Midterm Exam-- EE 6316 Fields and Waves
10/30/2013-11/11/2013 Professor D. L. MacFarlane

Instructions: Work through the following problems neatly and professionally, and without collaboration of any kind. You may consult your own notes, and any published textbook. You must cite all your references fully. Please be neat and professional in your presentation. Include (computer generated) plots and (your own) words to expand on your results. A perfect score on this exam is 30 points.

Problem 1. Reflection of a plane wave off a metal surface (10 points)

In class we considered a plane wave propagating in free space reflecting off a perfect conductor. In this problem you will consider a plane wave reflecting off a metal surface with finite conductivity σ.

A. What is the total E field in free space and in the metal?
B. What is the total H field in free space and in the metal?
C. What is the current distribution at the surface and in the metal?
D. Derive an expression for the power lost due to Ohmic heating of the metal.
E. Plot the ratio of the average Poynting vector reflected to the average Poynting vector incident (<Sr>/<Si>) as a function of angle of incidence for
    i. A green laser beam against an aluminum surface
    ii. A ultraviolet laser beam against a gold surface
    iii. A signal from a wireless modem against an aluminum plate.

2. Reflection off a dielectric (10 points)

Consider a plane wave propagating in free space that encounters a perfect (lossless) dielectric at an angle of incidence θ_i.

A. Prove the angle of incidence equals the angle of reflection.
B. Prove Snell's law, $n_i \sin\theta_i = n_t \sin\theta_t$ where n is the index of refraction for the materials. (You may choose to write this in terms of the material impedance or the relative dielectric constant.)
C. Prove that power is conserved in this situation.
D. Plot the ratio of the average Poynting vector reflected to the average Poynting vector incident (<Sr>/<Si>) as a function of angle of incidence for both TM and TE polarizations.

3. Polarization (5 points):

The complex magnetic field of a uniform plane wave is given by

$$\mathbf{H} = \frac{10^{-3}}{120\pi}(\hat{a}_x - i\hat{a}_z)e^{+iky}$$

A. Find the Electric Field
B. Find the Poynting vector
C. Find the polarization of the wave; Plot the figure the electric field traces as a function of ωt
D. Identify the point on the Poincare Sphere

4. Forces (5 points)

In a galaxy far, far away, a star explodes. Two electrons are sent hurling through space on parallel tracks. Given that each moving, charged particle exerts electric and magnetic forces on the other, how fast are they going if they stay on those parallel tracks?

Discuss.