Contemporary Microscopy and Biophotonics
BioEn 498/599, Phys 427B
Problem Set #2

Due 4/19/2017

1. **Single refracting surface.**

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

   $$\mathrm{OPL} = n_1 \ell_o + n_2 \ell_i, \tag{1}$$

   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 θ. You will derive the relationship:

   $$\frac{n_1}{\ell_o} + \frac{n_2}{\ell_i} = \frac{1}{R}\left(\frac{n_2 s_i}{\ell_i} - \frac{n_1 s_o}{\ell_o}\right). \tag{2}$$

   (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.

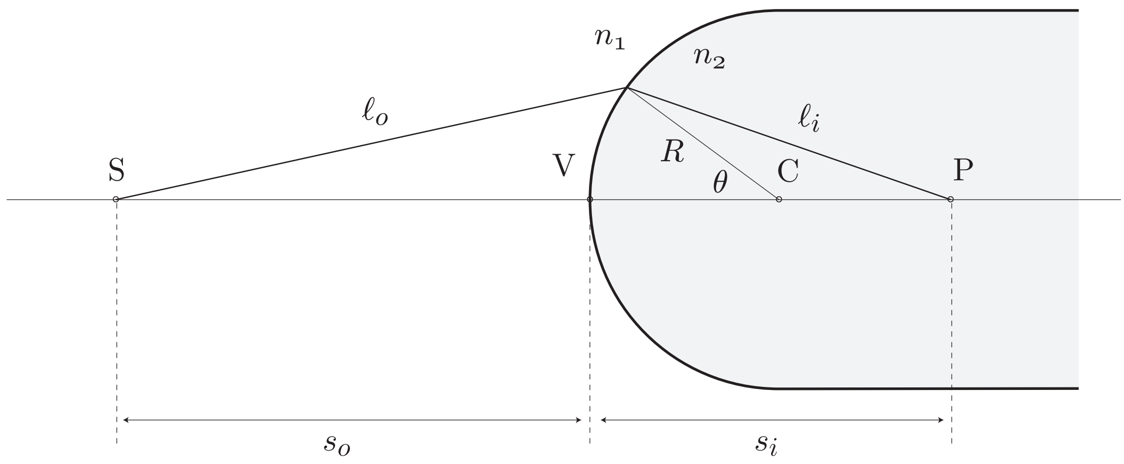

Figure 1: The figure shows light refracted by a single air-light interface.

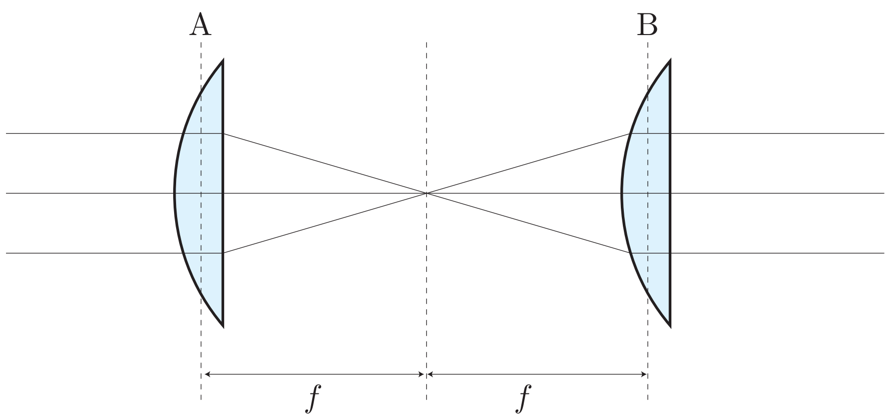

Figure 2: How could the configuration of the lenses be changed to reduce aberrations.

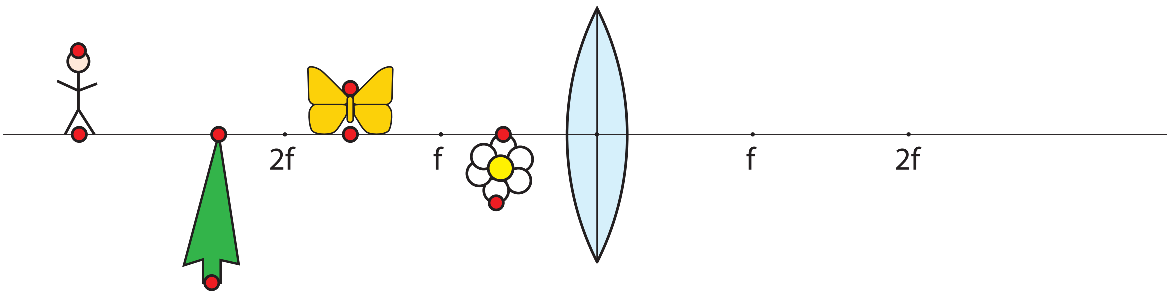

Figure 3: Use geometrical optics to graphically find the positions of the imaged objects.