# Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# PeopleSoft Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**ECE 6351/5317**

**Microwave Engineering**

**Exam 1**

**Fall, 2011**

Instructions

1. This exam is open book and notes. Calculators and Smith chart tools (e.g. compasses and rulers) may be used. Laptops and any devices that may be used for communication are not allowed.
2. If you need a Smith chart, please ask the instructor.
3. Please show *all of your work* and *write neatly* in order to receive credit.
4. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted.
5. Include units with all numerical answers in order to receive full credit.
6. For all solutions, ***no credit*** will be given if the work required to obtain the solution is not shown.
7. Perform all your work on the paper and charts provided. If you need more space, you may write on the backs of the pages.

**You will have a total of 80 minutes.**

**Problem 1**

For the following transmission line matching circuit, assume a 1 [V] wave is incident upon the 50 Ω to 25 Ω junction. That is, the incident voltage wave is described by

,

where *kz*1 is the wavenumber on the 50 Ω line (line 1), and *L* is the length of the 25 Ω line (line 2), given by , where  is the guided wavelength on the 25 Ω line

a) Derive formulas for the voltage *V*(*z*) and the current *I*(*z*) on the 25 Ω line.

b) Determine the SWR on the 50 Ω line and the 25 Ω line.

c) Use the Smith chart to find the input impedance (in Ohms) at a point that is at , where  is the guided wavelength on the 50 Ω line. Show your work on the attached Smith chart below.



+

-



Incident wave

Line 1

Line 2

**Room for additional work**

**Room for additional work**

**Room for additional work**



**Problem 2**

A coaxial cable has a 50 Ω characteristic impedance. The outer diameter of the coax is 1.0 cm. The inner wire is made of copper with a conductivity of 3.0 ×107 [S/m]. The outer shield is made of braided copper with an effective conductivity of 1.0 ×107 [S/m]. The filling material is Teflon, with a relative permittivity of  and a loss tangent of .

a) Calculate the dielectric and conductor attenuation in [np/m] at 12 GHz.

b) Calculate the total attenuation in dB at 12 GHz, if the signal travels a distance of 10 meters.

c) Calculate the frequency at which the first waveguide mode will start to propagate on the coax.

d) Calculate the maximum power that the coax can handle, assuming that the Teflon will breakdown when the electric field reaches a level of 1.97×107 [V/m].

**Room for additional work**

**Room for additional work**

**Problem 3**

A WR90 rectangular waveguide operating in the TE10 mode has dimensions *a* = 2.29 cm, *b* = 1.02 cm. An air-filled section of the waveguide meets a Teflon-filled section as shown below. The Teflon has a relative permittivity of *εr* = 2.2 . The loss tangent of the Teflon may be ignored in this problem.

A dielectric “ide, as shown below. of a guded wavelength away from the boundary between the air-filled waveguide and the TEflon-filled wave"plug” with a relative permittivity of *εrp* is inserted one-half of a guided-wavelength in the air region () away from the boundary between the air-filled waveguide and the Teflon-filled waveguide, as shown below. The length of the dielectric plug *Lp* is one-fourth of a guided wavelength in the plug region. The plug acts as a quarter-wave transformer to allow for a perfect match to be seen by the air-filled waveguide to the left, carrying the incident wave.

Determine the necessary relative permittivity *εrp* and length *Lp* of the plug (in cm), assuming operation at 10 GHz.

Top view

Teflon

Plug



Incident wave

**Room for additional work**

**Room for additional work**