2007 Physics Comprehensive Exam- Special Topic: Optics
Do 3 and only 3 of the following problems. They have equal value.

1. Irradiance is a measure of received power per area. Suppose two identical lasers having identical power producing capabilities. One laser has a circular output mirror and the other has a square output mirror. The two mirrors have identical areas. Which laser produces the largest average irradiance in the central order in the far field? The average irradiance is the total power in the central order divided by the total area of the central order.

2. Sketch a Michelson interferometer that utilizes a cube beamsplitter and label all the components. Let the interferometer be illuminated with unit amplitude plane wave monochromatic collimated light, normally incident on all optical surfaces, and ignore losses in all optical elements. State your assumptions regarding the transmission and reflection characteristics of any optical elements, and label separations between elements, etc. Describe what is seen on a screen placed in the "output" of the interferometer as one of the mirrors is translated. Now do the math and verify your answer.

3. Write down the transmission function for a simple optical wedge having an angle θ and an index of refraction "n". If this wedge is illuminated with unit amplitude plane wave monochromatic collimated light, calculate the far field irradiance distribution. You may assume the wedge is "lossless" and ignore reflection. State clearly any approximations you may make. Interpret your answer in terms of what you already know to be experimentally true.

4. My kids recently received a spherical fishbowl with the following specifications:

1. Outer diameter = 400 mm,
2. Inner diameter = 392 mm
3. Shell material = acrylic (refractive index = 1.492)

Assume the bowl is empty except for the water (refractive index = 1.33). Consider an object placed 10 m before the first surface, a full field of view of 2°, and let the first acrylic surface serve as the system aperture stop.

a) Perform a y-nu ray trace to find the parameters of the chief and marginal ray at each surface in the system. Determine the image distance (measured from the last surface), image size, and the lateral magnification. (50 %)

The bowl comes with a fire hazard warning indicating it should not be placed in a window. In a display of recklessness, I place the bowl next to a (completely transmissive) window. Consider the bowl to be an ideal paraxial lens and assume an average solar irradiance of 3000 W/m^2.

b) What is the <u>total</u> collected flux at the image plane assuming the sun to be located at infinity? (20 %)
c) Instead consider that the bowl will be, at best, diffraction limited. What is the average irradiance across the zeroth order Airy disk circle? Assume an incident wavelength of 550 nm and an irradiance of 300 W/m^2 at that wavelength. (20 %)
d) Do you think my house will burn down? Why? (10 %)