# Physics 140B: Problem Set 2

4/11/05. Due 4/18/05.

**1. Dielectric Function.** 30 points.
The Drude dielectric (for free but damped electrons) was given in the text as

$$\epsilon(\omega) = 1 - \frac{\omega_p^2}{\omega(\omega + i/\tau)}.$$

Since $\omega_p$ is clearly an important frequency scale, introduce the dimensionless variables $z = \omega\tau$ and $\alpha = \omega_p\tau$.
(a) Plot the real and imaginary parts of $\epsilon(\omega)$ on the same plot, choosing scales on the axes that show the important behavior of both real and imaginary parts. Make plots for $\alpha$=0.01, 0.2, and 5. Plot versus $\omega/\omega_p$ (or log of this etc. if appropriate). Identify important points of $y$ where notable behavior occurs, and try to interpret it.
(b) Do as in part (a) again, but instead for the inverse dielectric function $1/\epsilon(\omega)$. Note that the real and imaginary parts of this function are not just the reciprocals of the real and imaginary parts of $\epsilon(\omega)$. Again, make plots for the same three values of $\alpha$.

**2. Frequency-dependent Index of Refraction.** 30 points.
Consider again the Drude dielectric function in Problem 1. The real and imaginary parts of the complex index of refraction are given by $n(\omega) + i\kappa(\omega) = \sqrt{\epsilon(\omega)}$. Calculate and plot $n(\omega)$ and $\kappa(\omega)$ on the same plot, again for $\alpha$=0.01, 0.2, and 5. Keeping in mind the connection $ck = \omega\sqrt{\epsilon(\omega)}$ which give $k(\omega)$ or $\omega(k)$ (both being complex quantities, however), are there regimes, or limits, in which behavior approaches what we are more accustomed to, such as $\omega(k) = \frac{c}{n}k$ (whose interpretation is that light travels at the speed $c/n$ when this relation holds)?