Homework #4
Assigned October 2, 2008

1. Use the graphical construction method to sketch the image that results from an “arrow” object that is 20cm from a lens whose focal length is 10cm. Is the image real or virtual?

2. Use the graphical construction method to sketch the image that results from an “arrow” object that is 5cm from a lens whose focal length is 10cm. Is the image real or virtual?

3. Use the graphical construction method to sketch the image that results from an “arrow” object that is 20cm from a lens whose focal length is negative 10cm. Is the image real or virtual?

4. Suppose that the lens used in problem #1 has a diameter of 10cm. What is the diffraction-limited image resolution achieved in problem #1 and what is the corresponding depth-of-focus? Also find the object resolution and the corresponding depth-of-field.

5. A lens whose focal length is 20cm has a diameter of 10cm and suffers from spherical aberration. Under collimated illumination you measure rays from the edge of the lens aperture coming to a focus at a point 18cm from the lens. What are the values for TSA and LSA for this lens?

6. Consider three points in the object plane of an optical imaging system. These points are located on-axis at (0,0), and off-axis at (0,5), and (-7,-7). Sketch the image plane for a case in which the optical system suffers from spherical aberration and coma.

7. The focusing power of the human eye is distributed between the cornea ($D_c=43$ diopters) and the lens ($D_L = 17$ diopters). What is the total focusing power of the eye? What is the equivalent focal length of the cornea-lens optical system?

8. Design a pair of eyeglasses for a person who suffers from myopia. The far point for this person’s left eye is 1.5m and the far point for his/her right eye is 3m.

9. Sketch the rays through a telescope comprising a f = 10cm objective lens and a f = 1cm eyepiece. What is the angular magnification of this telescope for an object at infinity? What is the angular magnification for an object at 10m?

10. You have constructed a pinhole camera having an image distance of 5cm and a pinhole radius of 20μm. What is the maximum object size that can be imaged onto 35mm film at a distance of 50m? What is the corresponding (geometric) object resolution that can be achieved with this camera?
11. Compute the diffraction-limited (object) resolution of the camera described in problem 10 for light whose wavelength is $\lambda=500\text{nm}$. Also compute the optical power per unit area that is incident on the 35mm film for a single on-axis point object at 50m whose total optical power is 1W.

12. Show that in the paraxial domain, the magnification produced by a single spherical interface between two continuous media is given by $M_T = -(n_1 S_i)/(n_2 S_o)$, where $n_1$ and $n_2$ are the refractive indices of the two media and $S_i$ and $S_o$ are the image and object distances respectively.

13. A biconvex lens ($n_1=1.5$) has radii of 20cm and 10cm and an axial thickness of 5cm. Describe the image of an object 1 inch tall, placed 8cm from the first vertex. Use the thin lens equation to see how far off it is in determining the final image location.

14. What must the focal length of a thin negative lens be for it to form a virtual image 50cm away of an ant that is 100cm away? Given that the ant is to the right of the lens, locate and describe its image.

15. Write an expression for the focal length ($f_w$) of a thin lens immersed in water, in terms of its focal length in air ($f_a$).

16. An object is located at a distance $S_o$ from a spherical mirror of radius $R$. Show that the resulting image will be magnified by an amount $M_T = R/(2S_o+R)$.

17. A great many converging lenses, all of the same focal length $f$, are placed along the axis at distances, between each other, of $d=3f$, $d=2f$, or $d=f$. Assuming that the incident light is parallel, trace a ray through each of these combinations.