

Lecture S10 Muddiest Points

General Comments

In today's lecture, we began looking at circuits that include inductors. We saw that when using the node method, inductors fit into our scheme less easily than capacitors, although it can be done.

We also did three concept tests on inductors, meant to demonstrate how inductors behave in simple circuits. The fundamental concept is that inductors resist current change (not currents!). The results of the concept tests follow from this principle.

Responses to Muddiest-Part-of-the-Lecture Cards

(45 cards)

1. ***What is the intensity of the light bulbs actually related to, current, voltage, or power? (2 students)*** For any given light bulb, the voltage and current are related — there is a curve of current vs. voltage that describes the constitutive law of the bulb. Of course, the power is just iv . So if you specify either i or v , you know the total power. The brightness is most directly related to the power, which can be determined from either i or v , through the constitutive law.
2. ***How do we know that s is frequency? (1)*** Very often, we take $s = j\omega$, where $j = \sqrt{-1}$. ω is the frequency in radians per second. For $s = j\omega$,

$$e^{st} = \cos \omega t + j \sin \omega t \quad (14)$$

(This is Euler's formula.) I think it's clear why ω is frequency — so s is a generalization of frequency.

3. ***If we know what the impedance of a capacitor is, why don't we use them in the node method instead of the differential equations? (1)*** Today, I was trying to show how inductors enter the picture, and so backed up a little. In general, we can go directly to impedances, but we must always remember that we are solving differential equations — we can't treat the impedances too literally as resistances.
4. ***On the last PRS question, how did you figure that the voltage becomes higher by 2 volts? (1)*** I didn't say that the voltage is 2 volts — I said that it is 2 V, where V is the voltage across the source, not (here) the symbol for volts.
5. ***Why is the voltage across the two bulbs twice the voltage across the voltage source, in the last PRS question? (2)*** Before the switch is opened, the voltage across the inductor is zero, and the voltage across bulb A is V . For this value of voltage, there is a current i through the bulb, and also through the inductor. After the switch is opened, no current flows through bulb A, but the current i continues to flow through the inductor, at least initially. This current must flow through bulbs B and C, to satisfy KCL. Since the

current through bulbs B and C is the same as it was through A, the voltage across each bulb must be V . Therefore, the total voltage across the two is $2V$.

6. **What happens when a current source is connected to the same node as an inductor? (1)** That depends. Are there other elements attached? If not, the current through the inductor must be the same as through the inductor. Believe it or not, in my lab today, I had reason to connect an inductor to (almost) a current source. There's no problem doing this, so long as the current source strength doesn't change discontinuously, which would induce infinite voltage across the inductor.
7. **What was the "Runge-Kutta" integration technique that you mentioned? (1)** You should learn about this in 18.03. It's a method for numerically integrating differential equations (linear or nonlinear) to obtain a numerical solution.
8. **How does an inductor resist current? (1)** It doesn't. It resists current *change*. Physically, this is because the energy in an inductor is proportional to current squared. So changing the current requires that power be supplied to the inductor.
9. **For the RLC circuit differential equations, there are 4 variables, but only 3 equations. What other equation can be used to find s ? (1)** The three equations are linear and homogeneous in the three unknowns (E_1 , E_2 , I_4). Normally, this would imply that all three unknowns are zero. However, this solution is "trivial," meaning that it doesn't really give an interesting solution that can match the initial conditions. The requirement that the determinant of $M(s)$ be zero is what allows for possible solutions. The correct possible solution is determined by the initial conditions, which must be given.
10. **In the second PRS question, I'm not sure why bulb A gets brighter. (1)** After the switch has been closed for a while and the circuit reaches steady state, the voltage across the inductor is zero. So the voltage across A is V . Just after the switch is closed, the voltage across A is only $V/3$.
11. **Why can you throw out the differential equation and replace it with s ? (1)** Replacing d/dt with s is a result of assuming solutions of the form e^{st} . We aren't throwing out the differential equations — we are solving them, using algebra.
12. **In 8.02, we used $-L \frac{di}{dt}$, and we haven't been using a negative sign. Is this taken care of in the passive sign convention? (1)** If you use the PSC, there is no negative sign. I can't really say much about what was done in 8.02 — I haven't seen that.
13. **Is there a book where I can find out about inductors and their behavior in circuits? (1)** There are many. The book I used, which is very good, is *Introductory Network Theory*, by Bose and Stevens.
14. **Why is it that you shouldn't sub in I_4 when solving the differential equations? (1)** You can, but it makes it harder to solve for the initial conditions. If you eliminate I_4 , how are you going to apply the initial conditions on I_4 ? It can be done, but it is sometimes complicated.
15. **In the last PRS question, how do you explain the sudden jump in the voltage in terms of energy? Doesn't it mean that the power loss is suddenly doubled? (1)** Yes, the power dissipated by bulbs is doubled. But that's not a problem — energy is still

conserved, which means that the power supplied by the inductor is (initially) twice the power supplied by the battery before the switch is opened.

16. *Not sure how to use the differential equations to solve a circuit as opposed to using s as a frequency. I will review more before I panic! (1)* Good. Please don't panic.
17. *Confused on RLC circuits. (1)* Please see me, or ask questions in recitation.
18. *Please explain more on the PRS questions. (3)* See some of the explanations above.
19. *Can we build a circuit? (1)* There is a plan for a lab with circuits.
20. *What are the telltale signs to look for when setting up a differential equations? (1)* Not sure what you mean. Could you please see me at recitation?
21. *Could you provide a handout with a summary of the different methods and show we should handle circuits? (1)* To some extent, this is in the notes. For example, if you look at the S10 notes, it begins with such a handout.
22. *When the switch was closed in the PRS questions, was the current in the inductor flowing opposite the initial current (because an inductor resists current flow)? (1)* No. Inductors don't resist current flow, they resist *changes* in current flow. Eventually, though, the current flows in the obvious direction.
23. *No mud. (19)* There were some very nice comments: *“Very good lecture.” “No mud, cool lecture!” “Great concept questions!”*