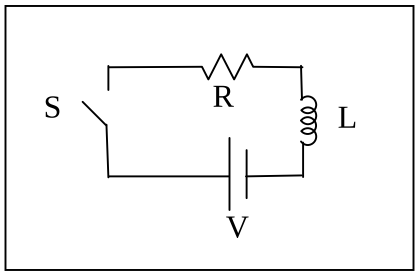
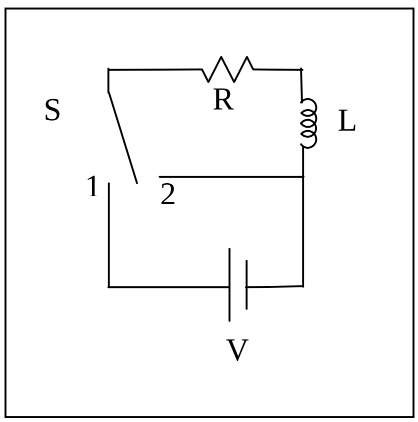
Physics 206b

Homework Assignment XII—modified (R and L values in problems #1 and #2 have been changed)
Due November 12, 2007
Note: This is a Monday.



1. In the circuit above, the resistance is 37Ω and the inductor is 140 mH. After switch S is closed, how long will it be before the voltage difference across the inductor is ½ V?



2. Now consider the circuit above. Initially, the switch is in position 1. After a long time, the switch is moved to position 2. Make a sketch of the current flowing through the inductor as a function of time after the switch is moved. Use the values for R and L from the previous problem. Be sure to indicate on your sketch the time at which the current will be at the $\frac{1}{e}$ level. If the EMF provided by the battery is 12 V, after 1 millisecond, what will be the current flowing through the resistor (this will be an actual value, not just a fraction)?

3. The heating coil in a toaster oven has an inductance of 1 μH. Assume that the toaster is being powered by a D.C. source (of course, they are usually plugged in to A.C. outlets, so this is a simplification) which results in 10 A flowing through the coil. A person making a piece of toast notices it start to burn and quickly unplugs the toaster. A 2 mm spark is observed to be produced by the tip of the plug when this is done. Take the breakdown voltage (dielectric strength) of air to be $3\frac{kV}{mm}$. Given this information, what was the initial rate of change of the current through the coil? (I.e., what was $\frac{\Delta I}{\Delta t}$ initially?)

4. An inductor consisting of a solenoid with 20,000 windings per meter that is 3 cm long and 1 cm in diameter is placed in series with a resistor whose resistance is 9 mΩ and a capacitor with a capacitance of 187 mF. The circuit is driven at 60 Hz. What is the impedance of this system?

5. In the previous assignment you performed the following calculation: "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). 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?" Now, calculate the contribution the inductive reactance has to the calculated energy. At what frequency would current have to be supplied in order for the inductive reactance to be as important to the stored energy as the resistance?

6. A "narrow pass" filter is to be constructed. It is desired that the filter pass signals at 88.1 MHz (that's the local radio station KDHX). An inductor with an inductance of 19 μH is used in this filter. A variable capacitor is included in the circuit to tune the filter. The separation between the plates is 0.7 mm and the area can be adjusted via a knob. What will be the area of the capacitor plates when the radio station is "in tune"? If the capacitor plates are square, what is the side-length of the plates?

7. In lab, you recorded the frequency at which the current passed by an LRC circuit was greatest. Ideally, this would be the "resonant frequency." Using the values you recorded for the resistance, inductance, and capacitance of the circuit (if you didn't record these, I will provide them to you in class), calculate the theoretical impedance of the circuit at the resonance you measured. Also calculate what the theoretical resonant frequency is for that system. What is the impedance of the system at the theoretical resonant frequency?

8. What is the wavelength, in vacuum, of the 88.1 MHz signal mentioned above?