PHYS 5130, Practice Final Exam

Potentially helpful constants and conversions: $h = 6.626\times10^{-34}$ J-s; $\hbar$=1.055×10^{-34} J-s; $h\nu = \frac{hc}{\lambda} = \frac{1240 \text{ eV}-\text{nm}}{\lambda}$; $\mu_B = 9.274 \times 10^{-24}$ J/T; 1 eV = 1.603×10^{-19} J.

1. Pulse description and measurement with chirp.
(a) Sketch a down-chirped pulse (envelope and actual E-field).
(b) Assume a center frequency of ω_0 and a chirp parameter a. If the pulse is moving through vacuum in the positive $\hat{z}$ direction and is circularly polarized, what is the complete mathematical description of this pulse?

2. We have a gas laser (λ=600 nm) with bandwidth of 2 nm that we are trying to spectrally resolved using a CCD camera with 20 μm pixels situated 150 mm away from our 1000 grooves/mm grating. The grating equation for first-order dispersion is: $\lambda = d\,[\sin(\theta_i) + \sin(\theta_r)]$, where d is the groove spacing (in units of distance), θ_i is the input angle from normal of the light (30° for this situation), and θ_r is the reflection angle from normal incidence. How many pixels does this bandwidth cover? (Hint: calculate θ_r (601 nm) and θ_r (599 nm) first, then find the positions of these spatially dispersed wavelengths on the CCD.)

3. Describe in words and pictures what carrier-envelope phase (sometimes called carrier-envelope offset) is. Why might spectroscopists want to have carrier-envelope-phase stabilized systems?

4. We are designing a THz detection system using $\langle 100 \rangle$-cut ZnTe. We anticipate the center THz frequency to be at 1.5 THz, which we will measure with a 800 nm NIR beam with a spectral bandwidth of 20 nm (over which the index of refraction changes from 1.4975 to 1.5025). If $n_{\mathrm{THz}} = 1.5$, how long should we make our crystal?

5. Circularly-polarized light.
(a) Write down the density matrix for an arbitrary polarized beam (*i.e.*, one with a phase ϕ, where $\phi = -\pi/2$ describes right-circularly polarized light and $\phi = \pi/2$ describes left-circularly polarized light).
(b) Obtain the eigenvalues and eigenvectors for this density matrix with $\phi = \pi/2$. Describe the physical significance of these quantities.