OPTI-502 **Optical Design and Instrumentation I** John E. Greivenkamp
Homework Set 4 Fall, 2009

Assigned: 9/15/09 Lecture 7
Due: 9/22/09 Lecture 9

4-1) A 50 mm cube is to be imaged by three optical systems:

a) The center of the cube is positioned 500 mm from the front principal plane of an optical system with f_F = -200 mm and f'_R = 300 mm.

b) The center of the cube is positioned 500 mm from the front principal plane of an optical system with f_F = 300 mm and f'_R = -200 mm.

c) The cube is imaged with an afocal system having m = 1/2. Assume $k_1 k_2 = 1$.

In each case, what are the dimensions of the image of the cube? For parts a and b, also determine the location of the cube image. You may assume that the cube is a wire grid so that obscuration, index and transparency are not issues.

4-2) The left end of a long plastic rod (n = 1.530) is formed into a convex spherical radius of 2.650 cm. This forms a single refracting surface. An object 2.5 cm high is located in air and on the axis a distance 16 cm to the left of the vertex.
a) Determine the Gaussian properties of the surface (ϕ, f_F, f'_R, and the locations of P, P', F, F', N, N'). Sketch.
b) Where is the image, and how big is it?

4-3) a) An object is located a depth d under a water/air interface. For an observer in air, how far below the water surface does the object appear to be? $n_{water} = 1.33$
b) What if the observer is underwater (for example, a fish), and the object is in air (d above the water)?
c) What happens if the underwater observer is wearing a diving mask (flat window) and is looking straight up at the object in air (d above the water)?

4-4) A goldfish is swimming in the center of a big spherical fish bowl. The fish bowl has an overall diameter of 666 mm, and the index of refraction inside the fish bowl can be assumed to take on a uniform value of 1.333. Where is the image of the goldfish? How big is the image of the goldfish?

4-5) You are the proud owner of a very special crystal ball. Light from a distant object is focused by the front surface of the sphere onto the opposite side of the sphere. What is the index of refraction of the sphere? The sphere is in air.

4-6) The image in the eye is formed in an index of refraction of 1.336. The rear focal length of the eye is 22.4 mm. An object is 1 m in front of the eye (in air) and has a height of 20 mm. What is the height of the image formed in the eye (on the retina)? Assume that the eye changes length to keep the image in focus.

4-7) An afocal system is to be fabricated by polishing convex surfaces onto both ends of a 150 mm long glass rod. The magnitude of the lateral magnification of the system is 0.5, and the glass has an index of refraction of 1.5.

What are the two required radii of curvature? $|m| = 0.5$