Raytracing Rules and Sign Conventions for Spherical Mirrors

1. A ray that is initially traveling parallel to the central axis of the mirror reflects back through the focal point.

2. A ray that initially passing through the focal point of the mirror reflects back parallel to the central axis.

3. A ray that passes through the center of curvature of the mirror reflects back upon itself.

4. A ray that strikes the intersection of the mirror and the central axis of the mirror is reflected symmetrically abut the central axis.

Formulas: $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$ $\qquad f = \frac{r}{2}$ $\qquad m = -\frac{s_i}{s_o}$

Sign conventions:

$s_o > 0$ if object is in front of mirror. (Real Object)

$s_o < 0$ if object is behind mirror. (Virtual Object)

$s_i > 0$ if image is in front of mirror. (Real Image)

$s_i < 0$ if image is behind mirror. (Virtual Image)

$f, r > 0$ if center of curvature is in front of mirror. (Concave Mirror)

$f, r < 0$ if center of curvature is behind mirror. (Convex Mirror)

Summary: s_o, $i, f, r > 0$ if they appear in front of the mirror. Otherwise, $s_o, s_i, f, r < 0$.

Magnification:

If $m > 0$, image is upright. If $m < 0$, image is inverted.

$|m| > 1$, image is enlarged. If $|m| < 1$, image in reduced.

s_o = Object distance
s_i = Image distance
f = Focal length
r = Radius of curvature
m = Magnification

Raytracing Rules and Sign Conventions for Refracting Surfaces

1. A ray bends toward (away from) the normal if it enters a region of higher (lower) refractive index.

2. A ray that is refracted toward (away from) the central axis with form a real (virtual) image.

Formulas: $\frac{n_1}{s_o} + \frac{n_2}{s_i} = \frac{(n_2 - n_1)}{r}$ for *spherical* refracting surfaces; $m = -\frac{n_1 s_i}{n_2 s_o}$

n_1 = refractive index of region of incident light
n_2 = refractive index of region of refracted light

Sign conventions:

$s_o > 0$ if object is in front of the lens. (Real Object) $s_o < 0$ if object is behind the lens. (Virtual Object)

$s_i > 0$ if image is behind the lens. (Real Image) $s_i < 0$ if image is in front of the lens. (Virtual Image)

$r > 0$ if incident light faces a convex surface
$r < 0$ if incident light faces a concave surface

Summary: $s_o > 0$ and s_i, r, < 0 if they appear in front of the lens.
$s_o < 0$ and s_i, r, > 0 if they appear behind of the lens.

Magnification:

If $m > 0$, image is upright. If $m < 0$, image is inverted.

$|m| > 1$, image is enlarged. If $|m| < 1$, image in reduced.

Raytracing Rules and Sign Conventions for Thin Lenses

1. A ray that is initially traveling parallel to the central axis of the lens will (would appear to) pass through the focal point for a converging (diverging) lens.

2. A ray that will (would appear to) initially pass through the focal point of the lens will emerge parallel to the central axis of a converging (diverging lens) lens.

3. A ray that is directed through the center of will emerge with no change in direction.

Formulas: $\frac{1}{s_o}+\frac{1}{s_i}=\frac{1}{f}$ $\qquad$ $\frac{1}{f}=\left(\frac{n_{lens}}{n_{med}}-1\right)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$ $\qquad$ $m=-\frac{s_i}{s_o}$

Sign conventions:

$s_o > 0$ if object is in front of the lens. (Real Object) $\qquad$ $s_o < 0$ if object is behind the lens. (Virtual Object)

$s_i > 0$ if image is behind the lens. (Real Image) $\qquad$ $s_i < 0$ if image is in front of the lens. (Virtual Image)

$f > 0$ for a Converging Lens. $\qquad$ $f < 0$ for a Diverging Lens.

Summary: $s_o > 0$ and $s_i, f, < 0$ if they appear in front of the lens.
$s_o < 0$ and $s_i, f, > 0$ if they appear behind of the lens.

Magnification:

If $m > 0$, image is upright. If $m < 0$, image is inverted.

$|m| > 1$, image is enlarged. If $|m| < 1$, image in reduced.