# Notes on Mirrors and Lenses (Chapter 31)

**Notation** (applied for both mirror and lens) – look at pictures in the book, since I can't draw in this file:
--- C: center of curvature, NOT center of the mirror/lens
--- R: radius of mirror/lens, measured along the mirror/lens axis from the center of the mirror/lens to the point C
--- f: focal length, measured along the mirror/lens axis from the center of the mirror/lens to the point F
--- s: distance from object to mirror/lens
--- s': distance from image to mirror/lens
--- h: height of object
--- h': height of image

Three **equations** to remember:

$$R = 2f$$
$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$
$$M = \frac{h'}{h} = -\frac{s'}{s}$$

where M is the called the *magnification* of the mirror/lens

The location of the image is the intersection of two rays from the top of the image, so we need to draw at least two *reflected* rays for mirror (or *refracted* rays for lens), using the ray tracing rules.

The actual rays don't always intersect, in which case we use dash lines to extend the rays to make them intersect to locate the image. The dash line rays are not real, therefore the image is virtual. A real image can be captured on a screen, a virtual image cannot.

**Ray tracing rules for mirrors**:
1. Ray parallel to the mirror axis *reflects* through F.
2. Ray passing through F reflects parallel to the axis.
3. Ray striking the center of mirror reflects symmetrically about the axis (incident angle equals reflected angle).
4. Ray passing through C returns on itself (the reflected ray is the same as the incident ray).
(It is most convenient to use the first two rays to locate the image)

**Ray tracing rules for lens**:
1. Ray parallel to the mirror axis *refracts* through F.
2. Ray passing through the center of lens goes undeflected (continues on a straight line).

Notice that a concave lens has F on the same side with the object, so concave lens is diverging. A convex lens has F on the opposite side with the object, so it's converging.

**Sign convention**: (a numerical check on the properties of the image to compare with the result obtained from ray tracing)

--- s is always positive
--- $h' > 0$: upright image;
--- $h' < 0$: inverted image
--- $|M| = \left|\frac{h'}{h}\right|$: if $|M| < 1$: reduced image; if $|M| > 1$: enlarged image

| | Mirror | Lens |
|---|---|---|
| Concave | $f > 0$ | $f < 0$ |
| Convex | $f < 0$ | $f > 0$ |
| Real image | $s' > 0$ (image and object are on the same side of the mirror, i.e. image is in front of the mirror) | $s' > 0$ (image and object are on opposite sides of the lens) |
| Virtual image | $s' < 0$ (image and object are on opposite sides of the mirror, i.e. image is behind the mirror) | $s' < 0$ (image and object are on the same side of the lens) |