UNIVERSITY ☺F P☺RTLAND
Sch☺☺l ☺f Engineering

EE 301-Electromagnetic Fields-3 cr. hrs.
Spring 2003

Midterm Exam # 1

(Prepared by Professor A. S. Inan)

(Friday, February 28, 2003)
(Closed Book Exam; 1 Formula Sheet Allowed)
(Total Time: 55 mins.)

Name:_____ ☺

Signature:_____ ☺

"Honesty is the best policy."
Aesop (~ 620B.C. - ?)

"An honest mind possesses a kingdom."
Lucius Annaeus Seneca (4B.C.-65A.D.)

"Honest people are the true winners of the universe."
Anonymous

(1) (15 mins., 30 points) **Step excitation of a lossless transmission line terminated with $R_L >> Z_0$.** Consider a 3-inches long lossless transmission line, characterized with per-unit-length parameters L = 45 nH-(inch)$^{-1}$ and C = 8 pF-(inch)$^{-1}$, excited at $t = 0$ by a step-voltage source of amplitude $V_0 = 4$ V (i.e., $4u(t)$) and source resistance of $R_s = 25\ \Omega$ at one end and terminated with a resistive load of value $R_L >> Z_0$ at the other end. Find the exact time (with the appropriate unit!) at which the load-end voltage V_L across R_L not only exceeds 3.7 V but also never falls below this voltage level beyond this time. (Show your work with a bounce diagram.)

(2) (15 mins., 30 points) **Step excitation of a loss-less transmission line terminated with an inductor.** Connect an extra lumped inductor of value 15 nH in parallel with the load resistor R_L at the load end of the transmission-line circuit of Problem (1) and reconsider the transient response of this circuit due to the same step voltage source with voltage $4u(t)$. Sketch the total voltage distribution along the transmission line at time t = 2.7 ns. Provide all the pertinent values on your sketch.

(3) (10 mins., 20 points) **The input impedance of a transmission line.** Consider a 20-cm long 100-Ω air transmission line excited by a 1.5 GHz sinusoidal voltage source at one end and terminated by an inductive load with impedance $Z_L = (75 + j25)\ \Omega$ at the other end. Find the input impedance Z_{in} of this line seen from the source end at steady state. Provide your answer in its simplest form.

(4) (10 mins., 20 points) **Transmission-line inductor design.** A short-circuit or open-circuit terminated 50-Ω air transmission line is to be designed to provide an inductance of value 50 nH at 3 GHz.

(a) (10 points) Design the above transmission-line inductor with the shortest possible length. Sketch your design with all the pertinent values provided on your sketch.

(b) (10 points) Find the new lumped element value of the transmission-line element designed in part (a) at 4 GHz. (Use the exact same circuit you designed in part (a). Provide the appropriate unit for your answer.)