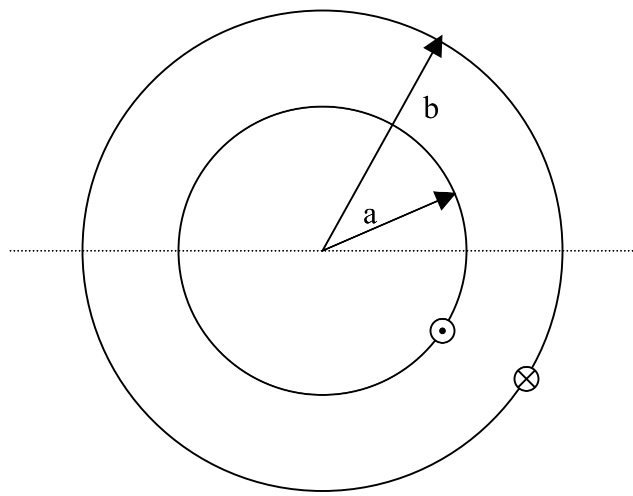
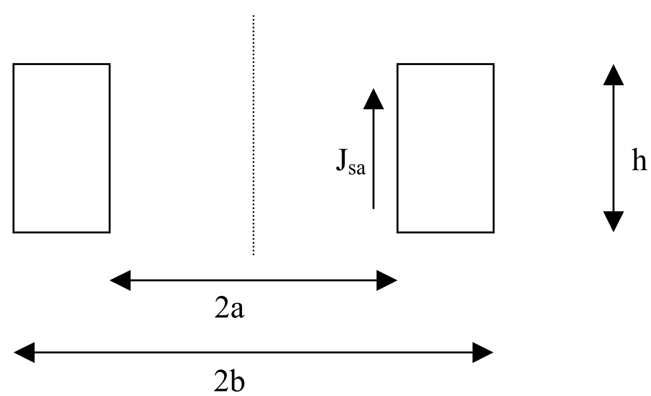
Homework 6

Due Thursday 10, April, 2003

1) Faraday's Law



Overhead View



Cross sectional view

The above two figures represent a toroid with a square cross section. In the overhead view, the dashed line represents the plane used to form the cross sectional view. In the cross sectional view, the dashed line represents the axis r = 0. As discussed in class, the magnetic field only exists inside the toroid ($a<r<$b and $0<z<l$). A surface current exists on the toroid (refer to the book for a figure illustrating a wire wrapped toroid). The current is DC.

You should already know the magnetic field from the previous homework assignment.

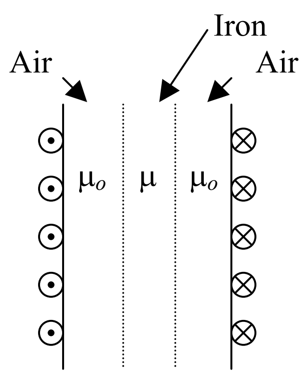
1) Determine the inductance of this geometry, using the total flux and total current.

2) Determine of the total energy, W_m, of this geometry by integrating the total field over the volume.

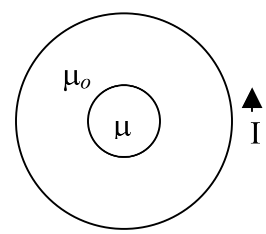
3) Determine the capacitance using the total energy and compare with your result from part 1.

2) Boundary Conditions

A long wire wrapped solenoid has wire density $n = \frac{N}{l}$ (N is the total number of windings and l is the length of the solenoid. The solenoid is partially filled with iron, $\mu_r = 4000$, as shown in the two figures below.



Side View



Overhead view

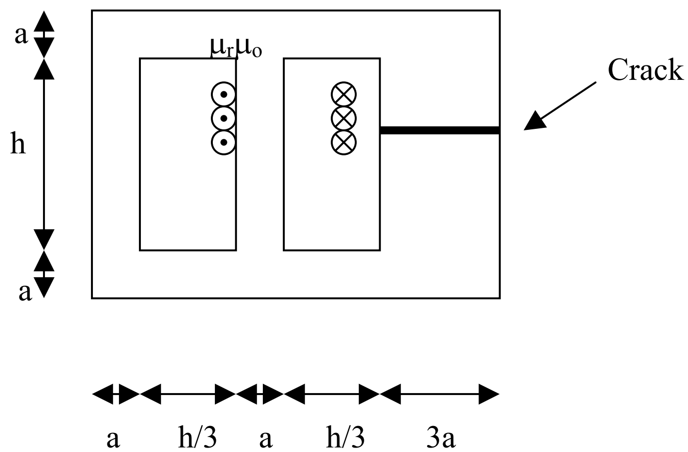
1) Determine the magnetic field, $\vec{H}$, and the magnetic flux, $\vec{B}$, everywhere.

2) Indicate all boundary conditions that apply to this geometry.

3) Determine the self-inductance of this geometry.

4) Where is most of the magnetic energy stored? What ratio of (radius of iron material/radius of solenoid) is necessary such that half the energy is in the air region and half the energy is in the iron?

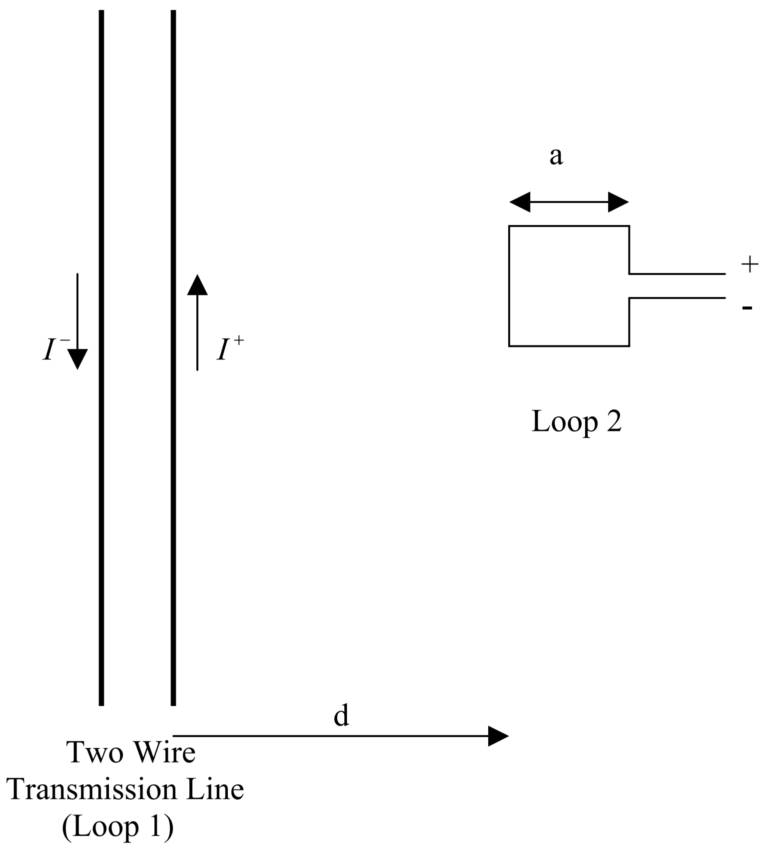
3) Magnetic Circuits



The above figure represents a silicon iron transformer with N windings around the center post. There is a thickness, *t*, perpendicular to the page as well. The field will "split" and loop through both left and right sides of the transformer. Notice, the right post has a larger cross-sectional area.

1) If the transformer is cracked, what is the maximum width of the crack such that the total flux on both paths is the same? Indicate what assumptions you made.

4) Mutual Inductance



A two-wire transmission line (like phone line) has current $I_o \cos(\varpi\ t)$. Remember, a transmission line consists of two conductors and the current is equal and opposite in each conductor. The directions indicated in the figure are arbitrary, though, you may assume they are correct for $t = 0$. A square loop is placed a distance, d, away from the transmission line. The loop is coplanar with the line.

1) Determine the mutual inductance L_{21}

2) Determine the EMF in the loop.