110B Homework 4

1. (30 points) Dispersion in a medium with sharp absorption band. Consider a resonant medium for which the susceptibility is given by a single resonance with electron concentration of $N=10^{23}/cm^{-3}$, oscillator strength f=1, resonance energy at 1 eV, and width of 0.01 eV.
(1) Plot the real and imaginary part of the dielectric constant.
(2) Plot the real and imaginary part of the refractive index.

2. (25 points) A wave propagating in a weak absorbing material will be attenuated as it propagates in the material. Derive a relation between the absorption coefficient (i.e. the length after which the intensity will attenuate to 1/e) and the susceptibility.

3. (15 points) The energy density of red light of wavelength 660 nm is reduced to one-quarter of its original value by passage through 342 cm of seawater.
(1) What is the absorption coefficient of seawater for red light of this wavelength?
(2) At what depth is red light reduced to 1% of its original energy density?

4. (30 points) Consider the self-oscillation of an electron gas with carrier density N in a slab of metal which thickness d. The oscillation of electrons between the two surfaces will induce surface charge, which provides a restoration force to the free electrons. Solve the problem self-consistently and show that the oscillation occurs at the plasmon frequency.