Problem Set 4
Electrodynamics
Spring, '05
Due: May 6, 2005

Problem 1: In class, I wrote down explicitly the equations that relate the traverse electric and magnetic fields for a wave guide in terms of the z-component of those fields. Derive those equations.

Problem 2: Jackson 8.1

Problem 3: For RG-58 (impedance = 50 Ω, inner diameter = .035", and index of refraction for the material in between the conductors = 1.5) and for RG-174 (impedance = 50 Ω, inner diameter = .019" and index of refraction = 1.5) coaxial cable, calculate the wave shape of a 10 nanosecond wide Gaussian pulse after 200 meters of the cable. Take the resistivity ($1/\sigma$) of the conductors to be that of copper (1.72×10^{-8} Ohm-meters) and the dielectric constant to be constant (an unrealistic assumption). Plot your results.

Problem 4: Wave guides do not have to be completely enclosed. Two parallel wires will support traveling waves also. (This is how you get high speed pulses over twisted pairs of wires.) For the TEM mode solutions for the transverse electric and magnetic fields are the same as those for the electrostatics and magnetostatics problems with constant charges and constant currents. These charges and currents are just modulated by a factor of $e^{i(kz-\omega t)}$. Because they are like electrostatic problems, you can use statics techniques to find the solutions. Find the static solution to two wires of radius r with their centers separated by a distance d embedded in a material of index of refraction n and held at a voltage difference V. As in Problem 2, use this to find the power transmitted and attenuated along the line and the characteristic impedance of the wires.

Problem 5: TE and TM modes can also propagate down coaxial cables. Find numerically for RG-58 and RG-174 cable the lowest cut-off frequency for each of these modes.

Problem 6: Jackson 8.20