Fields and Waves I

Name _______________ ECSE-2100 Spring 2000 Section _____

Preparation Assignments for Homework #4

Due at the start of class.

Reading Assignments

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

16 February Lessons 3.2 and 3.3

We will do problem 1 and Problem 2a from lesson 3.3 and complete the rest of problem 2 on 22 February.

1. The outer conductor of a coaxial cable has an inner diameter of 3 mm and an outer diameter of 3.5 mm. What is the resistance of a 100 m length of this outer conductor if it is made from copper?

2. In a reference on PC Boards (on the web), it was stated that a 7 mil wide trace had a resistance of about 0.1 ohms per inch. How thick is such a trace if it is made from copper?

3. What is the magnetic flux density B of a simple solenoid? Assume that the solenoid has N turns of wire carrying a current I. The area of the solenoid is S and the length is L. We have not gotten to magnetic materials yet, so assume that this is an air core solenoid.

4. What is the magnetic flux produced by this coil?

Class time 17,18 February

Open shop to work on Homework 4. Due at 5 pm on 18 February

22 February Lessons 3.3 and 3.4 (Note that Monday classes meet on Tuesday this week.)

1. What coordinate system is used to determine the magnetic field of a coaxial cable, a solenoid and a torus?

2. Which of the three magnetic field configurations mentioned in question 1 are you likely to encounter as a practicing electrical or computer engineer?

3. For the wire loop discussed in example 5.2, pick parameters such that the peak-to-peak voltage across the resistor is 20 milivolts.

4. For example B.1, assume that the magnetic field is comparable to that we experience from the earth here in Troy (assume it is all vertical) and that the two wires are railroad tracks and the sliding wires move with the speed of a typical train. What emf will be induced? Make any reasonable assumptions. Data on the Earth's Magnetic Field can be found at http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/igrfpg.pl

Homework #4

Problem 1. Magnetic Field Calculation

The center conductor of a coaxial cable has a current density flowing in the +z direction given by

$$\vec{J} = J_o \left(\frac{r}{a} \right)^{2.5} \hat{a}_z$$

in the cylindrical region r < a. There is a return current in an outer conductor (at r = b) that is sufficiently thin that it can be modeled as a surface current $\vec{J}_s$. The total current in each conductor is the same.

a. Find the magnetic field $\vec{H}(r, f, z)$ everywhere in space.

b. Verify that your answer is correct using the differential form of Maxwell's equations.

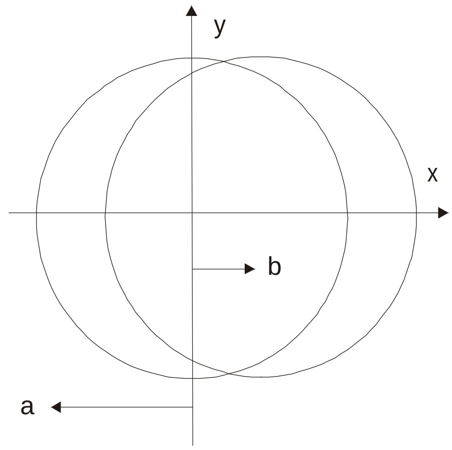
c. Determine the total current carried by each conductor.

d. Determine the surface current density at r = b. Be sure you write it in the form of a vector.

e. Determine the magnetic flux per unit length (1 meter) in the inner conductor (r < a) and between the two conductors (a < r < b).

f. If you assume that b = 3a, what fraction of the total flux is inside the inner conductor?

2. Saddle Coil



The electron beams in cathode ray tubes are controlled both electrostatically and magnetostatically. Magnetic deflection has been used extensively in television tubes. To analyze a magnetic deflection system, we will consider what happens when we combine two current distributions like the one for a wire with a uniform current density considered in example 4.6 of the text. The idealized model of the current distribution can be written as $\vec{J}(\vec{r}) = \hat{a}_z J_o$ for $\sqrt{(x-b)^2 + y^2} < a$, $\vec{J}(\vec{r}) = -\hat{a}_z J_o$ for $\sqrt{x^2 + y^2} < a$ and zero elsewhere. Note that these currents are just two uniform cylinders of radius a, one centered on the z-axis and one parallel to the z-axis, centered at x = b, y = 0.

a. Using the results of example 4.6, determine the magnetic field inside the current centered on the z-axis. To do this you only need to rewrite the solution for the example in terms of the quantities given here. Express your answer in cylindrical coordinates.

b. The second cylinder of current is not centered on the z-axis. To be able to represent it we need to re-write the answer to part a in rectangular coordinates. Remember that you have to convert both the cylindrical radius to x and y and the unit vector $\hat{a}_f$ to the unit vectors in the x and y directions, $\hat{a}_x, \hat{a}_y$.

c. Now write the magnetic field expression for the current centered at x = b and y = 0. It should look almost the same as your answer to part b.

d. In the region where the two currents overlap, there is no net current. This is where the neck of the CRT is located. Since we are dealing with a linear system, we can add the two magnetic fields to find the net field experienced by the electron beam in the CRT. Determine the magnetic field in this region. Sketch a few representative field lines on the figure above or, better yet, draw your own figure.

e. If the minimum dimension of the field region is about 3 cm, what is the total current necessary to produce a magnetic field of about 0.2 Tesla?