EE466 Optical Engineering
Homework 2

1. The following web site gives the specifications for the Cannon Powershot G7 digital camera: http://www.dpreview.com/reviews/specs/Canon/canon_g7.asp
    a. What is the total field of view (FOV) for the telephoto zoom?
    b. What is the total field of view (FOV) for the wide angle zoom?
    c. What is the pixel size of an image at a distance of 50m using the telephoto zoom?

2. In the simple thin lens-retina model of the unaided eye, let's suppose the distance between the lens and retina is 16.67mm. What diopter power is required for an emmotropic (normal) eye to focus clearly on a distance object?

3. A cormorant is a type of seabird that has very large accommodation. If the eye is emmotropic (it focuses at infinity at rest), what are the far and near point of the eye if it has 52.1D of accommodation. You do not know the initial lens power of the eye so keep this as a variable.

4. If the unaided human eye has a stronger lens with a power of +62 D (the lens/retina separation is 1/60), what are the near point and far point for this eye if it has 9D of accommodation? Is this eye near sighted or farsighted?

5. If the unaided human eye has a weaker lens with a power of +57 D (the lens/retina separation is 1/60), what are the near point and far point for this eye if it has 9D of accommodation? Is this eye near sighted or farsighted?

6. A Galilean Telescope is constructed using two lenses one with a positive focal length and one with a negative focal length. If the focal length of one of the lenses is f=30cm what is the focal length of the second lens such that the angular magnification is 10x? Draw the ray trace for this telescope.

7. The telescope from the previous problem is placed in front of a camera with a focal length of f=50mm. If the CCD imager of the camera has a width of 1 inch what is the field of view of this optical system?

8. A beam expander consists of two positive lenses of focal lengths f_1=10cm and f_2=30cm. (This configuration is called a Keplar Telescope.) These lenses can be arranged to cause an incident collimated beam have a larger collimated output beam. Determine the locations of the two lenses and draw the ray diagram. If you were looking in this telescope would the image be upright or inverted? What is the final diameter of the beam if the incident beam has a diameter of 5mm?

9. A lens with a power of 55D is used to make an image16.67mm from the lens. Use ABCD matrices to find the location of the object and the magnification.

10. Exercise 3.1-1 from the book

11. A helium-neon laser emits a Gaussian beam (λ=633nm) with a total power of 10mW and e^{-2} power radius of 1mm. (a) What is the intensity of the laser at the surface of the moon at a distance of 376,100km? (b) What is the laser intensity on the moon if the initial beam is expanded to an e^{-2} radius of 1m?

12. A simple digital camera has a single lens with a focal length of f=50mm, an aperture diameter of 35mm, and a CCD detector with 1024X1024 pixels and a total size of 1/3 inch. (Assume that there is no spacing between the individual pixels.) A HeNe laser (λ=633nm) with an e^{-2} full width of 1 mm is located 1km away from the camera.
    a. How many pixels does the laser illuminate if the camera is looking directly at the beam?
    b. If the laser is changed to 1m away, how many pixels does the laser illuminate?

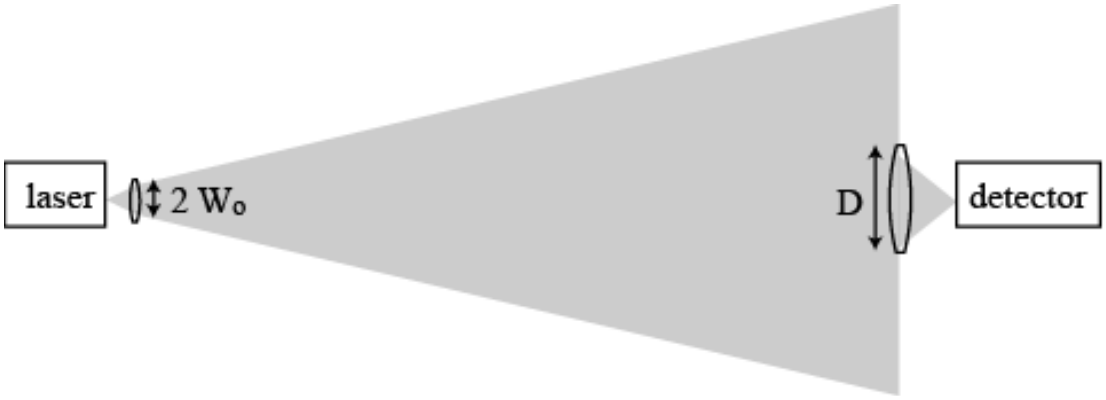

Figure 1. Free space optical communications link.

Figure 1 shows a free space optical communication link that consists of a laser transmitter and detector. The lens on the transmitter is designed to change the Gaussian beam waist. The lens on the receiver is designed to collect the light and focus it onto a detector. The laser has a power of P_t=5mW, a wavelength of λ=670nm, the receiver needs to collect P_{rec}=10μW to attain the required signal to noise ratio, and the separation between the transmitter and receiver is L=100m. In a free-space optical communication link there is a trade-off between the lens sizes and required alignment accuracy. There are two required alignments. (1) The pointing of the transmitter towards the receiver. (2) The pointing of the receiver towards the transmitter.

13. If the beam waist at the transmitter is W_o=1mm, what is the required collection diameter D?
14. With the transmitter beam waist of W_o=1mm, what is the transmitter alignment error for which the peak of the beam drops by 2dB?
15. Because of errors in the imaging quality of a lens, the ratio between the lens diameter and the focal length needs to remain below a certain value. If the maximum diameter of the collection lens is D<4f and the detector width is 2mm, what is the maximum pointing error of the receiver for the lens diameter calculated in problem 12?