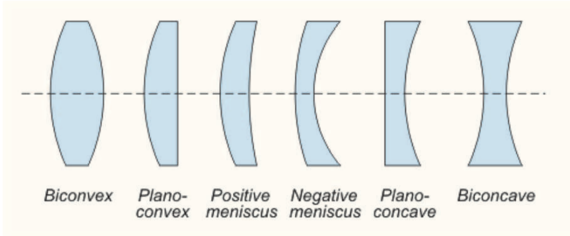
Optical Lenses 101

A **lens** is an optical device that transmits and refracts light (i.e. electromagnetic radiation). Lenses are typically made of glass or plastic, but can be made by any material that transmits electromagnetic radiation, for example silicon transmits in the infrared range. An important characteristic of the material used for a lens is its **index of refraction** (n), which is a measure of how fast light travels in the glass. This determines how much light will bend or refract in the lens.

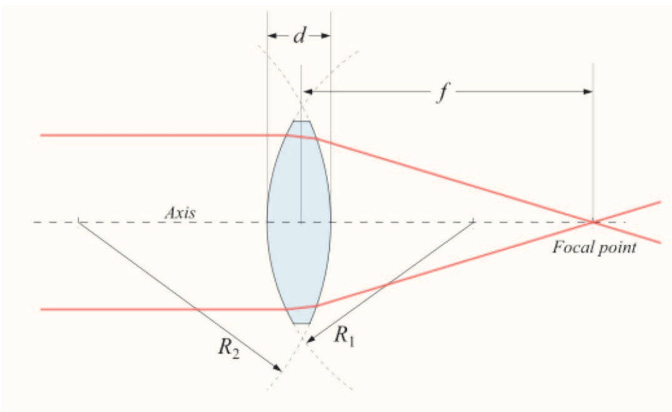
Advanced Glass Industries is a premier supplier of optical lens blanks. Advanced Glass Industries makes lens blanks out of fused silica, fused quartz, and optical glass.

Early uses of lenses were limited to magnifying glasses, burning lenses for starting fires, and eyeglasses. Today precision lenses are integral components of the optical systems used in many high-tech markets that serve us daily. Advanced Glass Industries supplies lens blanks for use in the following markets: Defense/Military, Aerospace, Lighting, Automotive, Medical, Semiconductor, Telecommunication, Education, Research, Manufacturing, Lasers, and more!

Lenses may take a variety of shapes and are described by their curvature. Each side of a lens may be plano (no curvature), spherical, cylindrical, toroidal, parabolic, or aspheric. Lens surfaces with curvature (i.e. not plano) may be described as convex (curving outward) or concave (curving inward). Different combinations of surfaces have different names. The drawing at right demonstrates some common shapes.



Many of the lens blanks manufactured at AGI are spherical. A spherical surface is described by its radius of curvature (i.e. the radius of the sphere the surface follows). Some commonly used properties of lenses and their calculations for spherical lenses are described below. For more formulas, check out our simple lens approximations reference chart.



Positive (converging) lens

The **focal length** of a lens is the distance over which initially collimated rays are brought to a focus at the focal point. Using the Lensmaker's Equation, focal length can be computed as:

$$\frac{1}{f}=(n-1)[\frac{1}{R_1}-\frac{1}{R_2}+\frac{(n-1)t}{nR_1R_2}]$$

where f is the focal length, n is the index of refraction of the lens material, R_1 is the radius of curvature of the first side, R_2 is the radius of curvature of the second side, and t is the thickness of the lens.

In cases where the radii of curvature of side 1 and side 2 are large compared to the thickness of the lens, the third term in the equation becomes negligible and the Thin Lens approximation can be used:

$$\frac{1}{f}=(n-1)[\frac{1}{R_1}-\frac{1}{R_2}]$$

The focal length of a compound lens system of two lenses in air is given by:

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$$

where f is the focal length of the compound system, f_1 is the focal length of the first lens, f_2 is the focal length of the second lens, and d is the distance in air between the two lenses.

In cases where the distance between the two lenses is small, the third term in the equation becomes negligible and the focal length can be approximated by:

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$$

The **f-number** of a lens is also referred to as the focal ratio, f-ratio, or f-stop of a lens is a ratio of the focal length, f, to the diameter of the lens, D, computed as:

$$F-number=\frac{f}{D}$$