[00:17:09] You mentioned the math sometimes got pretty tough in [Basic Circuits]. What did you do when the math got tough?

[00:17:25] "Tried to reason with it physically as much as I could. Cuz, it all started off in 160 with Hammer. I mean he--he did a really good job with...that was my first experience with making mathematical and physical concepts make sense. And not just getting your mind wrapped up in the math. Just. His thing was 'could you explain this to a 3rd grader?' And that just definitely hit home for me and the way I think of things. Cuz this just, it made sense. I mean really these concepts are in the end not that hard. You just have to think about them the right way. And if you try to--when the teacher writes it up on the board if you try to start, uh, you know just takin off with the math. You're gonna miss the physical sense. And then you won't understand the math later when the math gets tough.

[00:18:30] "So in 204, when things got hard. The best thing to do was go back to fundamentals. Go back to the class examples and go back to the notes. Start small and start thinking about it in the physical sense. So, he made this manipulation in the equation--why did he make this maniupulation in the equation. More than just, you know, he needed to get this value. 'How did this make sense in a physical way?' When things got more advanced that's the way you had to tackle it. Basically start small, start with examples, and think about things physically as much as you can. And sometimes you can't think of things physically. Just sometimes I couldn't at least think about them in a physical way. And then at that point, you, I mean just stick to your base fundamentals. Try to make it make sense with the fundamentals of the class. Versus physica. It's just, sometimes I mean I can't do it. But that doesn't happen too terribly often."

[00:19:37] Do you remember any of the times when it did happen?

[00:19:42] "I don't think so. Not. At least not necessarily a black and white kinda thing. But more of the little parts just didn't quite make sense to me. And you know other parts did."

[00:19:55] "Like for example when we started to have to tackle uh, diodes. Um. I mean I can go problem-solving through just a random problem. Uh, one of them you had a circuit--you had a diode, a battery and some other stuff down here. Um, and a diode doesn't let current through one of the wave directions. And I think we had like it was a capacitor over here or something like that. And again, I can't remember specifics, but so you just had. You know, some sort of circuit [inaudible] this. Including a battery. And then you had a switch over here. This and then it opened. And another battery over here."

[00:21:00] "Basically how capacitors work in a nutshell. I'm not--I never really got so great with the physical part of capacitors. Um, I got--I started to get close. And then I just had to move on and move onto other tough subjects that I was trying to tackle at the time. But, anyway this capacitor charged up and it charged up to a voltage like 120

volts from this battery. And no current can flow through the rest of this circuit because of this diode. And that's pretty obvious."

[00:21:38] "Um, then the switch opened, and there's a 12-volt source over here. So this is at 120 and there's 12-volt and some other stuff over here that doesn't supply voltage. So initially what one would say is that this capacitor has to go down to 12 volts because there's this big charge over here and there's only a little bit over here. So they have to become equal. And that also--you would also say that because let's say there was like a resistor over here. LEt's just say it's a battery and a resistor. Just for the heck of it. This would equal that because they're in parallel. And this is probably 12 volts, so they gotta--they gotta equal."

[00:22:30] "And I was working with some people. A couple group members on this. And um. Like they insisted that this had to go down. Mathematically that makes sense, because you say 'hey, parallel. Parallel things are equal. There you go.' But when you think about it physically, the capacitor has to discharge itself and create current in the opposite direction. And for it to discharge at the end of the day, it would have to create a current going this way, going against that diode. So when you think about it physically it can't discharge. So the final voltage would have to be 120 cuz there's just no way for it to be less."

I THINK HE'S IMPLICITLY TREATING VOLTAGE AS A THING-LIKE SUBSTANCE THAT WOULD LEAK OR DISSIPATE IF IT COULD. POSSIBLY SOME NIFTY MECHANISTIC REASONING ALONG WITH A HOLISTIC TREATMENT OF THE CIRCUIT AS ANIMATED OBJECT.

[00:23:19] "It won't be more because this is not gonna make a bigger charge on that. Uh, so that's where I think. You know initially it's a really tough problem. It looks kinda simple from the outside, but when you try to think of everything it gets complicated--you see where the trick question is. And when you think about it physically you can kinda get through it. And I mean that wound up being--it was a homework problem, that wound up being the correct answer as far as I can remember. So, that's how thinking about it physically really helped me get through the tough subjects of that class [Basic Circuits].

[00:23:53] "Cuz a lot--when it got at the end, toward the end of the year when things got really hard the difficulty was not necessarily in the components themselves. It was just the arrangement of the components and how--just seeing them in new ways that we hadn't gone over before. So there are new tricks that you have to kind of--not really tricks, they're just new configurations that you gotta think about. And you can't just say "oh we did this example in class so this is how you do it." That's just kind of, uh, you know just kind of just spitting out exactly what we did in class, and doesn't really show as much of an understanding."

[00:24:40] Hmm. Can I borrow this for a second? Um, so in this circuit.

Um, did anyone say like, 'Why can't the capacitor discharge that way?'

[00:24:56] "Um. What was the problem with that?"

[00:25:05] I mean you're drawing this from memory, right?

[00:25:07] "Yeah, yeah so. There could have been some stuff there. Uh, I think the way it worked. I--I don't think it had the option to charge that way. I honestly can't remember."

[00:25:32] But you--in other words, you looked at this diode and said 'for whatever reason, it would have to discharge this way.'

[00:25:39] "Yeah. From what I remember, just the way that the circuit was aligned. Yeah the only way for it to discharge would be for it to go that way. I think it was because curent flows, or by our convention that we were using. Yeah, let's say the convention was current flows from the negative to the positive. What happened was, because of the positive/negative alignment on the battery here, this--the positive end was here and the negative end was here. And for it to discharge it would have to go out the positive end."

[00:26:35] Oh. Cuz it would be opposing this battery. But in order for it to do that it would go this way through the battery, but it would hit that.

[00:26:45] "Yeah, in this case it would hit that. I think that's how it worked. I can think about it for a second and draw a better diagram."

[00:26:59] Did you find--so you were working on this with a group, you said?

[00:27:02] "Yeah there was, uh me and probably two other people. Or me and at least one other person."

[00:27:08] So what was it like when, I mean they were--were they pretty insistent that it should be twelve volts?

[00:27:14] "Yeah. Yeah. I mean I think at the end we probably just put down different answers because...maybe not on that one. There were a few where we put down different answers and, you know sometimes I was right and sometimes they were right. And for the exam, I pretty much met up with the same people, we reconciled all our answers, and that's how we you know came to terms with it. Uh, in this case that was probably one of those times actually. Yeah. Basically we wound up just putting--since it was a homework we put down different answers, saw--you know they, they really stuck to their guns. They wrote out their explanations of why that happened. I wrote out mine, and you know. We, we couldn't really get past our differences at that point."

[00:28:03] So was it the case that you felt you were reasoning from a physical sense, and that they were reasoning from maybe a more math--I

guess a more mathematical sense. You felt the current's sort of stopped, they felt it's the fact that they're in parallel that matters?

[00:28:18] "Yeah. Essentially like that. It wasn't necessarily that--I don't think that was their reasoning, that they were in parallel. That might have been where they thought things were going to have to go because, yeah, yeah. It wasn't just a sense that two things in parallel always have to be equal. For them, it was probably more 'two things in parallel always want to be equal to even out the voltage--the potential drop distribution.' So, one way or another, it would have to go to that equilibrium that they would want to be at. Versus just a--everything in parallel has to be equal so that's the answer of course. They didn't just jump to a conclusion. They definitely had some reasoning behind it. That's what I meant to say. Um. Yeah.

[00:29:14] So do you think that part of the reason you thought about the circuit that way was because of your experiences in Physics 160?

[00:29:21] "Yeah I think so. Because, it really taught me how to think of these problems in the way the charges are moving and physically what's going on. It wasn't anything close to what we did as an example in class. It was more of--I would say like, it was 270 taught me--and maybe a little bit of 160 too, that to tackle these problems what you need to do is think about physically what's happening first. Before trying to just dive into the math without more of like assessing what's going on. Um, so the way phys--summary of the way 270 helped me was it kind of taught me how to think about the problem versus how to solve this specific problem because this was--I think it was just beyond the scope of 260--270. Just, the subjects that we covered."