Phys 375 – Homework #4

1) *Birefringent* crystals have a special axis, known as the optical axis. Light waves which are polarized parallel the optical axis experience a different index of refraction than light waves polarized perpendicular to the optical axis. For calcite, ($n_{||}$ = 1.486), while ($n_{\perp}$ = 1.658), at the sodium wavelength of 589.3 nm.

a) (3 points) Show that the difference in time it takes the two polarizations to cross a calcite crystal of thickness d is $\Delta t = \frac{d}{c}\left|n_{||} - n_{\perp}\right|$.

b) (3 points) Show that the phase difference between the two polarization after crossing the crystal is $\Delta\phi = 2\pi\frac{d}{\lambda}\left|n_{||} - n_{\perp}\right|$.

c) (3 points) What thickness is needed to create a phase difference of π/2? (A crystal of this thickness is known as a *quarter-wave plate*.)

2) (3 points) Unpolarized light is incident upon two crossed polarizers, so that no light is transmitted through the pair. A sample of corn syrup is inserted between the two polarizers, and then 3% of the unpolarized light incident upon the first polarizer is now transmitted through the second polarizer. By what angle did the corn syrup rotate the direction of polarization of the light incident upon it?

3) (3 points) At what angles will light be completely linearly polarized when reflecting from a diamond-air interface? Consider both the air-into-diamond and diamond-into-air cases. The index of refraction of diamond is 2.42.

4) (3 points) An ideal polarizer rotates with an angular frequency of ω between a pair of stationary crossed polarizers. The set of three polarizers is illuminated by unpolarized light. Show that the intensity of the light transmitted by the entire apparatus as a function of time is $I = I_0 \sin^2(2\omega t)/8 = I_0(1-\cos(4\omega t))/16$, where I_0 is the intensity of the unpolarized light.