1. Consider a standard coax cable as an “infinite” length wire of radius $a$ surrounded by a thin conducting cylinder, coaxial with the wire, with inner radius $b$ and outer radius $c$. Assume $a<<b$ and $c-b << b$ (thin shell and wire). A current $I(t)$ flows along the wire and a corresponding current $I(t)$ flows in the opposite direction on the outer cylinder. Assume that we have the quasi-static situation in which the currents are identical in magnitude at each moment in time, and the changes in current are sufficiently slow.

(a) Find the self-inductance per length of the cable by considering the change in flux as $I$ is changed. Ignore the small amount of flux within the conductors themselves.
(b) Now find the self-inductance per length by considering the magnetic energy $W$ stored per length of cable and relating that to the energy $W$ stored in an inductor $L$ by current $I$. Does your answer agree with that from part A?

2. EMF in loop from oscillating field [30 points]
In the circuit shown in the figure, the power supply provides an EMF of $V = V_0 \cos(\omega t)$.

(a) Find the current through the power supply as a function of time after all the transients have died away.
(b) How does your answer behave in the limits $\omega \to 0$ and $\omega \to \infty$? Explain if/how this makes sense, given the characteristics of an inductor.

3. Go to Griffiths page 317, and work through the derivation that starts below Eq. 7.29, and continues to its culmination at Eq. 7.34. Imagine that you have been asked to give a guest lecture in an E&M II class, and your task is to do this derivation for the students. Work out all the details for yourself, really try to follow and understand this derivation. Write it up for yourself as though you were preparing your own lecture notes – explaining steps, pointing out spots you are confused about, making sense, thinking about WHY you’re doing what you’re doing. This doesn’t mean copying the solution in Griffiths - it means figuring it out, and then writing it up for yourself how you now think about it!
4. Consider the RLC series circuit shown in the figures above. First we’ll use a battery to supply EMF, then an AC power supply. In both cases, assume the circuit is underdamped, (i.e. R is small. As you solve the problem, you should be able to say small compared to what?)

(a) Consider the DC circuit on the left. If the switch is open, but then closed at time t = 0, Describe qualitatively what happens just after t=0, and then as t gets very large. Then compute a formula for the current through the capacitor as a function of time.

(b) Now replace the battery with an ideal AC power supply that provides a voltage V0 sin ωt. After letting all the transients from turning on the power die away, what is the current through the capacitor as a function of time? Make a rough sketch of the magnitude of the current as a function of frequency, showing (and briefly explaining) the main features of your sketch (e.g., what are its limiting behaviours, and what are any “interesting features”)

(c) Let’s use some realistic values appropriate to an inexpensive (homebrew) oscillator, say a 1 Ohm resistor, a 30 pF (picoFarad) Capacitor, and a 100 nH (nanoHenry) inductor. This circuit has a natural “resonant” frequency – what is it in this case? (Does that number give you a clue as to what this circuit might be useful for?) Use Mathematica to plot the magnitude of current as a function of frequency. (Be careful to set the scale of frequency to run past the resonance) Does the graph match the expectations of your “sketch” in the previous part? Briefly, comment.

5. (4 pts Extra Credit: Earn a problem back!) Review all your graded homework and the posted solutions up to now. Choose a problem on which you did not get full credit (Please clearly state which set, and which problem, you have decided to focus on.) State what was incorrect about the solution you had given on the first pass. (This means you should find a problem you got WRONG, rather than one you simply puncted). This is more than simply redoing an old problem with a solution set in front of you – we want you to explain what you have learned. Express your reasoning at the time, then explain the correct solution. As with the previous problem, we don’t want you to simply copy/reproduce a solution that is in front of you - we want you to understand it, own it for yourself!