1. Light ($\lambda=500$ nm) from a particular source has a frequency bandwidth of $\Delta \nu=6 \times 10^{11}$ Hz.
   a) What is the coherence length $\Delta x$ and the coherence time $\Delta t$ of this light?
   b) What is approximately the largest optical path length difference in an interference experiment with this light, which would still give you observable interference fringes? (Make schematic sketch of such an experiment.)
   c) For a double slit of $a=1.2$ mm slit distance, what will be the angular separation of neighboring interference fringes, and what will be their spatial separation on a screen 2 meters away from the double slit? What will be the approximate angle at which the highest order interference fringes can be observed given the bandwidth of the source?
   d) If you chop the above light into pulses of pulse-duration $\Delta t=2 \times 10^{-13}$ sec, what changes under a), b) and c)?

2. Two narrow parallel slits illuminated by light from He-Ne laser ($6328\text{Å}$) are found to produce fringes with a separation of 0.3 mm on a screen 1.5 meters away. What is the distance between the slits? What would change (and by how much?) if the same experiment is performed under water? What would change in the fringe-pattern if you use instead of the HeNe laser an Ar laser operating at $\lambda=4880\text{Å}$?

3. No lens can focus light down to a perfect point due to diffraction. Estimate the size of the minimum spot of light at the focus of a lens with an f-number of 0.8. Discuss the relationship between the focal length, the lens diameter and the spot size for this lens.

4. Interferometry:
   a) Make a sketch and describe briefly the instrumental set-up, optical beams, and operation of a Michelson Interferometer.
   b) How do you determine with this instrument the wavelength of a laser? Give a numerical example for a laser of $\nu=4.8 \times 10^{14}\text{Hz}$: what will you observe (quantitatively) when moving one of the interferometer mirrors by 2.3 mm in one direction? How would you extract the wavelength from this measurement?
   c) Together with the above laser, you are given a 6 cm long gas cell which you can place into one arm of the interferometer (filled with air, @1 atm). What is the fringe shift if the air is pumped out of the cell.
   d) If the coherence length of your laser is only 1.8 cm: how do you have to position the mirrors to observe useful interference fringes?
5. In the two slit diffraction experiment, the far-field diffraction pattern depends only upon center to center slit separation $a$, and width $b$ of the two slits. What would be the effect of increasing the width of one of the slits about its center? (same center to center slit separation $a$, but one slit of width $b_1$ and the other of width $b_2$)

6. Determine the diffraction pattern for a plane wave (wavelength 1 um) incident at an angle of 20 degrees upon a transmission grating of period 5 micrometers). Identify the diffraction maxima in terms of the transmission angle as measured by the perpendicular to the grating surface.

7. Problem 10.25 from book

8. Problem 10.30 from book


10. Explain why you get a diffraction pattern from a random distribution of small identical particles.