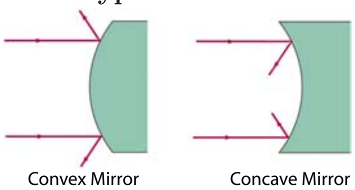
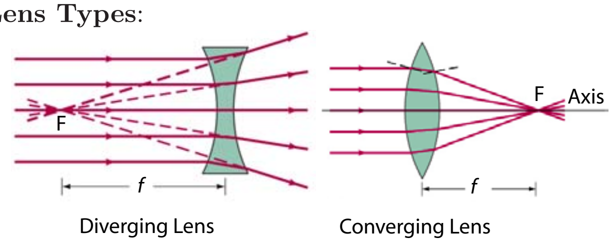
Physics 21
Fall, 2004

Optics

Mirror Types:



Lens Types:



The Mirror Equation:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

- f is positive for concave mirrors and negative for convex mirrors.
- When the object, image, or focal point is on the reflecting side of the mirror, the corresponding distance is positive. If any of these points is behind the mirror, the corresponding distance is negative.
- h_i is positive if the image is upright, negative if inverted.

The Lens Equation:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

- f is positive for converging lenses and negative for diverging lenses.
- d_o is positive if object is on the side of the lens from which the light comes; otherwise negative.
- d_i is positive if it is on the opposite side of the lens from which the light comes; otherwise negative. Equivalently, d_i is positive negative) for a real (virtual) image.
- h_i is positive if the image is upright, negative if inverted.

Ray Tracing for Lenses and Mirrors:

- Ray 1 is parallel to the axis; after reflection/refraction it must pass through F. For a lens, you must determine which of the two F's the ray passes through.
- Ray 2 or its extension passes through the appropriate F and reflects/refracts so that it is parallel to the axis.
- Ray 3 passes through the center of curvature of a mirror or the center of a lens.

Refraction at a Spherical Surface:

$$\frac{n_1}{d_o} + \frac{n_2}{d_i} = \frac{n_2 - n_1}{R}$$

Snell's Law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Total internal reflection:

$$\sin\theta_c = \frac{n_1}{n_2} \qquad (n_1 < n_2)$$

Lensmakers Equation:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Focal ratio:

Lens or mirror diameter D is often expressed using the focal ratio or f-number:

$$f\text{-number} = f/D$$

Magnification of an Astronomical Telescope:

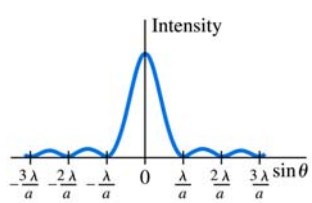
$$M = -f_o/f_e$$

Interference:

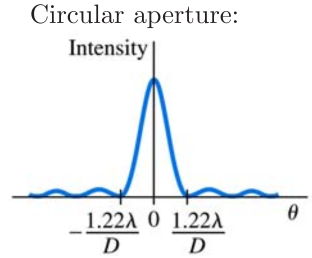
$$d\sin\theta = \begin{cases} m\lambda & \text{constructive} \\ (m+\frac{1}{2})\lambda & \text{destructive} \end{cases}$$

Diffraction Patterns:

One slit:



Circular aperture:



The diagram for one slit contains essentially the same information as the equation that $a\sin\theta = m\lambda$ for a minima.

Phase change:

When light propagates from one medium (n_1) to another (n_2), there is a 180° phase change in the reflected wave if $n_2 > n_1$.

Polarization:

$$I = I_0 \cos^2\theta$$

LEHIGH UNIVERSITY

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