ELEC 306
Problem Set 6
Due: October 10, 2014

Homework Problems.
Work the following problems in Sadiku:

H6.1 7.14

H6.2 7.27

H6.3 8.6

H6.4 8.45

H6.5 In Example 8.11, Sadiku computes the inductance per unit length of a coaxial cable. However, although he includes the internal inductance of the inner conductor, he omitted the internal inductance of the shield. There are three possible reasons for this: (1) he forgot, (2) it's small enough to be ignored, (3) it's really hard to compute. Since Sadiku is usually very thorough, we can eliminate (1). (2) can be tested with the following formula:

$$L_{int} = \frac{\mu_0}{2\pi}\left[\frac{c^4 \ln(c/b) - c^2(c^2 - b^2) + \frac{1}{4}(c^4 - b^4)}{(c^2 - b^2)^2}\right]$$

That leaves (3). Your task is to verify that the above formula is in fact correct.

Real Problems.

R6.1 Computation Problem.

A *Helmholtz coil* consists of two identical circular coils aligned coaxially and separated by a distance equal to their radius. Each coil carries the same current in the same direction. It is also possible to make a square Helmholtz coil. In this case, the spacing between the coils is 0.5445 times the length of the side of the square.

For the purpose of this problem, let the two coils have radius R, be centered on the z-axis at $z = \pm\frac{R}{2}$, and be parallel to the xy-plane. In your computation, assume that each coil consists of a single turn of diameter 1 m, carrying a current of 1 A. You may utilize either a circular or square Helmholtz coil.

(a) Compute the magnetic flux density ($\mathbf{B}$) in the volume between the coils, i.e. $|z| < \frac{R}{2}$ and $(x^2 + y^2) < R^2$. You may utilize either an analytic or numerical solution. Use a uniform grid of at least 50 points in each direction (you may choose the exact number so as to simplify your computation). Plot the field lines in the xz-plane.

(b) The purpose of a Helmholtz coil is to produce a uniform field in the region between the coils. Using the value of the field at the origin as the reference, define the magnitude error at a point to be the difference between the magnitude of the field at that point and the magnitude at the origin. Define the direction error to be the magnitude of the angle between the direction of the field and the z-axis.

Produce contour plots of both errors in the xy-plane and the xz-plane. Plot graphs of both errors along both the x-axis and the z-axis.