HW #6; due Mon. 3/13 (No late HW! Midterm on 3/15)

1) Problem 9.19 (4th Ed.), (9.18 in 3rd.)

2. Problem 9.29 (4th Ed.), (9.28 in 3rd)

3) In a plasma, the relationship between current and oscillatory E-fields at a frequency ω is effectively **imaginary**; $\mathbf{J} = i\frac{\alpha}{\omega}\mathbf{E}$. Alpha is a positive constant.

A) What does the "imaginary" conductivity mean, in terms of physically measurable quantities?

B) Starting from Maxwell's equations, show a derivation of the wave equation for EM waves in a plasma, in terms of α and ω. Use vacuum values for ε and μ.

C) Find an expression for the "skin depth" of a plasma, over which EM waves are absorbed. (Your answer will depend on the frequency in an interesting way; comment on what happens at some special frequemcy.)

D) Find the dispersion relation, $\omega(k)$, and deduce the phase velocity and the group velocity of EM waves in a plasma. Show that everything that is **supposed** to be slower than c is slower than c.

4) Sample Midterm Problem (from last year):

A square loop, carrying a constant current I, has a length A on each side. The square loop is rotating around its own diagonal in the middle of a large solenoid (with n-turns per unit length). (The diagonal is aligned with the diameter of one of the circular solenoid loops.) The solenoid has n turns per unit length, and a radius of "r".

A) At t=0, the entire square loop is in the same plane as one of the circular loops in the solenoid. Find the magnetic flux through the (entire) solenoid at t=0.
(HINT: The only way to calculate this answer uses a certain trick involving the mutual relationship of the loop and the solenoid.)

B) If the square loop is rotating at an angular velocity ω, find the induced current in the solenoid as a function of time. Assume the solenoid has a total resistance of R. Ignore the back-EMF of the solenoid on itself. (Hints: the answer is not zero; think through how your answer to part A will change as a function of rotation angle before calculating.)

C) As the loop starts to turn (but before it's gone very far), will your answer to part B) tend to increase or decrease your answer to part A)? Explain/define all signs.