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**ECE 5317/6351**

**Microwave Engineering**

**Exam 1**

**Fall 2017**

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. Please show *all of your work* and *write neatly* in order to receive credit. No credit will be given if the work required to obtain the solution is not shown, or if it is not easily readable.
3. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted.
4. Please circle your final answers.
5. Include units with all numerical answers in order to receive full credit.
6. Perform all of your work on the paper and Smith charts provided. If you need more space, you may write on the backs of the pages.

**Problem 1 (35 pts)**

A lossless transmission line with a load and a source connected to it is shown below. Assume the following:











(The wavelength in the dielectric material filling the transmission line is denoted as *λd*.)

Derive a formula for the current *I* (*z*) on the transmission line, where the load is at *z* = 0 and *z* is negative on the line. Leave your answer in terms of *β z*. There should not be any unknown constants appearing in your final formula. That is, your final formula should have only numbers appearing in it along with *β z*.



**Room for additional work**

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**Problem 2 (35 pts)**

A coaxial cable with a characteristic impedance of 50 [Ω] is filled with Teflon, having *εr* = 2.1 and a loss tangent of 0.001. The outer conductor (the shield) has a radius of 5 mm. (The inner radius is not specified, but you should determine this.) The inner conductor is copper having a conductivity of *σ* = 3.0×107 [S/m]. The outer conductor (the shield) is made of aluminum having a conductivity of *σ* = 2.0×107 S/m.

a) Determine the maximum distance that one can transmit a 10 [GHz] signal on the coax without losing more than 10 dB.

b) At what frequency will the first waveguide mode appear on the coax?

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**Problem 3 (30 pts)**

A hollow X-band rectangular waveguide of dimensions *a* = 2.0 [cm] and *b* = 1.0 [cm], operating in the TE10 mode at 10 [GHz], has a bend in it as shown below. On the left side of the bend (on the section of the waveguide that is horizontal in the figure), a standing wave is measured and it is found that the SWR is 2.0 and that a minimum in the magnitude of the electric field occurs at *z* = -0.5 [cm]. (Note that *z* is measured on the horizontal section of the waveguide, as shown in the figure.)

Determine the distance *d* from the junction (i.e., a location *z* = -*d*) where an inductive post (which is a lossless shunt element) can be put in order to obtain a perfect match, as seen from the feeding waveguide in the region *z* < -*d*. Choose the smallest distance *d* possible.

Please show your work on the Smith chart provided below.



**Room for additional work**





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