Physics 323, Spring Quarter 2016
Electrodynamics: Homework Assignment 2
(a) Turn in all problems and clearly note all constants and assumptions you use.
(1-point penalty each otherwise)
(b) Use 8½ x 11 paper & staple
(1-point penalty each otherwise)
(c) Due April 14 either 9:00 am in class or 8:45 am in the instructor's mailbox;
late homework gets 0.

1. Consider electromagnetic waves in a medium containing completely free charges; there's no restoring force and no damping, only inertia. The non-magnetic medium consists of *N* free particles in a volume *V*, each charge of mass *m* and charge *+Q*. To keep the system neutral, there's *N* rigidly fixed charges each of charge *–Q*. The fixed charges play no dynamical role.
a. Each particle feels an external field **E**. From Newton's law, write the equation of motion of a charge.
b. Suppose $\mathbf{E} = \mathbf{E}_0 e^{-i\omega t}\hat{x}$. Find the displacement of a charge.
c. What's the phase relation between **E** and the particle displacement?
d. Find the dipole moment *d* of a charge and find the dipole moment per unit volume *P* of the free charges.
e. Find the electric susceptibility χ_E and the relative dlelectric constant ε_R of the medium. You can assume a linear medium.

2. A plane wave travels in the above medium. The complex wave number **k** is in the z-direction, $\mathbf{E}_0$ is along the x-direction, and $\mathbf{B}_0$ is along the y-direction. You can assume the total free charge is zero and the total free current is zero.

a. Taking the free current as zero seems wrong since there are free charges that can move in response to **E** fields. Why can we assume this?
b. Find the wave number k in terms of ω and ε_R.
c. Find the relations between **E** and **B**.

Now assume there's a boundary (the x-y plane) between vacuum and the medium.

d. In terms of ω and k, find the ratio r between the amplitudes of the reflected and incident waves.
e. Find the reflection coefficient (sometimes called the reflectance) of the medium using k from part b and ε_R from Q1 part e. Hint R=rr*.

3. In the infrared, silicon has a relative dielectric constant of 11.6. Consider the interface between vacuum and silicon. The following require numerical answers.
a. What's the refractive index?
b. What's the normal-incidence reflection coefficient? What's the phase change between incident and reflected wave?
c. What's Brewster's angle?
d. For incident waves at Brewster's angle, what's the ratio r (defined in Q2 part d) for the two polarizations?(One of them is zero, of course.)

4. Consider a hollow conducting cylindrical tube of inner radius *R* possibly containing solely transverse (relative to the tube axis) electric and magnetic fields.
a. What is the "parallel" (tangential) component of **E** at the inside surface of the tube?
b. Find the components of **E** and **B** everywhere inside the tube. Explain.
c. Discuss how your result in part b would change if there were a small-diameter conductor coaxial with the tube.
d. You can obviously shine light down the tube axis. How do you reconcile this observation with your result of part b?

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