NAME: _____

ELEE 6340
Fall 2001

EXAM I

INSTRUCTIONS:

This exam is open-book and open-notes. You may use any material or calculator that you wish. Please show all of your work and write neatly in order to receive credit. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted. Include units with all answers in order to receive full credit.

Helpful formula (you may use this in any calculations that you wish, in order to save time):

$$\sqrt{1+z} \approx 1+\frac{z}{2} \quad \text{for } |z| << 1.$$

Problem 1 (20 pts)

A glass of water is inside a microwave oven, operating at a frequency of 2.45 [GHz]. The water occupies a volume of one liter, which is 0.001 [m^3]. At the operating frequency, the water is absorbing 1000 [W] of power. Assume that the real part of the complex relative permittivity is 80 and that the loss tangent of the water is 0.1 at this frequency. Assuming that the electric field is uniform throughout the water, what is the peak value of the electric field inside the water?

ROOM FOR EXTRA WORK

Problem 2 (25 pts)

Pure water has a low frequency relative permittivity of 81. The imaginary part of the relative permittivity is a maximum at a frequency of 17 GHz. At this frequency the real part of the relative permittivity is 42.

Determine the complex relative permittivity at a frequency of 2.45 GHz (microwave oven frequency), assuming that pure water obeys the Debye model.

ROOM FOR EXTRA WORK

Problem 3 (20 pts)

A practical transmission line has both metal loss and dielectric loss. Assume that the loss tangent of the dielectric material does not change with frequency. Give a convincing argument as to why the attenuation due to metal loss must be larger than the attenuation from dielectric loss at low frequencies, while the attenuation due to dielectric loss must be larger at sufficiently high frequencies. Use appropriate equations to support your argument.

ROOM FOR EXTRA WORK

Problem 4 (35 pts)

A certain transmission line is filled with a material having a relative permittivity of 2.1 and a loss tangent of 0.001 (the loss tangent is assumed to be independent of frequency). At a frequency of 10 [MHz], the attenuation along the line is measured and found to be 0.01 dB/m. At this low frequency it may be assumed that the attenuation is due only to metal loss.

a) Determine the attenuation constant α_d due to dielectric loss at 1 [GHz].

b) Determine the attenuation constant α_c due to metal loss at 1 [GHz].

c) Determine the total attenuation in dB/m at 1 [GHz].

ROOM FOR EXTRA WORK