NOTE: CHOOSE 3 out of 6 problems.

**Problem 1:** Using the data from Table 8.1 of Hecht OPTICS,
(a) Compute the MINIMUM thickness of calcite required for a ½ waveplate.
(b) Compute the MINIMUM thickness of calcite required for a ¼ waveplate.  
Note that the thickness of material required means that the crystals are thin and fragile. There are called Zero-Order waveplates.
(c) An alternative is to make the waveplates thicker (so that they are less fragile). There are called multiple-order waveplates. For these multiple order waveplates, the thickness should correspond to a whole number of 2\(\pi\) phase shifts plus the desired \(\pi\) or \(\pi/2\) additional phase shift depending on whether it’s a ½ wave or ¼ waveplate. For Calcite, determine the minimum thickness LARGER THAN 1mm that is required for a ½ wave multiple-order waveplate.

DATA FROM TABLE 8.1: \(n_o=1.6584\) and \(n_e=1.4864\) for calcite at 589.3nm.

**Problem 2:** It is well-known that optical fibers are birefringent. The birefringence can be due to stress applied to the fiber from bending/ twisting or residual stress from the manufacturing process. Assuming that the birefringence for linearly polarized light traveling in the fiber is \(\Delta n = 10^{-6}\), calculate
(a) for two orthogonally linearly polarized light waves that enter the fiber at the same time, the time delay between one polarization and the other polarization exiting the fiber after traveling over a distance of 1km in the fiber. Use a wavelength of 633nm (He-Ne laser wavelength). You may assume that the effective index of refraction for the faster wave is 1.5.
(b) The length of fiber required to use the fiber as a fiber-optic equivalent of a ½ waveplate.

The relatively short length of fiber that you calculate in (b) implies that the polarization state of light in an optical fiber is very easily changed from one state to another. To alleviate this problem with changing polarization, one can use “polarization maintaining fiber”. This fiber is designed so that polarization of light remained fixed throughout the length of the fiber.

**Problem 3:** Show that Right Handed Circularly polarization light becomes Left-Handed Circularly polarized light when the light is reflected (at normal incidence) from a mirror. (This is the basis for the OPTICAL DIODE device discussed in Lab 3. **HINT:** Follow the class notes (or HECHT page 327) for representing circularly polarized light by a combination of two LINEARLY polarized light rays. When the light is reflected from a mirror, use the Frensel reflection coefficients (HECHT SECTION 4.6.2) to show that the phase of each linearly polarized light ray is changed by 180 degrees upon reflection. What happens to the direction of the wavevector upon reflection?

**Problem 4:** Assume you want to measure glucose through the anterior chamber of the eye as a means of noninvasively quantifying blood glucose. Given glucose has a specific rotation of 41.89 degrees for a 10cm path length in a 1g/100ml solution at a wavelength of 656nm and the anterior chamber of the eye has a path length of approximately 0.8cm, calculate the
concentration of glucose for a rotation of 15 millidegrees. Is this a reasonable value from a physiological point of view? Would the patient be considered normal or diabetic?

**Problem 5:** Using the specific rotation of glucose in the problem above, what would be the net angular rotation (through a 5cm path length) for a solution of
(a) d-glucose : 5g/L
(b) d-glucose: 5g/L mixed with a solution of l-glucose: 5g/L
(c) d-glucose: 3g/L mixed with a solution of l-glucose: 7g/L

**Problem 6:** In a solution of d-glucose, the rotational orientation of the glucose molecules is random. How would you expect the value of the specific rotation to change if you could “freeze” the orientation of the molecules so that they all had the SAME rotational orientation? WHY?