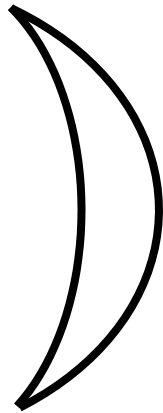


Homework for Ch.3/4

1 Meniscus Lens



Consider the germanium meniscus lens in the figure. The index of refraction is 4 and the lens is used in air. The focal length is $f = -30\text{mm}$. We choose to make

$$\frac{r_1 + r_2}{r_1 - r_2} = 5$$

for reasons that we will see in Chapter 5. Use the thin lens assumption to determine the radii of curvature. The thickness is 6mm.

- What are the radii of curvature?
- What is the actual focal length?
- Where are the principal planes?
- Where are the focal planes?

2 Compound Lens

Let's consider a compound lens consisting of two simple lenses.

The first lens is a convex–plano with the first surface having a radius of 10cm on the front surface and a planar rear surface.

The second is a plano–convex, with the convex radius of 3cm. Remember what this means for the sign.

The lenses are separated by 5cm. It's easiest to think of four surfaces, their radii and the distances between them and use subscripts carefully.

For each simple lens, show the vertex–to–vertex matrix for that lens, the optical power in diopters, and the focal length.

Then find the matrix, \mathcal{M} for the whole system from the first vertex of the first lens to the second vertex of the second lens, along with the optical power and focal length.

Find the principal planes and draw them with the lenses to scale.

Now plot s . vs. s' according to the lens equation, and plot on the same axes, w / vs. w the object and image distances from the front and back vertices respectively. Use an appropriate range of axes to show the behavior.

For a real object, over what range of w is the image real?

3 Microscope

A microscope objective is labeled 20X 0.5NA, meaning magnification of 20 and numerical aperture of 0.5. The manufacturer uses a 200mm tube lens and a 20mm field stop.

- What is the focal length of the objective?
- Where is the aperture stop located relative to the back principal plane of the objective?
- What is the diameter of the aperture stop?
- What is the field of view of the image?
- What is the numerical aperture in image space?

4 Scanning Laser Radar

We want to design a telescope for a laser radar so that we can transmit a 1cm diameter laser beam out through the primary, from a 1mm laser beam we put into the secondary. The primary has a 200mm focal length and a 12.5mm (half inch) diameter. Assume thin lenses.

We wish to place a scanner at the entrance pupil of this beam-expanding telescope. Notice that we would call this the exit pupil if we were using the telescope in the normal way to view a star.

- a. What is the focal length of the secondary?
- b. Where is the entrance pupil? In other words, where should we place the scanner mirror?
- c. Suppose we incorrectly place the scanner 2cm before this location. Sketch the aperture of the lens and the laser beam as two circles for various scan angles from zero to an angle such that no laser light passes through the telescope. Hint: It may be easier to calculate the locations in object space using the entrance pupil and then apply the magnification equation. Just find the center of the laser beam and make a circle around it. That isn't quite correct as the off-axis spot will be elliptical, but it's close enough.