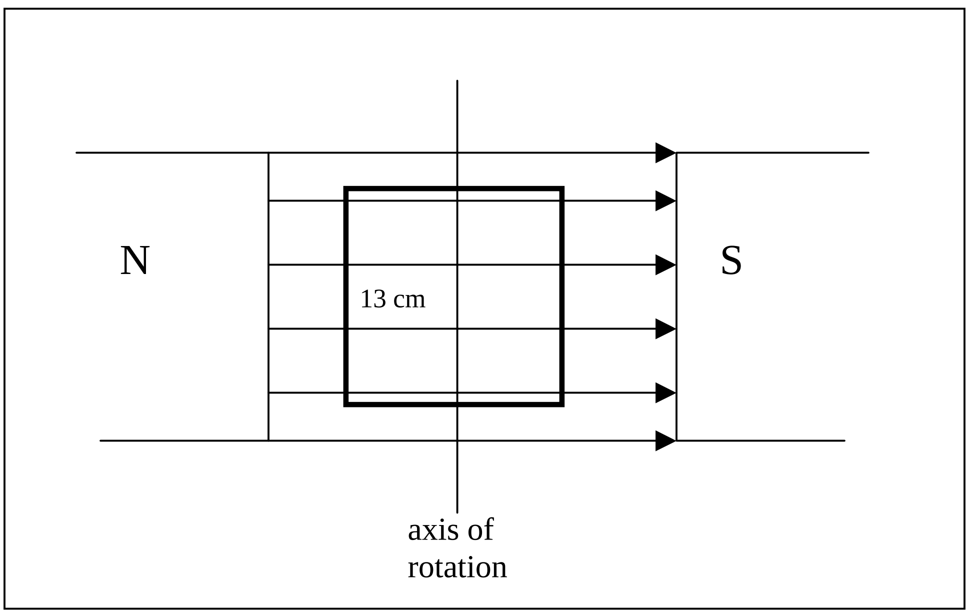
Physics 206b

Homework Assignment XI
Due October 31, 2007 (BOO!)

Note that I mislabeled the previous assignment as #8. It was, in fact, #10. This one is correctly labeled.)

1. A square loop of wire with a side length of 13 cm is in a constant magnetic field of $\vec{B} = 2.1T\,\hat{x}$, as shown. The wire has an overall resistance of 3Ω. What average torque is needed to rotate this loop with a constant rotational speed of $20\pi \frac{rad}{s}$ (i.e., $10\,\frac{rev}{s}$)? For this problem, it is sufficient to take $\Delta\Phi_B = \Phi_{B\max} - \Phi_{B\min}$. That is, the difference between the maximum flux and the minimum flux over the entire rotational range. Then, Δt would be the time over which that change happens.



2. A sinusoidal electric potential with a peak strength of 120V oscillating at 60 Hz (i.e., U.S. household current) is applied to solenoid with 1100 windings per meter. The total resistance of the wire is 7Ω. The solenoid has an air-core (i.e., no chunk of metal running down its middle). A single wire loop with a diameter of 0.6 cm is placed just outside of the solenoid facing it. (Assume the diameter of the solenoid is much greater than that of the wire loop.) The resistance of the wire loop is $R = 0.3\Omega$. How much power is dissipated by the wire loop? You may consider the average current in the loop to be ½ of the peak current. Neglect mutual inductance in this problem.

3. The primary coil in a transformer has 1000 windings. The secondary coil in the transformer has 37 windings. If a peak potential of 120V at 60 Hz is applied to the primary, when the secondary delivers a peak current of 13 A, what current will pass through the primary coil? What peak potential will appear between the leads of the secondary?

4. What is the total energy stored in a 17 nF capacitor when fully charged with a potential difference of 11V between its faces? Assume the capacitor is air-spaced. If this is a parallel-plate capacitor with a separation of 0.01 mm, what is the stored energy density? (Yes, this deals with material from earlier this semester. Consider this just a reminder.)

5. Consider again the solenoid described in problem #2. Take the diameter of the solenoid to be 2 cm and its length to be 11 cm. What is the maximum energy stored in its magnetic field under the conditions described in that problem? What is the inductance of the solenoid?

6. In words (a sketch or two or three or four might not hurt either!), contrast the current flowing through a circuit with an inductor in it and that of a circuit with a capacitor in it. Similarly, contrast the induced EMF in an inductor with the back EMF of a charging capacitor in a circuit with a current flowing in it.

7. A D.C. potential, V, is applied to a solenoid with n windings per meter and a total resistance R. The solenoid has a total length L and a diameter D. Assume the magnetic field inside the solenoid to be the same everywhere. There will be a force exerted on the solenoid by its own magnetic field that looks like a pressure. I.e., it is a force distributed over the area of the solenoid. Note: The magnetic field inside of a solenoid can be considered to be constant both in size and direction everywhere and is in the $\pm\hat{z}$ direction. (*Hint: See problems #5 and #6 of Assignment #10.*)

    a. Calculate the magnetic pressure of this system.

    b. Is the pressure outward or inward?

    c. If the solenoid were a container holding a monatomic ideal gas, it would take some amount of mechanical work to create that same net pressure. Calculate the mechanical work of a "tin can" with the same dimensions as the solenoid needed to create the same pressure in the gas. Compare this to the energy stored in the magnetic field of the solenoid. What current, I, would be needed to have these numbers agree?