Physics 106c: Electrodynamics
Problem Set 5

Due: 4pm Friday, May 11, 2012

Remember: Late homework will be granted 50% credit up to one week late, unless you have a note from the Dean or a health official.

Reading: Griffiths Chapter 10.

Problems:

1. A linearly polarized plane electromagnetic wave of frequency $\omega$, propagating in vacuum along the $z$–axis with an electric field of amplitude $E_0$ polarized along the $x$–axis, is normally incident upon a very thin metal sheet. The metal sheet lies in the x-y plane. Assume that the penetration depth $\delta$ at the frequency $\omega$ is much greater than the sheet thickness $t$, and that the metal sheet has an ordinary ohmic conductivity $\sigma$.

   a) Find the reflected and transmitted electromagnetic waves (both the electric and magnetic fields). You may assume that the sheet is essentially infinitely thin, but that the product $\sigma \cdot t$ is non-zero.

   b) Find the fraction of the incoming energy flux which is reflected, transmitted, and absorbed by the metal sheet.

   c) Determine what conditions (on $\sigma$ and $t$) will maximize the energy absorption. What is the maximum energy absorption fraction?

2. A TE$_{10}$ mode is propagating down a rectangular waveguide. Show that the total amount of energy per unit time flowing down the guide is given by the stored energy per unit length in the guide times the group velocity of the mode, $d\omega/dk$.

3. Design a waveguide (with rectangular cross-section) in which the cut-off frequencies of the lowest two propagating modes are 10 GHz and 18 GHz respectively. Give real physical dimensions for the cross-section. Are these modes TE or TM? How many modes of each type propagate in the band from 18 to 22GHz?