Fields and Waves I – Summer 2000
Homework
Due: Wednesday 7 June 2000

1. Mutual Inductance Problem – 4.8.2 in the text.

2. Solenoid Inductance – 4.8.3 in the text.

3. Toroid Inductance – 4.8.4 in the text. The torus in this problem has a circular cross-section. The approach used gives an approximate answer, since it uses only the average magnetic flux density to determine the flux. There is an exact analysis of a square cross-section torus in example 4.7. This problem is done exactly, since the integration of the flux density over the square cross-section is relatively easy to do (see example), while a similar analysis for the circular cross-section torus is significantly more difficult. One can do the same simplified analysis for the square cross-section torus (using the average value for B). Use your result for the circular cross-section torus to obtain the corresponding expression for square cross-section torus. Then compare the two expressions for the inductance for the cases where $a=w$ and $a=5w$. You should see very good agreement for the second case.

4. Beakman's Motor Preparation – A standard Beakman's motor coil has 7 turns of 28 gauge wire that was wound around a paper tube with a radius of 1cm. Find the resistance and inductance of this coil. There is a very good formula for the inductance of this coil at the website http://emcsun.ece.umr.edu/new-induct/circular.html (there are also other good inductance formulas there http://emcsun.ece.umr.edu/new-induct/.

Next, determine the emf (voltage) induced in such a coil spinning at a frequency of 20 Hz in an average magnetic field of 0.035 T. There are two problems that relate to this question in the Fall 1999 Quiz 2 posted in the class reserves. Look at the short questions b and d.

Quiz for 5 June

You will be doing an experiment in which you study the coupling between two coils (Problem 3 of Lesson 3.6). One of the things you should notice is that the voltage you can apply across the input coil will be very different with and without the ferrite core. This is because the inductance the input coil is very, very much larger with the core than without. At frequencies high enough that $wL > R = 50\Omega$, the full voltage from the function generator will appear across the inductor. Without the core, the inductance is very small and the impedance of the inductor will be a small fraction of the internal impedance of the function generator. We can use this effect to determine the inductance of the coil with the ferrite core and from this information determine the relative permeability m_r of the ferrite. First, set the function generator for an amplitude of 1 $V_{p\text{-}p}$. Then, using the scope, find a frequency where the voltage at the input is as close to 1 $V_{p\text{-}p}$ as you can manage. When this occurs, the impedance of the inductor will be 50 ohms, since the function generator only produces the voltage you specify when the load equals its internal impedance. You can then use this information to determine the inductance *L*. The toroidal ferrite core wrapped with 10 or so turns will behave exactly like the inductor analyzed in example 4.7. Measure the dimensions of the core (there are some tape measures available in the studio) and compare your numbers with the other students in the class. Count the number of turns you have used and then evaluate the inductance of the torus, leaving the relative permeability m_r as a parameter. Set this expression equal to the measured inductance and then find m_r.

Note, you should do this quiz, immediately after doing the experiment, since everything is set up.