Mirrors and Lenses

Mirrors and lenses can be convex or concave.

- The inside of a sphere is a concave mirror and the outside of a sphere is a convex mirror.
- Convex lenses are thicker in the middle and concave lenses are thinner in the middle.
- Converging lenses are convex and converging mirrors are concave.
- Diverging lenses are concave and diverging mirrors are convex.

Images can be real or virtual, upright or inverted.

- For one lens, real images are always inverted, virtual images are always upright
- A concave lens and a convex mirror always produce a virtual image
- The real side of a concave mirror is the same side as the object
- The real side of a convex lens is the side opposite the object

Here are the terms used to describe mirrors and lenses.

- s_o=position of object, always positive
- s_i=position of image, positive for real images, negative for virtual images
- f=focal length, positive for converging mirrors and lenses, negative for diverging mirrors and lenses
- h_o = height of object
- h_i = height of image, positive for upright images, negative for inverted images

Here are the two main equations for mirrors and lenses. The magnification has a sign and a magnitude, the sign determining whether the image is upright or inverted, the magnitude the amount of magnification.

- $\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$

- Magnification $= m = -\frac{s_i}{s_0} = \frac{h_i}{h_o}$
  - If the magnification is positive the image is upright, if negative the image is inverted.

The way to solve a mirror or lens problem is to use the facts in the description to determine the signs of the appropriate variables and then use the mirror equations to find the unknown quantities.

Double slit experiment

- X is the distance between bands of constructive interference
- λ is the wavelength
- d is the distance between slits

$$\lambda = \frac{dX}{L}$$

- n is the order of the constructive band
- Θ_n is the angle between the n^{th} constructive band and the central maximum

$$d\sin(\Theta_n) = n\lambda$$

- θ_n is the angle between the n^{th} destructive band and the central maximum

$$d\sin(\theta_n) = (n + 1/2)\lambda$$

Standing Waves

- Closed at both ends
  - L is the length of the string
  - λ_n is the wavelength of the nth harmonic

$$\lambda_n = \frac{2L}{n}$$

- Closed at one end, open at one end
  - L is the length of the string

  - λ_n is the wavelength of the *nth* harmonic

$$\lambda_n = \frac{4L}{2n-1}$$

Velocity of waves on strings

- T is the tension of the string
- μ is the linear mass density of the string
- ν is the velocity of waves on the string

$$\nu = \sqrt{\frac{T}{\mu}}$$

Doppler shift

- f_s is the frequency of the wave emitted by the source
- f_r is the frequency of the wave received by the receiver
- v_r is the velocity of the receiver, positive (negative) if approaching (receding from) the source
- v_s is the velocity of the source, positive (negative) if approaching (receding from) the receiver
- v is the velocity of waves in the medium

$$f_r = \frac{v + v_r}{v - v_s} f_s$$