Fields and Waves I

Name _____ ECSE-2100 Fall 1999 Section (The Only One)

Preparation Assignments for Homework #5

Due at the start of class.

Reading Assignments

Please see the handouts for each lesson for the reading assignments.

25 October Lessons 3.7 and 3.8

a. Read over problem 1 of lesson 3.6 in which a toroidal core is added around a long straight cylindrical wire. From the information provided, determine the additional inductance caused by adding the toroid. Don't try to figure out the inductance per unit length of the wire since it will be infinite. Rather, figure out the inductance of the core region, with and without the core material and take the difference. You might find it easier to use the energy method, but you can also use the flux method if you prefer. An approximate answer will suffice.
b. Read over problem 2 of lesson 3.6. Write out the general expressions for the boundary conditions used in this problem. Then solve the same problem for the case where the permeability of the iron is assumed to be 40 times that of air, rather than 5000. Then draw a diagram of the vectors at the boundary like the one given in the problem. The same kind of diagram is drawn for similar problems in figure 4.30 of the text. Give the B field vector in iron a length of 10 cm and then draw the correct length and orientation for the vector in air that satisfies the boundary conditions. The lengths of the vectors should be proportional to their magnitudes.
c. Determine the reluctance of the core used in problem 1 of lesson 3.6. Again, an approximate answer will suffice.

Class time 13 October (Note the date – Wednesday)

Open shop to work on Homework 5. Due at 5 pm on 27 October.

Homework #5

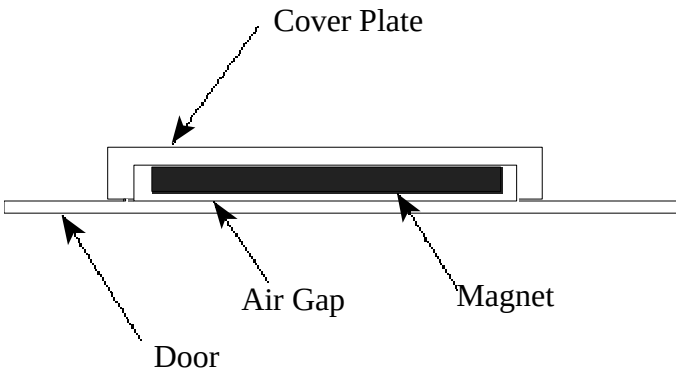
Problem 1. Inductance of a Torus (10 Points)

a. Using the last set of numbers for the three layer air core coil in the solution for problem 2 of Homework #4 (see page 10 of 11 in the class reserves), find the **external** inductance of the coil. Be sure you understand what is meant by external inductance. Repeat the calculation for the case where the core material is iron with a permeability of $5000\mu_o$.

b. Roughly estimate the **internal** inductance of each coil. That is, do you think that it is about 10%, 40%, 80%, 100%, 200%, 1000% of the internal inductance?

Problem 2. Inductance Using Magnetic Circuits (10 Points)

Read over the write up on Refrigerator Magnets that can be found in the Supplementary Materials web page for this course. In that document, you will find a diagram that looks like the one below. Assume that you have exactly the same geometry (with the same dimensions) as in the Refrigerator Magnet write up, but the magnet is replaced with the same steel as is used for the cover plate and the door. For clarity, let the new piece of steel that replaces the magnet be called the core. To create the magnetic field, assume that we wrap N turns of wire around the core through which we will drive a current I_o to create an electromagnet. Please note that this problem is really not fundamentally different from what we have seen in lesson 3.7.



a. Determine the inductance of this magnetic configuration. Use the ideal reluctance method that is applied in the write up and in Examples 4.21 and 4.22 in the text.
b. Determine the force exerted by this electromagnet using the method applied in the write up and in Example 4.23.

Since there are several steps to part a, it will be worth 8 of the 10 points for this problem.