

Lecture S8 Muddiest Points

General Comments

In today's lecture, we began learning about capacitive circuits. We did a concept test that emphasized the rule that capacitors resist voltage change, and began learning how to write the differential equations of circuits with capacitors. We also learned that capacitors can be treated a little like resistors — a capacitor has a conductance (more properly called an *admittance*), and we can use it just like a conductance when we do the node method.

There were only 39 cards today. Please, I would like everyone to participate in the muddiest-part-of-the-lecture exercise.

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

(39 cards)

1. ***Still don't understand how to find node equations "by inspection." (4 students)***
At any node (say, e_1), the left hand side of the node equation is the sum of the conductances touching e_1 times e_1 , minus the conductance connecting e_1 to e_2 times e_2 , minus the conductance connecting e_1 to e_3 times e_3 , ... The right hand side of the node equation is the sum of current sources flowing into e_1 . (Note: I have assumed that there are no voltage sources attached to e_1 . If there is, either the node voltage is known at e_1 , and there is no need to write KCL at that node, or e_1 is part of a supernode, and the rule is more complicated.)
2. ***Why is a bandpass filter called a bandpass filter? What does it do? (2)*** It is common to think about filters in the "frequency domain," that is, to think about how they affect sinusoidal signals of different frequencies. The output of a bandpass filter is attenuated (i.e., is smaller than the input) for all input signals except those in a narrow band of frequencies, which are passed through the filter with little attenuation. For example, if you wanted to receive the AM channel transmitting at 680 kHz, you might build a bandpass filter that passes signals with frequencies in the range 670–690 kHz, and attenuates signals at other frequencies.
3. ***How exactly does a lowpass filter work? How did you know how to draw the curve of the filter transfer function vs. frequency? (1)*** Here's one way to think about it: A resistor has a constant impedance (its resistance). A capacitor has an impedance that varies with frequency. The impedance gets smaller as the frequency increases. So the circuit I drew is a voltage divider, but the amount of attenuation of the input signal depends on the frequency. For low frequencies, the impedance of the capacitor is much greater than that of the resistor, so the "transfer function" of the voltage divider is close to unity. For high frequencies, the impedance of the capacitor is close to zero, so the transfer function is close to zero.
4. ***What is the point of telling us about the filters? (2)*** I'm trying to show you some useful things that you can do with dynamic circuits.

5. **Will we be building any of these circuits? (1)** I'm trying to develop a lab for this material, which I hope that you all will do.

6. **Why was one graph plotted with**

$$\left| \frac{y(t)}{u(t)} \right|$$

on the x axis and the other with

$$\left| \frac{u(t)}{y(t)} \right|$$

on the x axis? (1) If I did that, it was a mistake. Both should be

$$\left| \frac{y(t)}{u(t)} \right|$$

on the x axis.

7. **Why was the plot labelled**

$$\left| \frac{y(t)}{u(t)} \right|$$

I'm plotting the ratio of amplitudes, for sinusoidal inputs and outputs. The labeling is a bit imprecise; we will make it more precise later.

8. **How can we write the differential equations for nodes with inductors? (1)** Short answer: You can't! Long answer: Wait and see. It is complicated (a little) to mix capacitors and inductors.

9. **What is the physical meaning of s ? (2)** s is the exponent in e^{st} . We'll talk about this more in class next time.

10. **How does a dead battery complete a circuit? (1)** That depends on the battery. A voltage source with strength 0 V is just like a conductor (a wire) — it causes the potential at each terminal to be the same. A dead car battery does this as well. Other dead batteries may behave a little differently, and some resistance across the terminals.

11. **Please explain the PRS question question. After the switch is closed, and the current starts to flow ... (1)** ... the capacitor begins to charge, increasing the potential across its terminals, therefore decreasing the potential across the bulb, reducing the current flow, and the brightness of the bulb. Eventually, enough current flows into the capacitor so that the voltage across its terminals is the same as the battery, and no more current flows.

12. **For the last example you gave, when the capacitors are charged, do sign conventions work for them the same way as for a voltage source? (1)** If I understand your question, yes. Even though one terminal is labeled +, it is still possible for current to flow into that terminal.

13. **In the last circuit example, it seems that the 2 capacitors must start charged, and they pass current back and forth until it is dissipated by the resistors. Is that right? (1)** Essentially. I would modify this by saying "back or forth" – RC circuits can't oscillate, as back and forth implies. I would also say "until the energy is dissipated." Your wording implies that it is the current, or perhaps charge, that is dissipated.

14. *Please explain $(G + Cs)$ more and how this can work. (1)* We will pick this up in lecture next time.
15. *No mud. (19)* Good! There were a few comments: *Good lecture!* Thanks! *Anxious to find out how to solve the RC circuit equations.* That will come in the next lecture. *If your son wanted a tour of Harvard, would you still go on the tour?* Yes, reluctantly. *It was really cool learning about what a bandpass filter and what a lowpass filter are ...* Good! We will use bandpass filters again later this year when we do amplitude modulation.