How does depth perception work? When light strikes and object it scatters light in all directions. Some of this light hits your eyes. Light hitting your left eye does so at a slightly different angle than light hitting your right eye. Your brain can trace these rays of light back to their source. However, if something causes the light to bend out brain will trace these rays of light back to an image that might be in a different position than the actual object.

We will start with spherical mirrors. These mirrors will have a radius of curvature r and a focal length of $f = \frac{r}{2}$. The focal point is located half-way between the center of curvature and the mirror. Concave mirrors will have a positive focal length while convex mirrors will have a negative focal length. The simple rule is that the side where the light goes is the positive side. For a concave mirror light will reflect back to the side of the mirror where the center of curvature is located; for a convex mirror it will reflect back away from the side where the center of curvature is located.

We draw our object as an arrow. We draw the optical axis as the line passing through both the tail of the object and the center of curvature (and also the focal point). We then draw rays of light leaving the tip of the arrow. Our eye will trace back the rays to the point from which they appear to emanate. This is the tip of the image.

- Rays that are parallel to the optical axis reflect back through the focal point.
- Rays that pass through the focal point reflect back parallel to the optical axis.
- Rays that pass through the center of curvature reflect straight back.
- Rays that hit the mirror at the optical axis reflect at the same angle

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$: s is the object distance. It will always be positive (for the case of a single mirror). s' is the image distance. It will be positive if the image is on the same side of the mirror as the object and negative if it is on the opposite side. $m = \frac{h'}{h}$ is the magnification: the ratio of the perceived height of the image to the height of the object. This is given by $m = -\frac{s'}{s}$. When the magnification is negative the image will be inverted (upside down).

Real images have a positive image distance. Rays of light actually cross at the image. This image could project onto a screen or develop film in a camera. Virtual images have a negative image distance. Our eyes trace the rays back to the image, but the actual light rays don't cross there.

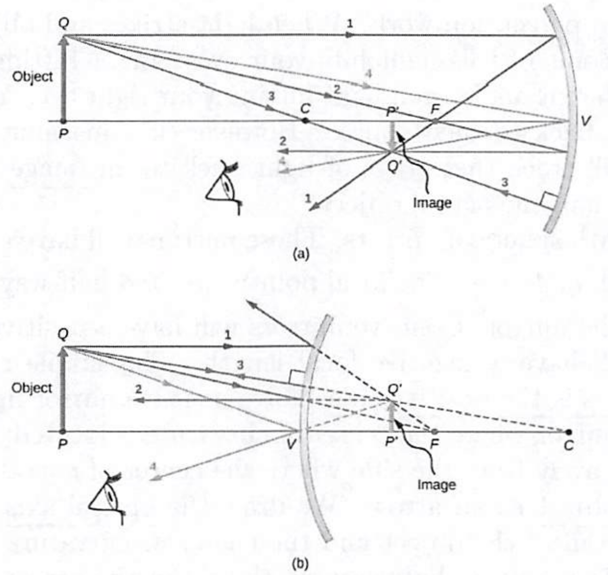

Figure 1:
Figure 2.9 from *OpenStax University Physics Volume 3.* Read for free at openstax.org.

We have a concave mirror with $r = +24$ cm. $f = \frac{r}{2} = +12\text{cm}$

(a) The object distance is 15 cm. What is the magnification? Is this image real or virtual?

$\frac{1}{15\text{cm}} + \frac{1}{s'} = \frac{1}{12\text{cm}}$ $s' = 60\text{cm}$

$m = -\frac{60\text{cm}}{15\text{cm}}$ $\boxed{m = -4}$ Real

(b) The object distance is 9 cm. What is the magnification? Is this image real or virtual?

$\frac{1}{9\text{cm}} + \frac{1}{s'} = \frac{1}{12\text{cm}}$ $s' = -36\text{ cm}$ $\boxed{m = +4}$ Virtual

$m = -\frac{-36\text{cm}}{9\text{cm}} = 4$

We have a convex mirror with $r = -24$ cm. $f = r/2 = -12\text{cm}$

(c) The object distance is 15 cm. What is the magnification? Is this image real or virtual?

$\frac{1}{15\text{cm}} + \frac{1}{s'} = \frac{1}{-12\text{cm}}$ $s' = -6.667\text{cm}$ $\boxed{m = +0.444}$

$m = -\frac{-6.6667\text{cm}}{15\text{ cm}} = +0.444$ Virtual

(d) The object distance is 9 cm. What is the magnification? Is this image real or virtual?

$\frac{1}{9\text{cm}} + \frac{1}{s'} = \frac{1}{-12\text{cm}}$ $s' = -5.143\text{cm}$

$m = -\frac{-5.143\text{ cm}}{9\text{cm}} = \boxed{+0.571}$ Virtual