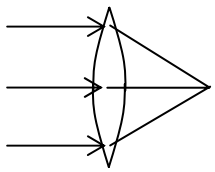
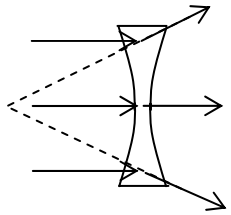
4–25 Geometric Optics

Lenses and Mirrors: Mirrors reflect light and lenses transmit light. They both fall into two main categories. **Converging** lenses and mirrors converge parallel rays of light on the focal point, and thus the focus is $+f$. **Diverging** lenses and mirrors diverge parallel rays of light away from the focus, with a $-f$. The shapes, convex and concave are secondary, but must be memorized.

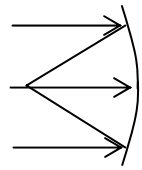
Converging Lense, +*f*
Convex Lense



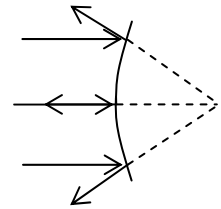
Diverging Lense, -*f*
Concave Lense



Converging Mirror, + *f*
Concave Mirror



Diverging Mirror, - *f*
Convex Mirror



Spherical Lenses and Mirrors: We are working with lenses & mirrors that have been cut from spheres. Each curved surface has a center of curvature. The focal point is located half way between the center of curvature and the lens or mirrors surface. Focal distance is measured from lens or mirror surface to the focal point. $\boxed{F = r/2}$ and the distance to the center is $\boxed{C = 2F}$.

Ray Tracing: Remember light goes through the lens, while it bounces off mirrors.

Rules for Lenses: Rays arriving parallel to the optical axis, either converge on the far focus or diverge from the near focus.

Rays that go through the center of the lens keep going straight.

Rules for mirrors: Rays arriving parallel to the optical axis, either converge on the near focus or diverge from the far focus.

Rays arriving through the focus, go out parallel.
Rays that go through the center of curvature bounce ($C = 2F$) bounce straight back.

Images: Two types of images are formed by light interacting with lenses and mirrors. To find the location and the size of an image use ray tracing practiced in the following worksheet. If the ***forward ray traces*** touch (converge to create an image) the image is considered **real** and has a positive distance from the lens, $+s_i$. ***Real images can be projected on a screen***. ***Real images are always inverted***. But, when rays diverge (separate) the forward ray traces will not intersect. You then must draw a **back ray trace** through the other focus. In this case the image is **virtual**, and since it resulted from the intersection of the negative ray traces it has a negative distance, $-s_i$. ***Virtual images are always upright.***

Converging Lens / Mirror: Object outside of focus	Converging Lens / Mirror: Object at focus	Converging Lens / Mirror: Object inside of focus	Diverging lens / Mirror
Real Images, $+s_i$	No Image: $s_i = \infty$	Virtual Image, $-s_i$	
Inverted, $-h_i$, and $-M$	$f = s_o$	Upright, $+h_i$, and $+M$	

Geometric Optics

$\boxed{f = \frac{r}{2}}$ The center of curvature is located at $2f$. So the focal point is half of the radius. $\boxed{\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}}$ Shows the geometric relationship between the focal length, object distance, and image distance. $\boxed{M = \frac{h_i}{h_o} = -\frac{s_i}{s_o}}$ Relates the magnification to the height of the object and image, and the distance to each. The only conversions needed are in cases where you lack unit agreement. Variables are either all the same or they cancel out. Centimeters are commonly used in optics. The magnification formula tells the relationship between s_i and h_i. These variables always have the opposite sign. Remember negative M does not mean the image is smaller. It means the image is upside down. 0.5x is a smaller image and upright, while –2.0x is a larger inverted image.

For example problems complete the Geometric Optics Worksheet.

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