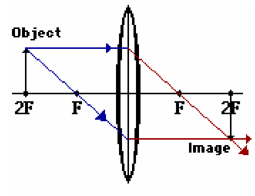
where n is the index of refraction of the lens, and R_1 and R_2 are the radii of curvature of the front and back surfaces of the lens, respectively.

As before, the lateral magnification is $M = -\, s_i/s_O$

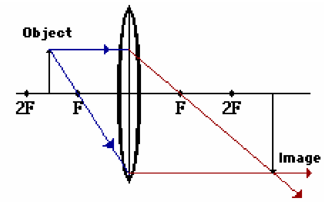
Some examples of ray tracing and image formation with thin lenses:



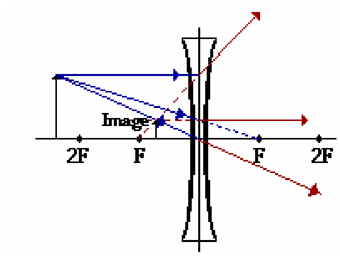
Ray Diagram for Object Located in Front of F



Ray Diagram for Object Located at 2F



Ray Diagram for Object Located Between F and 2F



Ray-tracing rules for thin lenses are summarized on pages 36-37 of P^3.