Homework 2
Fields and Waves
Fall 2008

1. We have spoken of the lossless line in class. In this case we ignore R' and G'. There is a special case in transmission lines called the distortionless line which has losses but the velocity is independent of frequency and the characteristic impedance is purely a real number. In this case we have R'C'=L'G'. Find α, β and Z_0 for this case.

2.a) Calculation: The inductance per unit length of a coaxial cable is $l = \left(\frac{\mu_0}{2\pi}\right)\left\{\ln\frac{b}{a} + 0.25\right\}$. For this problem you can ignore the internal effect (the 0.25) and use $l = \left(\frac{\mu_0}{2\pi}\right)\left\{\ln\frac{b}{a}\right\}$. The capacitance per unit length is $c = \frac{2\pi\varepsilon}{\ln\frac{b}{a}}$. See Appendix B for the values of permeability and permittivity of free space. For the coax cable in the lab (RG 58A/U) there is polyethylene dielectric insulation with $\varepsilon_r = 2.3$ and copper conductors with inner radius $a = 0.4$ mm and outer radius $b = 1.4$ mm. To model a 4 meter section of the cable what values of L and C should we use? (As in the text, lower case *l* and *c* are per unit length and upper case L and C are total values.) Compare these values to the lumped circuit transmission lines in the lab; $l = 2.5\times10^{-7} H/m,\ c = 10^{-10} F/m$. This should represent 80 meters of RG 58 by 20 sections.

We have seen that $V = V_0\cos(\omega s)$ where $s = t \pm z/u$ is a solution to $\frac{\partial^2 V(z,t)}{\partial z^2} - lc\frac{\partial^2 V(z,t)}{\partial t^2} = 0$ Find the velocity, *u*, for the RG 58 A/U cable. What is the time delay for the 4 meter section? What is the characteristic impedance of the cable?

2.b) Experiment: Take a lumped line, a coaxial spool and a 50 Ohm terminator (not the California governor type but a special resistive connection). Set the function generator to a 600 kHz sine wave. Terminate the spool with 50 Ohms and measure the input and output voltage simultaneously. Measure the time delay. Measure the magnitudes. Replace the spool with the lumped line. Repeat the measurement. Measure at several of the nodes in the lumped line and draw conclusions. From the measurements, what is the length of the cable? By measurement, what is the length of the artificial line?