The Refraction of Light

Index of Refraction: \[ n = \frac{\text{speed of light in vacuum}}{\text{speed of light in the material}} = \frac{c}{v} \]

Snell’s Law: \[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

Total Internal Reflection:
\[ \Rightarrow \text{total internal reflection can only occur if } n_2 < n_1 \]

Critical Angle: \[ \theta_c = \sin^{-1} \left( \frac{n_2}{n_1} \right) \]

Images from Lenses:
\[ \Rightarrow \text{a diverging lens always produces a virtual, reduced, and upright image} \]
\[ \Rightarrow \text{a converging lens can produce a:} \]
\[ \begin{align*}
\text{a real, enlarged, inverted image (if object is between F and 2F)} \\
\text{a real, reduced, inverted image (if object is beyond 2F)} \\
\text{a virtual, enlarged, upright image (if object is between F and lens)}
\end{align*} \]
\[ \Rightarrow \text{from a single lens, real images are always inverted and virtual images are always upright} \]

Thin Lens and Magnification Equations:
\[ \text{thin lens equation: } \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \quad \text{magnification equation: } m = \frac{h_i}{h_o} = -\frac{d_f}{d_o} \]
\[ f > 0 \quad \text{converging lens} \]
\[ f < 0 \quad \text{diverging lens} \]
\[ d_o > 0 \quad \text{real object (on the left of the lens)} \quad d_i > 0 \quad \text{real image (on the right of the lens)} \]
\[ d_o < 0 \quad \text{virtual object (on the right of the lens)} \quad d_i < 0 \quad \text{virtual image (on the left of the lens)} \]
\[ m > 0 \quad \text{image is upright} \quad |m| > 1 \quad \text{image is enlarged} \]
\[ m < 0 \quad \text{image is inverted} \quad |m| < 1 \quad \text{image is reduced} \]

Lenses in Combination:
\[ \Rightarrow \text{the image produced by the first lens serves as the object for the second lens} \]