1051-733-20072 Homework #5 Due 2/20/2007 (W)

Read Chapters 7 and 8 in the notes; do the following problems

1. A rectangular plate of plane glass is placed atop an identical plate. A thin paper strip is placed between the plates along one edge to form an "air wedge" between the inner surfaces of the glass (i.e., a gap with linearly variable thickness). This "system" is illuminated by sodium light ($\lambda_0 = 589\,\text{nm}$) at normal incidence to the upper plate. If the period of the observed fringe pattern is $D = 1\,\text{mm}$, find the angle between the inner surfaces.

2. A plano-convex lens is placed convex side down on a plane surface of glass to make a Fizeau interferometer. The system is illuminated from above by monochromatic light. The *radius* of the first bright ring in the observed fringe pattern is 1 mm.

   (a) If the radius of curvature of the convex surface of the lens is 4 m, determine the wavelength of the light.

   (b) If the space between the glass surfaces is filled with water, describe the differences in the observed pattern *qualitatively* and *quantitatively*.

3. A Michelson interferometer is illuminated by a plane wave of white light. The interferometer is adjusted so that the path lengths are equal and one mirror is tilted *very* slightly.

   (a) Describe and sketch what is observed in the field of view.

   (b) The illumination is replaced by plane waves from a sodium lamp with $\lambda_0 = 589.0\,\text{nm}$ and $\lambda_1 = 589.6\,\text{nm}$. Describe what is observed in the field of view.

   (c) With the sodium source in place, one mirror is moved by a distance L until the fringe pattern disappears. Calculate L.

   (d) The sodium source is replaced by a monochromatic He:Ne laser with $\lambda_2 = 632.8\,\text{nm}$. Describe what is observed as one mirror is moved (again, one mirror is tilted relative to the other.

4. A Michelson interferometer is illuminated by red cadmium light with mean wavelength $\lambda_0 = 643.897\,\text{nm}$ and a linewidth $\Delta\lambda = 0.0013\,\text{nm}$. The initial OPD is set to zero so that the phase difference between light emerging from the two arms is $\Delta\phi = 0$. One mirror is slowly moved until the fringes disappear. How far has the mirror moved in physical distance and in number of wavelengths?

5. Light from a quasimonochromatic line source of length L traverses the distance z_1, where the light illuminates a pair of apertures separated by the distance d; the two apertures may be modeled as identical Dirac delta functions. The light from the aperture plane propagates a distance z_2 to the observation plane. The separation distance d between the apertures may be varied. Find the separation d_0 where the visibility of the fringes goes to zero.

6. A monochromatic light source with $\lambda_0 = 460\,\text{nm}$ is located 2 mm above the plane of a mirrored surface and 1 m from the plane of observation. The mirrored surface has index $n > 1$. Describe qualitatively and quantitatively what is observed at the observation plane; include a sketch of hte pattern observed.

7. A lens with $\mathbf{f} = +200\,\text{mm}$ is sawn in two pieces through a plane cutting through the optical axis (i.e., the cut is along a diameter). A point source S of monochromatic light with $\lambda = 500\,\text{nm}$ is placed on the optical axis at a distance $z_1 = 400\,\text{mm}$ from the lens. The half lenses are gradually moved apart; each creates an image of the point source that are mutually coherent. The light is observed on a screen placed at a distance $z_2 = 1000\,\text{mm}$ from the lens. Determine the width of the interference fringes observed on the screen if the lenses are moved apart by a distance of 0.5 mm.

8. The radii of curvature of the two surfaces of a lens are +200 mm and +100 mm. The index of refraction of the lens is $n = 1.5$.

   (a) Sketch the lens.

   (b) If an object is placed 200 mm in front of the lens, find the image distance, describe the nature of the image (real or virtual), and draw a diagram showing the object, lens, and image.

9. The relationship of the the focal length and the object and image distances is:

$$\frac{1}{z_1} + \frac{1}{z_2} = \frac{1}{\mathbf{f}}$$

   Prove that the minimum separation between a real object and its real image is $4\mathbf{f}$.

10. A man's face is located 250 mm from the bowl of a soupspoon. The magnification of the resulting image is $M_T = -0.064$. Determine the image location and the radius of curvature of the spoon.

11. An object 10.0 mm tall is located 150 mm in front of a thin positive lens with $\mathbf{f}_1 = +100\,\text{mm}$. A thin negative lens with $\mathbf{f}_2 = -75.0\,\text{mm}$ is located 250 mm behind the first lens.

    (a) Sketch the system, locate the image, find its magnification, and and describe its nature (real or virtual).

    (b) If the two lenses have equal diameters, determine which lens is the aperture stop and locate the entrance and exit pupils.