UNIVERSITY OF MARYLAND

DEPARTMENT OF PHYSICS

COLLEGE PARK, MARYLAND 20742

PHYSICS 732
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HOMEWORK ASSIGNMENT #1
Due Tuesday, February 13

Read Marder, chapter 20
Read Ashcroft and Mermin, Appendix K

1. Ashcroft and Mermin, chapter 1, #4.

2. Ashcroft and Mermin, chapter 1, #5.

3. Show that σ is diagonal in zero magnetic field. Show that for a system with 3-fold or higher rotational symmetry that the two components of σ in the plane perpendicular to the rotation axis are degenerate. For a system with 3-fold or higher rotational symmetry in a magnetic field applied along the symmetry axis derive the inversion relation between the conductivity tensor and the resistivity tensor.

4. Derive the conductivity of classical electrons of density n acted on by a linear restoring force (harmonic oscillator). Prove the oscillator strength sum rule by direct calculation of $\sigma_2(\omega)$ in the high frequency limit.

5. The case of zero force constant is the Drude model for free carriers. Show that the Drude conductivity obeys the Kramers-Kronig relations. Consider the reflectance $R(\omega)$ of a Drude metal. The spectral absorptivity is $A(\omega)=1-R(\omega)$ where $R(\omega)$ is the reflectivity. The $\omega\tau<<1$ regime is called the Hagen-Rubens limit and the $\omega\tau>>1$ regime is called the Mott-Zener limit. Calculate $A(\omega)$ in these two limits. What is $A(\omega)$ for copper at room temperature at 10 microns wavelength?

6. A sphere of dielectric constant ε is placed in a uniform external electric field E_0.

a). Show that the polarization of the sphere is $P = \chi E_0 /(1+4\pi\chi/3)$, where $\chi = (\varepsilon - 1)/4\pi$ is the susceptibility.

b). Find χ for the case of a metallic sphere at a frequency ω» $1/\tau$ where τ is the carrier relaxation time. Assume that the static dielectric constant of the metal is 1.

c). Use this result to determine the resonance frequency of a metallic sphere and compare with the plasma frequency.