FREQUENTLY ASKED QUESTIONS

April 29, 2003

Administrative Questions

What's going to happen to CyberTutor?

I'm afraid I really have no idea!

What else is there to learn after RLC circuits?

Before the quiz, we'll be talking about electromagnetic waves, and Maxwell's equations. There are a few more topics after the quiz.

What are we going to do in class after next Wednesday's test, since there is no final?

We will be covering a few more topics, mostly to do with wave phenomena: interference, diffraction, scattering. Also there will still be the microwave experiment to do.

Content Questions

How do you know how to solve differential equations if you're not in 18.03?

Well, I guess the best thing to do is to learn by example. There are really only a few basic ones to know. The basic procedure is to "separate variables": get the variable you want to solve for as a function of the other on one side of the equation. Then integrate from the start to the point where you're trying to find the solution (see the first practice problem from today, for example.).

In the first practice problem, why does L_2 have more current? Shouldn't it have less if it opposes the change in current more?

Whether it has more or less current depends on whether the current is increasing or decreasing. In this particular case, the current is decreasing.

L_2 opposes the change more, so it *slows* the decrease more. Since it slows the decrease more, the current will go to zero more slowly– so L_2 will have more current at any given time.

When doing the Loop Rule in an R/L/C problem, how do you choose the sign for the potential difference across the capacitor? How was this sign chosen for the second practice problem? How about the sign for the inductor term?

The signs are a little tricky. The best way to keep them straight is to draw a careful picture following the instructions of the R/L/C How-To: draw the directions of currents and the signs of charges on the capacitor plates, choosing directions and signs consistently if not specified in the problem. For instance, in the LC practice problem, you could draw the top plate as + and the bottom plate as −. When the switch is closed, charge leaves the top plate, so direction of current is CCW. The sign of the inductor's ΔV is $-LdI/dt$ (walking around the loop CCW, and minus sign since walking in the direction of the current). The minus sign means that if dI/dt is negative (decreasing), the induced emf is positive and vice versa. Walking around CCW from the − plate to the + one is an increase in potential, so you get $+Q/C$. The D.E. is $-LdI/dt + Q/C = 0$. But now we want to relate I and dQ/dt. When charge is leaving the top plate, $Q(t)$ is decreasing. So I is positive (CCW) when dQ/dt is negative. So we then put in $I = -dQ/dt$, to get $Ld^2Q/dt^2 + Q/C = 0$.

(You would get the same equation if you initially picked plate charge signs and directions the opposite way... in fact in this particular example, the charge oscillates back and forth, and so both situations – top plate positive and CCW current, or bottom plate positive and CW current – actually happen).

In the second practice problem, when the charge oscillates back and forth, does it produce a spark?

No, the charge just sloshes back and forth. If it sparked across the capacitor, that would discharge the circuit (at least partially) and oscillations might stop.

What exactly do you mean by a "steady-state situation"?

"Steady-state" generally means a situation in which the current does not change. If there's an AC power supply, it's not steady state, since the power supply is driving the current back and forth and there's in general a non-zero dI/dt at any given time. However, for a DC power supply (which provides constant voltage), the situation may or may not be steady state. There may be a "transient" situation, for which there's current changing over a short period of time, but after a long time the situation will settle to a steady state. An example would be closing or opening a switch to add or remove a battery: current may initially change, but then reach a final "steady-state" value after a long time, or go to zero, depending on the situation.

What would happen with a constant DC voltage? Is that a steady state?

It may be or not, depending on the situation. As mentioned above, you can have a "transient" situation with a DC voltage, for which the situation isn't steady until it's settled down after a long time.

Is there a table of formulas you could use for RL, RC, RLC, etc?

Well, you could write one up, but there are really a lot of possible situations and IMO this is not so useful. It's really simpler to just know the rules for writing the differential equation you need to solve (see the R/L/C How-To).

Where does the mechanical analogy come from? Why are the variables analogous to each other?

It comes from the fact that the same math describes the behavior of a mechanical system and of an electrical system. You can see that the variables (e.g. Q for x and so on) are analogous, just by substituting them. The equation is the same, just different variable names – so the solutions for each case must show the same behavior.

What is the meaning of L?

The physical meaning is "sensitivity of EMF to change in current". A big self-inductance means a big induced EMF for a given change in current in the coil; a small L means a small induced EMF for the same change in current. In the mechanical analogy, L is like mass. It provides a sort of "electrical inertia". If you imagine a mass with some force applied to it, the bigger the mass, the harder it is for a given force to accelerate it. Similarly, the bigger the L, the harder it is for a given EMF to change the current through it.

Will we see examples where a voltage source is present in an R/L/C circuit?

Yes, you will see transient examples where a DC voltage is applied (like your CyberTutor problems this week). You've already seen RLC examples where a sinusoidal voltage source is present.

In the demo in class on Monday, why did the brightness of the light bulb change when the iron rod was moved in and out of the inductor?

Prof. Roland showed in class how the current of an RLC circuit depends on frequency. There's a big peak in the current versus frequency plot at what's called the "resonance frequency", where $\omega = \omega_0 = 1/\sqrt{LC}$. This happens when the "driving frequency" ω of the power supply equals the "natural frequency" ω_0 of the RLC circuit.

This phenomenon is called *resonance*, and the mechanical analogy is: imagine shaking a slinky back and forth. If you push it back and forth at just the same frequency that it would naturally oscillate at, you can make it oscillate with very big amplitude. Other analogies: pushing a child on a swing at just the right frequency to make her swing really high, and the swinging ball demo from class. What Prof. Roland was doing with the inductor was actually not changing ω, but changing the L so that the resonant frequency changed. When this resonant frequency became equal to the frequency of the AC power supply, the current peaked and the bulb burned brightly.

See section 31-6 in your text, and figure 31-9; I'll try to go over this in recitation if we have time.

Does the Hall effect say that electrons move in a circuit?

The Hall effect is described in Section 27-8 of your text. It causes separation of charges perpendicular to the direction of current in a wire in a magnetic field (due to the Lorentz force on the moving charges.) We will neglect this in most of our discussions.

Can you give us some hints about the last problem on the pset?

I think this one will become more clear once we cover displacement current in class.

Can you explain Experiment AMP?

I've had the most requests for this, so I'll cover it in detail on Thursday.

Can you explain AC circuits?

I've also had a lot of requests for this. We may not have too much time left on Thursday, so I've posted an AC Equation Summary which I hope will help. I'll try to go over some things Tuesday, too.

Can you help on CyberTutor?

Yes, but please be specific about which problems are causing you the most trouble, since there are a lot of problems.

In the first CT problem for points, it asks for the current immediately after the circuit is closed. The textbook says a current immediately starts to flow, but why does CT say it's zero?

Current *does* immediately start to flow. But it starts from zero at $t = 0$ immediately after the switch is closed, and increases from there.

In the first CT problem for points, second part, part D, I'm sure the answer is 0.0575. Why does CT say it's .0576?

I think this is a round-off problem. When you do the calculation, try keeping more significant digits all the way through the intermediate steps. I get 5756 seconds for part d, which rounds to 5760 with 3 significant figures.

Tidbits

RLC Java Applet.