Extra Credit – Spring 2006

Up to 20 extra credit points can be earned for Fields and Waves I. The first option is to do the extra credit project (information on the project page). The second option is answering some quiz questions listed on WebCT. This document has some figures, etc. that are used in the questions. The geometries for these problems are found in the appendix posted on WebCT that describes the basic configurations for capacitors, inductors and transmission lines.

1. A spherical capacitor whose inner radius is 10cm and outer radius is 10m is insulated with air. Assuming that a voltage of 1000V is placed across the capacitor, what is the charge density on the surface of the inner sphere?
2. A standard RG/58 cable is built with a new experimental insulator that has a dielectric constant 9 times that of solid polyethylene. What are the characteristic impedance and propagation velocity for this modified cable?
3. A lossless transmission line is being used in a matched configuration (the source, line and load impedances are all 50 Ohms). The load impedance is replaced by a Tee with two 50 Ohm loads connected to it. How much power will be reflected from this load?
4. The inductance of a particular square cross-section torus is found to be 10H. If it is tightly wound with 5000 turns of wire and the dimensions of the core are width and height equal to 2cm and inner radius equal to 5cm, what is the relative permeability μ_r of the core material?
5. A parallel plate inductor consists of two conducting plates (*length = 10m, width = 10cm, thickness = 2mm*) separated by a distance of *1cm.* If the plates carry a current of *1000A*, what is the total force they exert on one another?
6. An air insulated parallel plate structure consists of a grounded conducting plate at *x=0* and a conducting plate at *x=d* where the second plate is connected to a voltage V_o. The region between the plates has a uniform charge density ρ_o . What is the voltage as a function of position *V(x)* in the region between the plates?
   a. $V(x) = \left(\frac{V_o}{d}\right)x$
   b. $V(x) = -\frac{\rho_o}{\varepsilon_o}\frac{x^2}{2} + V_o\frac{x}{d}$
   c. $V(x) = \left(\frac{\rho_o}{\varepsilon_o}\frac{d}{2} + \frac{V_o}{d}\right)x$
   d. $V(x) = -\frac{\rho_o}{\varepsilon_o}\frac{x^2}{2} + \left(\frac{\rho_o}{\varepsilon_o}\frac{d}{2} + \frac{V_o}{d}\right)x$
   e. $V(x) = -\frac{\rho_o}{\varepsilon_o}\frac{x}{2} + \left(\frac{\rho_o}{\varepsilon_o}\frac{d}{2} + \frac{V_o}{d}\right)$
7. Sunlight is incident obliquely on a glass ($\varepsilon_r = 5$) surface at an angle of 45 degrees. Since sunlight is randomly polarized, it has an equal amount of power in

each polarization. What is the ratio of the perpendicularly polarized electric field $E_{\perp}$ to the parallel polarized electric field $E_{\parallel}$?

8. A conducting ($\sigma = 1x10^{6}$) pipe (length *d=10m*), is rolling down an incline at a speed of *3m/s*. If the earth's magnetic field is approximately *1 Gauss = 10^{-4} Tesla*, what voltage is induced between the ends of the pipe?
9. A sinusoidal voltage source (*V_s=100V, f=1MHz, R_s=50 Ohms*) is connected to a *100 Ohm* load through a lossless *75 Ohm* transmission line. The transmission line is insulated with Polyethylene. If the power delivered to the load is *24.9 Watts*, what is the input impedance of the line if it is known to be real?
10. If the conducting pipe of question 8 is hollow (*inner radius = 3cm, outer radius equal 3.5cm*), what is its resistance?