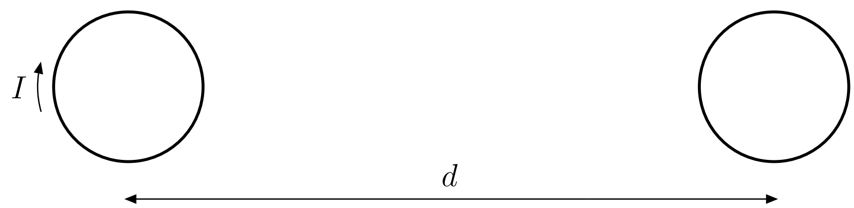
Physics 470/570 Homework 3 Due Wednesday, September 20, 2017

Reading assignment: Griffiths sections 7.2.3 through 7.3.3.

Problem 1. A small circular loop of wire (of radius a) lies a distance z above the center of a large circular loop (of radius b). The planes of the two circular loops are parallel, and perpendicular to the common axis going through their centers. Assume $a \ll b$.
(a) Suppose current I flows in the big loop. Find the flux through the small loop. (The small loop is so small that over its area you can consider the magnetic field due to the big loop to be essentially constant. You should use the results of Example 5.6 in Section 5.2.2 of Griffiths.)
(b) Suppose current I flows in the small loop. Find the magnetic flux through the big loop, by treating the small loop as a magnetic dipole.
(c) Find the mutual inductances found by the two different methods of parts (a) and (b), and confirm that $M_{12} = M_{21}$.

Problem 2. A long solenoid of radius a, carrying n turns per unit length, is looped by a wire with resistance R, as shown in Figure 7.28 on page 320 of Griffiths.
(a) If the current in the solenoid is increasing at a constant rate, ($dI/dt = k$), what current flows in the loop, and which way (left or right) does it pass through the resistor?
(b) If the current I in the solenoid is constant, but the solenoid is pulled out of the loop and reinserted in the opposite direction, what total charge passes through the resistor? [HINT: The current is the amount of charge per unit time passing a given point, so the total charge passing between times t_1 and t_2 is $\Delta Q = \int_{t_1}^{t_2} I_{\rm loop}(t)dt$. But $I_{\rm loop}(t)$ is itself related to the derivative of the flux, so you are evaluating the integral of a derivative. That's why you can do this problem without knowing details such as how quickly the solenoid is moved.]

Problem 3. Two small wire loops, each of radius a and resistance R, are a distance d apart, and lie in a common plane:



Assume that $d \gg a$. A current $I(t)$ flows clockwise in loop 1.

(a) What is the magnetic field $\vec{\mathbf{B}}_1$ due to loop 1, at loop 2? [Since $d \gg a$, you may assume that $\vec{\mathbf{B}}_1$ is essentially constant over the entire area of loop 2.]

(b) What is the current induced in loop 2? (Be sure to specify the direction.)

(c) What is the mutual inductance of the two loops?

Problem 4. An inductor consists of a solenoidal coil 1.5 centimeters long and with radius 1.0 millimeters. It has a total of 1000 turns of wire. The core of the solenoid is air.

(a) Find the self-inductance of the coil, numerically, in Henrys.

(b) If 1 milliampere flows through the coil, how much energy is stored in its magnetic field, numerically?

(c) A capacitor is charged to a potential of 1 volt. If it stores the same amount of energy that you found in part (b), what is its capacitance numerically?