1. A pair of thin lenses are used to create a telephoto lens system. The front lens has a focal length of 37 c.m. and the back lens has a focal length of -25.5 c.m. The separation between the two lenses is 19 c.m.

a) Find the equivalent focal length, the location of the principal planes, and the front and back focal points. Make a sketch roughly to scale of the lens, the principal planes, and the front and back focal points, labeling the relevant distances.

b) If an object is placed 12.0 meters in front of the front vertex, what will be the location relative to the back vertex of the image and what will be the magnification? Add the image to the sketch with the object and image distances labeled.

3) Two lenses are characterized by the system matrices:

$$M_1 = \begin{bmatrix} .8 & 2. \\ -.06 & 1.1 \end{bmatrix}$$

$$M_2 = \begin{bmatrix} .9 & 1.5 \\ -.053 & 1.2 \end{bmatrix}$$

where the units are c.m. If the two lenses are separated by 10 c.m., what is the system matrix for the whole system, and where are the principle planes located? (M1 is in front).

1. A thick lens used in air is double convex with an index of refraction n=1.6, a thickness of 6.0 c.m. and |R1|=40.0 c.m. and |R2|=20.0 c.m.

a) Find the equivalent focal length, the location of the principal planes, and the front and back focal points. Make a sketch roughly to scale of the lens, the principal planes, and the front and back focal points, labeling the relevant distances.

c) If an object is placed 25.0 c.m. from the front vertex, what will be the location relative to the back vertex of the image and what will be the magnification? Add the object and image to the sketch with the object and image distances labeled.

2. A plano-concave lens is used between water (n=1.33) on its front planar surface and air at the back concave surface. The lens glass has an index of 1.63 and a thickness of 4.0 c.m. The back surface has a radius of curvature |R2|=30.0 c.m.

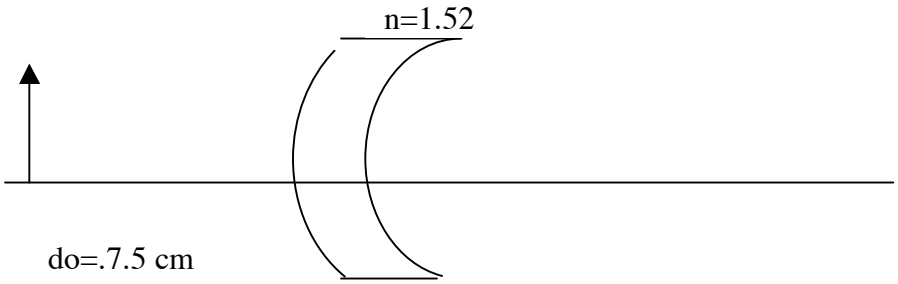
Find the system matrix for this lens. Find the principle planes.

1. A thin lens of power +4.1 diopters is followed after a space of 13. cm by a thin lens of power -10. diopters in a certain optical system. Find the system matrix for this system by explicit matrix multiplication. Then find the image location and magnification for an object placed 2.1 meters in from of the first lens.

Two thin lenses of power 5 diopters and 10 diopters are situated 4 cm apart.

a) Find the equivalent focal length for this system.

b) If an object is located 5 cm in front, where is image point?



t=0.4 cm

$|R1| = 6.7cm$

$|R2| = 3.4cm$

Find the system matrix for the lens as pictured. Locate the principle planes and sketch them onto the drawing above. Find the location of the image and its magnification.

A fish is inside a fishbowl with very thick sides. The outer diameter of the fishbowl is 32 cm and the inner diameter is 27 cm. The glass of the fish bowl has an index of 1.60 and the index of the water is 1.33. Find out where the image of a cat's face that is 90 cm outside the bowl will appear and what will be the magnification. You will have to use thick lens technique of your choice.

2) Set up the matrices (you don't have to multiply them out) that would multiply out to give the system matrix of a plano convex lens. The front surface should be a plane. The back surface should have radius of curvature |R2|=30.0 centimeters and the thickness of the lens should be 1.3 centimeters. Write out all three matricies in the order in which you would multiply them. (10 pts)

4 a) If you have a thin lens of focal length 2.0 meters, what will be the location and magnification of the image of an object located 22 meters in front of the lens. (3pts)

4b) In this afternoon's lab we will combine a lens of 2.0 meters focal length with a second lens of focal length –60 cm. The separation between the two lenses will be 1.8 meters. Find the **equivalent focal length** for the system (a telephoto lens), find the location of the **two principle planes H1 and H2**. Find **the image location** (relative to the back vertex of the second lens) and **magnification** for an object 22 meters in front of the front vertex of the first lens. Finally **sketch the whole system** plus object and image and principle planes with the dimensions indicated. (12 pts)

.) A telephoto lens system is contrived by placing a long focal length positive lens in front of a shorter focal length negative lens. Lens A is in front and has a focal length of 100 cm. Lens B is behind it with a focal length of **–**30 cm (note that it is negative).

a) Find the distance d which must separate the two lenses in order for the equivalent focal length of the system to be 200 cm.

b) Find the system matrix.

c) Where are the two principal planes located relative to the two lenses?

d) If and object is placed 85 meters in front of lens A, where is it's image compared to lense B, **and what is the magnification?**