

ECE 604 Electromagnetic Field Theory

Spring 2020

Homework No. 7. Due Date: Mar 27, 2020.

Read lecture notes 1-25. **Warning: Since you have a two weeks duration before this homework is due, please start on this early and do not wait till the last minute.**

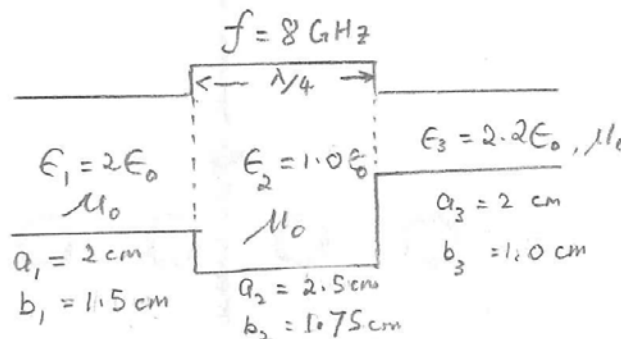
Since there are 6 problems for this HW, it will be counted as two homeworks.

1. A three section rectangular waveguide is shown and the dimensions and material parameters are also shown.

(i) Ignore junction effects, find the transmission line equivalence model of this waveguide.

(ii) Explain why there are extraneous stored energy at the junction.

(iii) Explain how you would augment the transmission line model in order to account for junction effects.



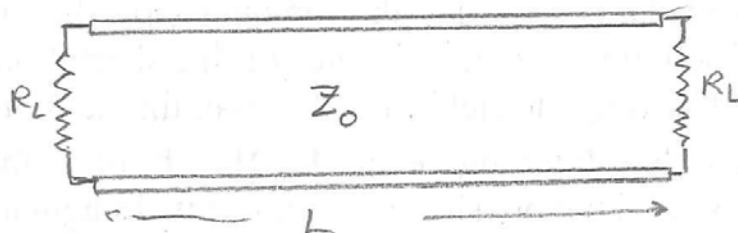
2. The fundamental mode of a circular waveguide cavity is the TM_{010} mode. (Hint: Discussion on this mode can be found in Kong's book.)

(i) Find the formula for the Q of this mode.

(ii) Assume a transmission line resonator is loaded with two resistors at its two ends. Assume that these resistors are much smaller than the characteristic impedance of the line. Find an approximate expression of the Q of this transmission line resonator with the loads at the two ends.

(iii) Now, assume that you can model the wall loss of the waveguide by replacing $j\omega L$ with $j\omega L + R$ where R is small. Find the contribution to the Q from this wall loss alone.

(iv) If you know the Q due to the end walls and the side wall loss, how would you find the total Q of the system.



3. Repeat the last part of Take Home Exam 2 now that you have seen the solution. There are more than one ways of finding the solution. Can you think of a different way from the solution provided by the TA?

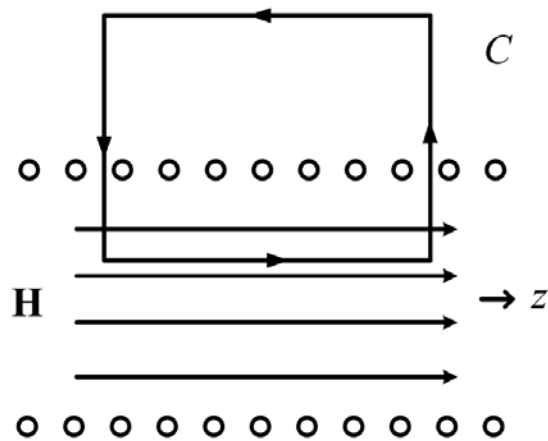
4. The equations for vector and scalar potentials have been found using the Lorenz gauge in the lecture notes.

(i) Now, find these equations using Coulomb's gauge. (Hint: This is described in J.D. Jackson's book, and many other physics texts.)

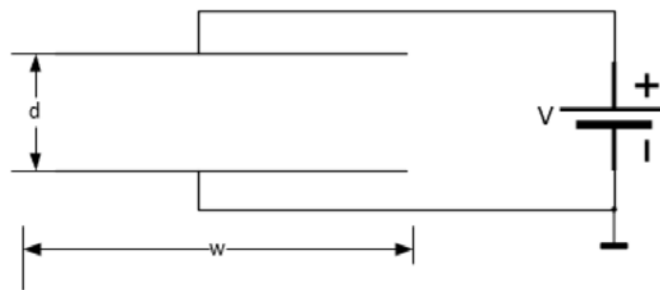
(ii) Discuss the pros and cons of Coulomb's gauge versus Lorenz gauge.

5. Use the energy storage method:

(i) Find the inductance of the solenoid and show that it is the same as that obtained by the flux linkage method. (Hint: Ramo et al has a discussion of this.)



(ii) Find the capacitance of a parallel plate and show that it is the same as that obtained by solving the boundary value problem between the parallel plates, then followed by calculating the total charge stored in the plates.



6. (i) Assume a sinusoidal current distribution on a short dipole like a half-wave dipole (but retardation effect on the dipole is ignored or the current on the dipole has equal phase), find the radiation resistance of this short dipole.

(ii) Since we know the complete field of a Hertzian dipole, both in the near field and the far field, find the complex Poynting vector $\mathbf{E} \times \mathbf{H}^*$ as a function of r . Explain the physical meanings of the real part of this vector, and its imaginary part.

(iii) Find the decay rates with respect to r for the real part and imaginary part.

(iv) Explain the decay rates. Which part decays faster, the real part or the imaginary part? Explain why.