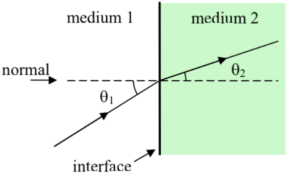
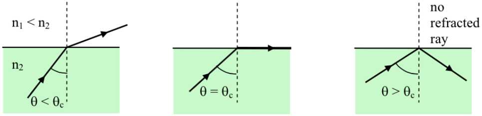
Refraction:

$$\boxed{\textbf{Snell's Law:}\quad n_1 \sin\theta_1 = n_2 \sin\theta_2}$$

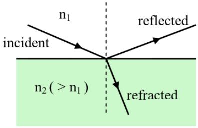
index of refraction $\boxed{n = \frac{c}{v}} = \frac{\text{speed of light in vacuu}}{\text{speed of light in the me}}$



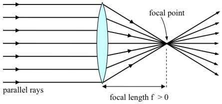
Total internal reflection:



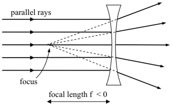
Reflection and refraction:



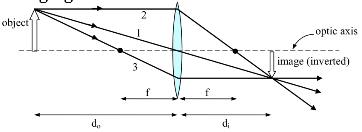
Converging lens



Diverging lens

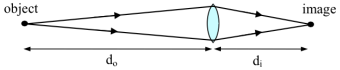


Imaging with lenses:



Lens equation:

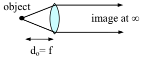
d_o = distance from object to lens $\quad$ d_i = distance from image to lens

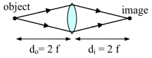


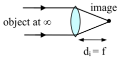
d_o, d_i, and focal length f are related by the image equation: $\boxed{\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}}$

Special cases:

- $d_o = \infty \Rightarrow d_i = f$ [if object very far away, then image is 1 focal length from the lens]
- $d_o = f \Rightarrow d_i = \infty$
- $d_o = 2f \Rightarrow d_i = 2f$ since $\frac{1}{2f} + \frac{1}{2f} = \frac{1}{f}$

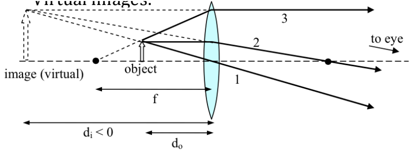






Standing waves in a pipe:
L = wavelength/4, L = 3 wavelength/4, L = 5wavelength/4
L = (2n-1)*wavelength/4
$f_n = (2n - 1)(v) / 4L$

Virtual images:



Doppler effect

If the source is moving toward you:

$$f_{observed} = \left[\frac{v}{v - v_{source}}\right] f_{source}$$

If the source is moving away from you:

$$f_{observed} = \left[\frac{v}{v + v_{source}}\right] f_{source}$$

Standing wave:
$L = (n-1)/2 * \lambda$