4A: Observe & Analyze I

Chris Phare, Graduate Research Fellow, Electrical & Computer Engineering [00:00:00] So now that we've discussed how to deal with problems with single resistors, we're going to talk about problems with, that have multiple resistors in a complex circuit. So this'll prepare you for the rest of the course; you're gonna use this technique a lot, pretty much every day in here. And it also relates to the key learning objective of having to analyze complex circuits and find all the currents and voltages in these circuits. Additionally, if you're an electrical engineer, you're going to use this pretty much every day. Pretty much every circuit you have has more than one component and you, it's kind of just a bread and butter technique you need. So I want to go ahead and have you pair up and work with a partner, and I'm going to solve a problem for you on the board and then we can work through it together. Sound good? All right.

Student [00:00:40] This is really cool. We've spent so much time on individual parts of circuits, it's nice to finally see how they all work together.

Student [00:00:46] I know. I actually thought this class was going to be a little dull, like a lot of memorizing, but now we're actually getting to do the work that real electrical engineers do. Sounds exciting.

Chris Phare [00:00:55] All right. Go ahead and take some notes while I work through the problem then. So in this problem we have a five-volt battery that's connected through a 50 ohm resistor to two resistors in parallel, one five ohms, one 15 ohms. Okay? So step one of solving these sorts of problems is to pick something to call ground, so we just pick down here. Step two, label the voltages in the circuit. Step three, Ohm's law, really simple here, 5 minus V1 over 50 is I1. I2, I3, so V1 over 5 is I2, V1 over 15 is I3. Step four is the current equations. You have I1 minus I2 minus I3 is zero. Step five, just solve these, pretty straightforward algebra, right?

Student [00:01:56] Wait, how do you use Ohm's law?

Chris Phare [00:01:58] Okay, so you see how I use it here across this resistor to relate the voltages to the currents across it?

Student [00:02:04] But how do you go about getting that? I'm not sure if I get it.

Chris Phare [00:02:08] Okay, so, you know from, from previously, when we were solving just one resistor, we knew that V equals Ir or the voltage across the resistor is equal to the current through it times its resistance. So here we have 5 minus V1, that's the voltage across it. And then I1 times 50. So that's just this equation here. Yeah?

Student [00:02:30] Can you repeat the steps again? I think I missed one.

Chris Phare [00:02:32] Yeah, sure. So here I picked a point of the circuit to call ground. I labeled all the voltages in the nodes between the resistors. Then I used Ohm's law for every single resistor to get these three equations. Then I wrote the current sum at every node, and then I can solve all the equations that I have. Is it clear?

Student [00:02:52] I get the first few steps, but then I get confused with the multiple resistors.

Chris Phare [00:02:55] Okay, since this isn't working so well, let's work through another problem. It'll use the exact same steps as the previous one. It'll just be a slightly different circuit and I'll go, try to go through it a lot clearer step-by-step.

Chris Phare [00:03:13] So in this problem, we have a three-volt battery that's connected to three resistors in series, and series is just a fancy word for end, connected end-to-end. And these resistors are 20 ohms, 30 ohms, and 10 ohms. So now we want to solve for the voltages and currents through every resistor, just like the last one. So step one, we want to pick a point of the circuit to call ground. So here I normally just pick the bottom terminal on the circuit, but you really can pick anywhere you want. It's just for simplicity. And then step two, you label the voltages. So every connection between two components gets a name. This one called V1, this one called V2. Then step three, use Ohm's law on each of these resistors. So for this resistor, we have three volts here minus V1. So 3 minus V1 equals I1 times 20, where I1 is just this current through that resistor. Notice this is just V equals Ir for every single resistor. So now for this one we have V1 minus V2 is I2 times 30, right? And then step four is to solve the, write the equations for the currents at every node. So at every place that we labeled, we want to write an equation that has the currents in minus the currents out is 0. So here we have I1 minus I2 equals 0. And then at this spot, we have I2 minus I3 equals 0. So then the fifth step is just to solve these equations. We have five equations and five variables so you can solve it pretty simple. Is that clearer?

Student [00:05:06] It's a little clearer.

Chris Phare [00:05:07] Okay. So I'd like you to go ahead and work through the original problem in pairs again. I'm going to walk through the class and answer any questions you might have. And I'll also be posting a solved example of this problem or a very similar one on the course website where I'll type up every step, going step-by-step through the problem. It's really important, we're going to use this pretty much every day in the rest of the class and it'll also be on the midterm. Okay? Great.