1. Consider an optical system consisting of two thin lenses, both with index of refraction $n_\ell = 1.5$. The first lens is bi-convex with the same radius of curvature $R_1 = 10$ cm on both sides. The second lens is bi-concave with the same radius of curvature $R_2 = -20$ cm on both sides. If the lenses are separated by a distance $d = 5$ cm, how far from the second lens will an image be formed if an object is placed 50 cm in front of the first lens? *Please draw a diagram.*

2. Referring to problem (1), calculate the ray-tracing matrices that represent the following:

1. propagation 50 cm from the object position to the first lens

2. refraction through the first thin lens

3. propagation 5 cm to the second lens

4. refraction through the second thin lens

5. propagation an unknown distance s_i to the final image position

   Then, calculate the system matrix and solve for s_i when the initial and final rays are

$$y_i = \begin{pmatrix} \alpha \\ 0 \end{pmatrix}$$

$$y_f = \begin{pmatrix} \alpha' \\ 0 \end{pmatrix}.$$

You'd better get the same answer you got for question (1).

3. Calculate the position of the image if the lenses were 1 cm thick, but located in the same positions. Draw a diagram of the whole system and identify the ray tracing matrices that describe each transformation. Then multiply them to calculate the system matrix and solve for the image position that gives the final ray, y_f.

The answer should be within a couple of centimeters from what you calculated in questions (1) and (2).

4. An aperture stop with a diameter of 2 cm is placed on the optical axis with no other optical elements between it and an object which is placed a distance of 20 cm away.

(a) Calculate the angular extent of the entrance pupil through this aperture stop.

(b) A thin lens with focal length $f = 10$ cm is placed mid-way between the object and the aperture stop. Calculate the angular extent of the entrance pupil through this configuration of the optical system.

Draw a diagram!