
   (a) Work out the relationship between the source and image positions in figure 1 using the Fermat Principle of minimizing the optical path length:

   \[ \text{OPL} = n_1 \ell_o + n_2 \ell_i, \]  

   where \( n_1 \) and \( n_2 \) are the index of refraction of air and glass respectively. Hint: keep S and P constant and minimize the path length with respect to \( \theta \). You will derive the relationship:

   \[ \frac{n_1}{\ell_o} + \frac{n_2}{\ell_i} = \frac{1}{R} \left( \frac{n_2 s_i}{\ell_i} - \frac{n_1 s_o}{\ell_o} \right). \]  

   (b) What is the small angle limit of this formula?

2. Orientation of lenses. Figure 2 shows two plano-convex lenses. How could the configuration of the lenses be changed to reduce spherical aberrations? Hint: The paraxial limit is the small incident angle limit for each ray. Remember to treat the refraction of both surfaces of the lens as incident.

3. Finite Imaging. Use geometrical optics to graphically find the positions of the imaged objects.
Figure 1: The figure shows light refracted by a single air-light interface.

Figure 2: How could the configuration of the lenses be changed to reduce aberrations.
Figure 3: Use geometrical optics to graphically find the positions of the imaged objects.