Assignment 7
Due November 1, 2011

Text readings

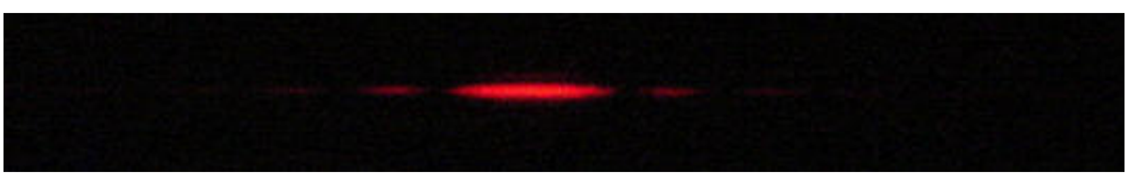
Diffraction (sections 10.1 and 10.2)

Problems

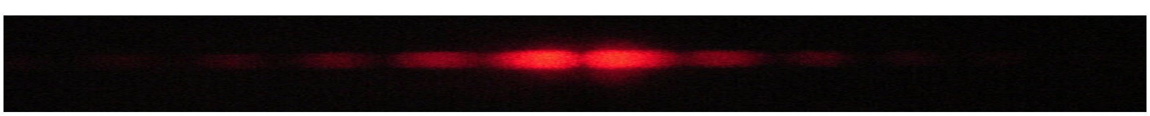
Problem 1

Diffraction from a Single Slit: Use a helium neon laser operating at 632.8 nm and a single slit to observe the pattern shown below. Make all necessary measurements to determine the width of the slit.

(a) In this problem determine the slit width from measurements of the diffraction pattern.
(b) Derive a general formula for the intensity of the diffraction pattern of a single slit of width b.
(c) Plot the intensity distribution you derived in part b for the data you obtained in part a. How does your calculated intensity distribution differ from what you observed? Explain.
(d) Plot the intensity distribution you derived in part b for different b values. Discuss your results.



(e) **Thin Hair Diffraction**: tape a piece of hair across a He-Ne laser beam to produce the diffraction pattern shown below. Make all necessary measurements to determine the width of the hair.



Problem 2

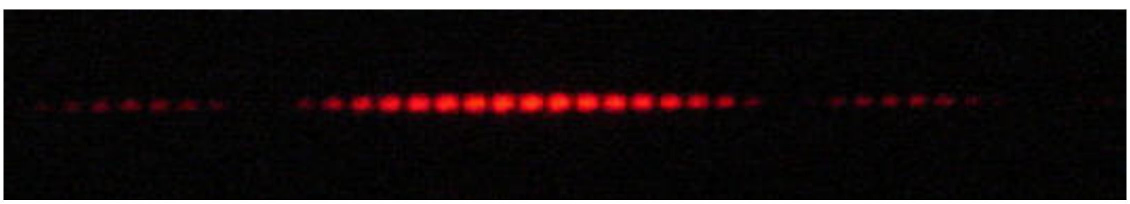
Double Slit Interference Pattern: Use a helium neon laser operating at 632.8 nm and a double slit to observe the pattern shown below. Make all necessary measurements to determine the separation of the two slits.

(a) In this problem determine the slit spacing from measurements of the interference pattern.

(b) Derive a general formula for the interference intensity pattern of two point sources having separation "a."

(c) Plot the intensity distribution you derived in part b for the data you obtained in part 1. How does your calculated intensity distribution differ from what you observed? Explain.

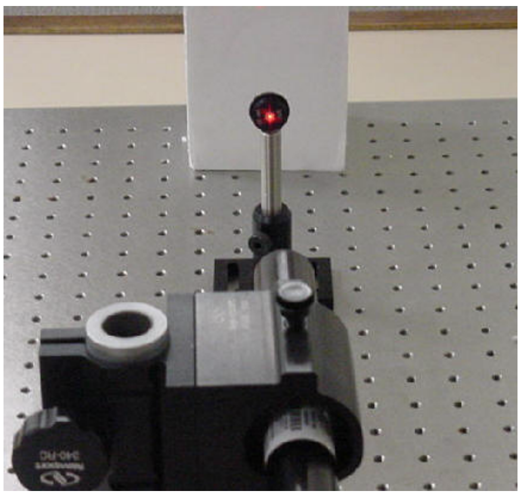
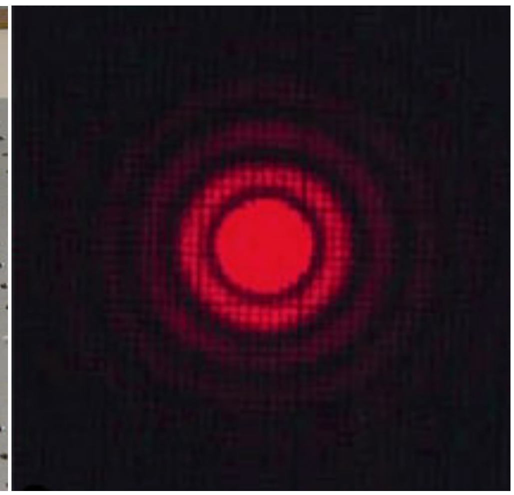
(d) Plot the intensity distribution you derived in part b for different slit separations. Discuss you results.



Problem 3

Pinhole Diffraction: The picture below shows a helium neon laser beam directed at a pinhole, and the photo on the right shows the light emerging from the pinhole. You need to project the diffracted light onto a screen in a dark room to take measurements.

(a) Measure the width of the diffracted intensity minima and/or maxima. Don't forget to measure the distance between the pinhole and the screen.
(b) From the measurements of part (a) determine the pinhole diameter?
(c) Plot the expected theoretical irradiance distribution for your pinhole diameter and wavelength measurements and compare it to your experimental data.

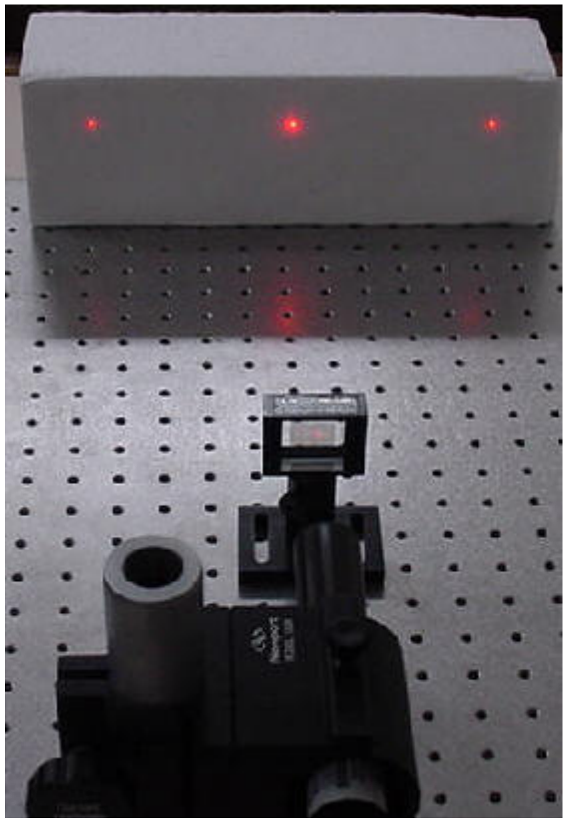



Problem 4

Transmission Grating: Reproduce the diffraction pattern shown in the picture by using a helium neon laser operating at 632.8 nm and a diffraction grating. Make all necessary measurements to determine the line spacing.

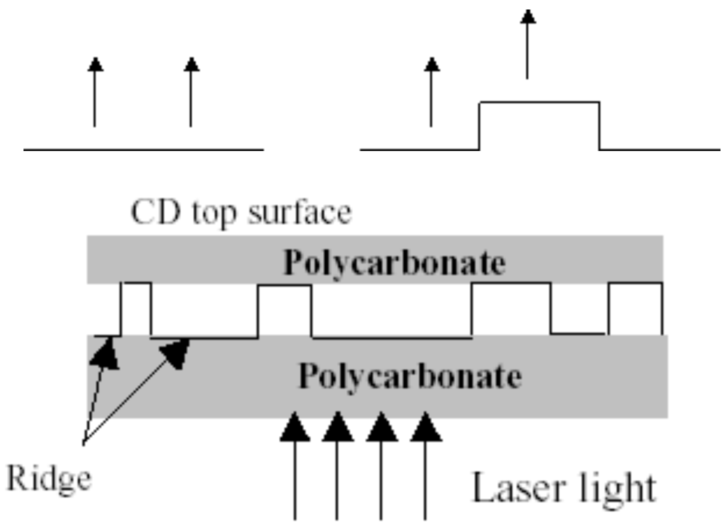
(a) Determine the line spacing in the diffraction grating used to obtain the pattern.

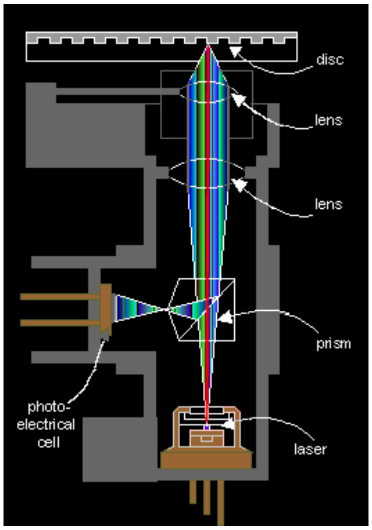
(b) What is the "free spectral range" and "resolution" of this grating?



Problem 5

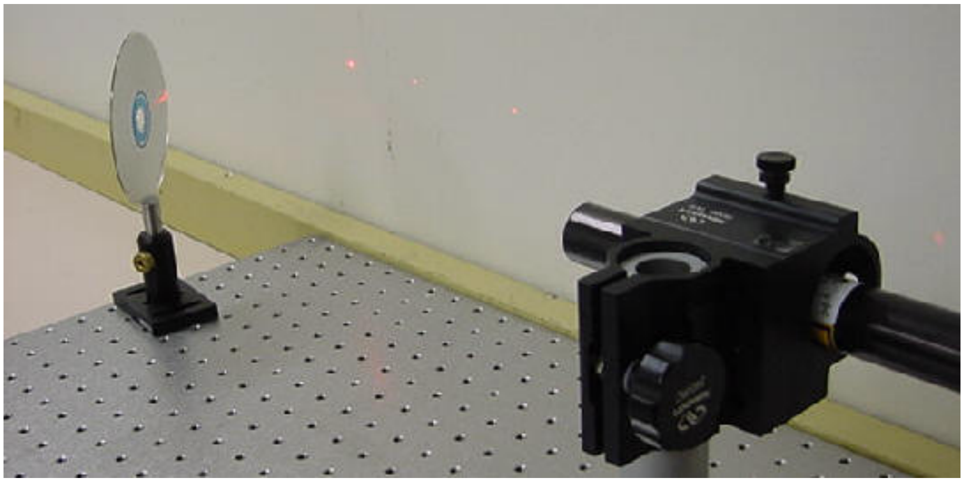
Diffraction and CD: Compact disks (CD's) are used o store audio, image, text and, numerical information in a binary format. A focused laser beam used to illuminates a track along the spinning disk. If the disk surface is flat good portion of the beam power will be reflected to the detector. However, If there are ridges within the illuminated region, the reflected laser light will have two different paths (and path lengths) to the detector. This causes a destructive interference when the beams mix at the detector.





(a) Calculate the depth of the ridge if the wavelength of the used diode laser is 780nm and is incident normal to the disk surface?

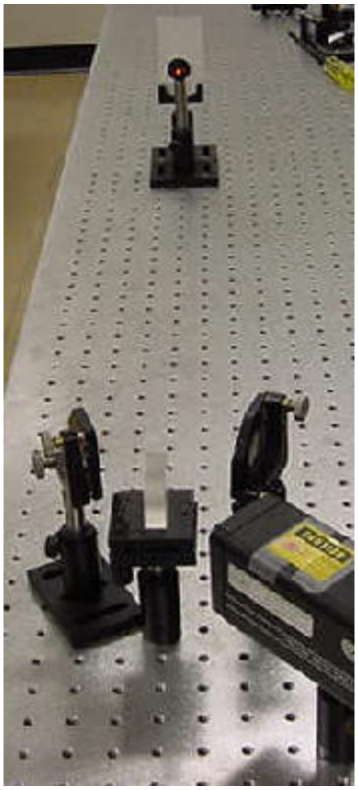
(b) The pattern of the tracks on a CD act like a diffraction grating. It is responsible for the rainbow appearance when white light illuminates the CD. Determine the track spacing on a CD by examining the diffraction pattern when a He-Ne laser beam operating at 633nm illuminates the CD. Assume that the surface of the CD behaves like a ***regular reflection grating***. Measure the incident and diffraction angles of as many orders of diffraction as possible.



Problem 6

Resolution of Imaging Systems: Direct two lasers beams at a pinhole as shown below. Use a beam splitter and two mirrors to accomplish this task. Also this can be done using two lasers pointing toward the pinhole. You should see two spots on the screen behind the pinhole. Move the pinhole and the screen further away from the laser, keeping the distance between the pinhole and the screen constant. You need to rotate the mirrors in order to keep the beams at the pinhole. This will decrease the angle between the beams. As the angle decreases, the spots on the screen move closer together.

(a) Estimate the mirrors-pinhole distance when you will not be able to distinguish the two spots from a single spot. You don't actually have to do this but answer the question considering the results from the previous pinhole problem and discussion of "resolution" in your text.



(b) How far away must a car be on the highway so you cannot distinguish it from a motorcycle at night?

Problem 7

Diffraction of Many Point Sources:

(a) Derive a relation that describes the intensity of the diffraction pattern for N point sources distributed evenly on the circumference of a circle. Consider only discrete point sources to sum over.

(b) Plot the intensity pattern (***see examples below***) using contour plots for N=2, 3, 4, 5, 7, 15. Note that two point sources pattern is that of the Young double (point) source pattern.

(c) Consider light with wavelength λ incident normally on a grating having N regularly spaced lines with spacing a. Treat the light coming from the grating with wave vector k as coming from a series of point sources. Assume that the point sources line up along the z-axis. Compute the Electric field distribution dependence on k for this grating using the formula given below.

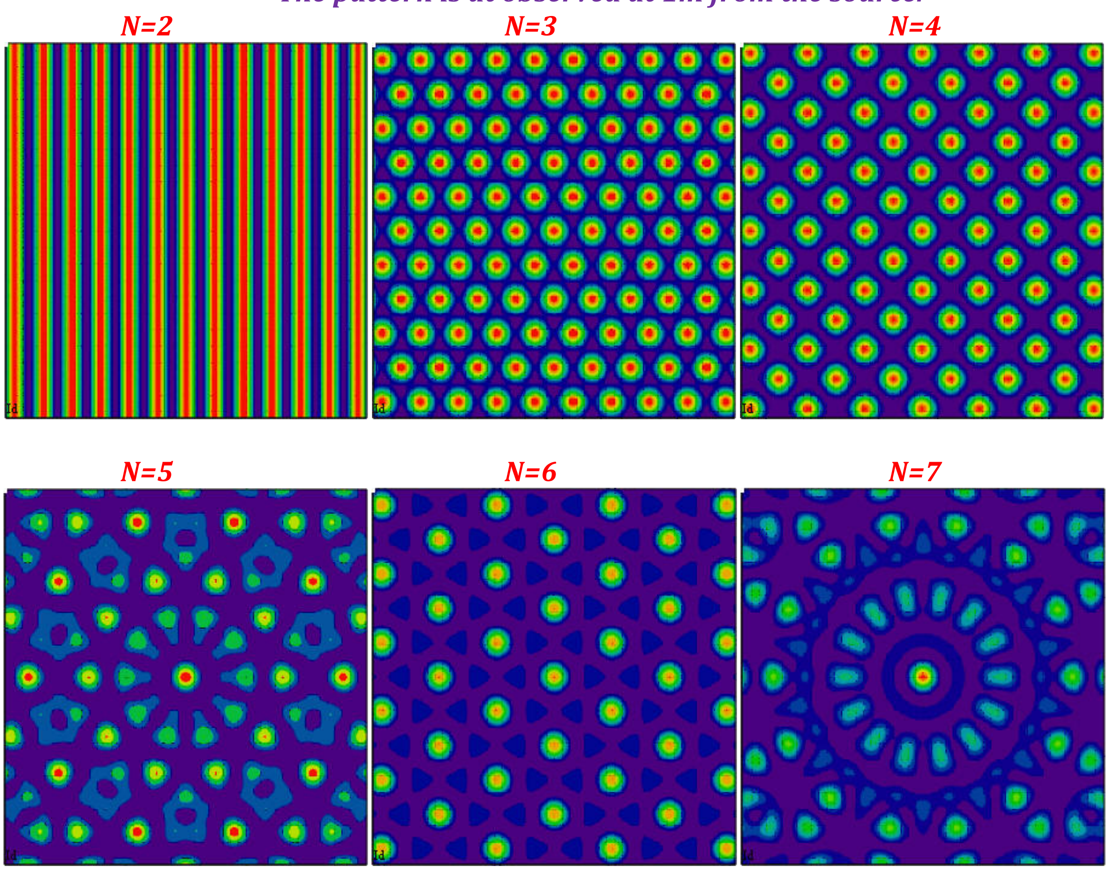
$$E_s = A\sum_{j=1}^{N} e^{i\vec{k}.\vec{r_j}}$$

(d) Compute the Irradiance distribution dependence on k from the Electric field function.

(e) Plot the Irradiance as a function of k with a = 1 (mm) for N = 2, 10, 100. Show how the irradiance maxima change as the number of lines increases.

(f) Derive a formula for the width of the irradiance maxima (Angular Resolution).

Diffraction pattern for N point sources spaced evenly on a circle of 1mm radius. The pattern is at observed at 1m from the source.



Problem 8

Book Problem:10.31

Problem 9

Book Problem:10.34