SIMG-303 MIDTERM EXAM #2
DUE FRIDAY 2 May 2004 at 3:30PM

Open Book: you may use any sources (written or electronic), but you may NOT get help from any persons (or other carbon-based life forms, directly OR indirectly) except the instructor. Do not discuss the form, content, or degree of difficulty of the questions with anyone else (in class or not) until after the test is due.
Do all problems – point totals are given.
Staple problems together and submit *in numerical order.*

1. (40%) Consider the two thin positive lenses and the thin negative lens in your optics kit (these are the so-called "tombstone" lenses, named for the shape of the plastic holder). If you do not have these lenses, you can borrow mine for a short time.

   (a) Experimentally determine the diameters and *approximate* focal lengths of the lenses; you may use any method but tell how you did it (note emphasis on "approximate" – this does not have to be exact, I'm more interested in how you figured it out).

   (b) Use these lenses to design two different kinds of magnifying telescope. Specify the system parameters you used in your telescopes.

   (c) For both types of telescope, locate and determine the transverse magnification of the images obtained by both telescopes of an object located 500 mm in front of the first lens, i.e., $\overline{\mathbf{OV}} = 500\,\text{mm}$.

   (d) For both types of telescope, locate and find the magnification of the image created by the second lens of the first lens – you might want to try the experiment with your lenses to see this image.

   (e) Now change the separation of the lenses in the the Galilean telescope to create a telephoto lens. You may base this lens design on the one we modelled in class, but you are free to choose any lens separation that produces a "telephoto".

   (f) For your telephoto design, find the focal points and principal points of the system, locate the image of an object located 500 mm in front of the first lens, and find its magnification.

   (g) Now "reverse" the lens so that the negative lens is in front, but use the same separation as in the telephoto. Locate both principal and focal points of the "reversed" lens and find both focal distances.

   (h) Find the image of an object located 500 mm in front of the first lens of the reversed telephoto and find its magnification.

   (i) Scale this model reversed lens to make a system with $BFD \equiv \overline{\mathbf{V'F'}} = 35\,\text{mm}$ instead of the value you obtained in the previous section. Determine the focal length, focal distances, etc.

   (j) Graph the image distance from the vertex ($\overline{\mathbf{V'O'}}$) as a function of the object distance from the vertex ($\overline{\mathbf{OV}}$) for the scaled reversed lens.

   (k) (OPTIONAL BONUS) Determine and justify a useful application for the reversed lens.

MORE→→→

2. (20%) I am nearsighted, which means I need a negative corrective lens positioned at the front (object-space) focal point of my eye. My particular prescription requires a lens with a *power* of -3.25 diopters.

   (a) Design a lens made of glass with $n = 1.5$ that will give the necessary correction if used in air.

   (b) I also like to swim and need swimming goggles that give me the same correction. Design the lens for swimming goggles made of the same glass that will have the same power when used in water AND when used in air.

3. (15%) Consider a thin lens with $R_1 = +200\,\text{mm}$ and $R_2 = +150\,\text{mm}$ made of glass with $n = 1.5$.

   (a) Sketch the lens

   (b) Locate the focal and principal points of this lens on the sketch, including labels of all relevant distances.

   (c) Locate the image of an object placed 400 mm in front of the first surface, so that $\overline{\mathbf{OV}} = +400\,\text{mm}$. Determine the transverse magnification.

   (d) Locate the image of an object placed 400 mm "behind" the second surface. Determine the transverse magnification.

   (e) Repeat (a), (b), and (c) for the case where the object space and image space are "glass" with $n = 1.5$, but the lens is "made" of air with $n = 1.0$.

4. (15%) We discussed how a "quarter-wave plate" delays the phase of light polarized along one direction measured relative to light with the orthogonal polarization. The "fast" axis is that aligned with the polarization that has the smaller refractive index. If the thickness of a quarter-wave plate is doubled, we (naturally) have a "half-wave plate". Determine the effect of a half-wave plate on incident linearly polarized light that is oriented at an angle θ relative to the "fast" axis.

5. (10%) We derived two types of "magnification" of optical imaging systems: transverse and longitudinal. However, the use of the latter magnification in imaging is rather rare. Explain why this is so.