Mujtaba: Today, we're going to learn about Ohm's Law.

Mujtaba: I'm curious how many of you have heard of or know about Ohm's Law?

Student: I know.

Student: I do.

Student: I've yeah, yeah. I've heard about it. Yeah.

Mujtaba: So the simplest way it is represented is V equals IR. That is, the voltage drop, or the potential drop across a resistor in this case is just the current that passes through the resistor times its current. So if we were to draw a resistor right here with a value R, and this is the current, then the voltage drop across this resistor, this V is equal to the current times that resistor value that the resistor has so the resistance value of the resistor and the current path that passes through it. Current is the flow of electrons and V is the potential. So think of it as a force essentially, that allows or enables these electrons to move from an area of higher potential to low lower potential.

So if you guys have drunk boba bubble tea before, what happens is in the cup, you guys have these bubbles at the bottom. And when you try to at the end, once you're done with your drink, you're trying to suck these bubbles up. The when you're trying to suck these bubbles out of this straw, the pressure that you're putting on to it is essentially analogous to this voltage and the flow of these bubbles in this straw is essentially like the current and the resistance is essentially the friction of these bubbles with this straw. And that is the pressure you will need to overcome the flow of these bubbles in this straw against this friction to to get it. This is essentially analogous to that. So what we're doing is essentially this. Oh, sorry about that. This concept is pretty much described in almost every high school and high school physics and early college physics. But a lot of people have a hard time using this in real life. So one of the ways we can use it is if we have a simple circuit.

Mujtaba: So if we have a simple circuit, and we have an LED here.

Mujtaba: So essentially, these are little light bulb-looking things that emit light when you

drive a current through them so they light up. So in a circuit like this, what happens is we have a potential drop or voltage source right here. Let's say it is two volts.

And there's a resistor right here. And we need a current to flow through this LED to light it up. So right here I have a red LED that I'll show you guys in a minute. But red LEDs have a current rating of 20 milliamps. And in order to make a circuit where we can light up this red LED, we need to know what should be this resistor value for the current in the circuit to be exactly this current that this LED needs to turn on.

Mujtaba: Okay, so we will be finding this resistor value to do this, and this is a real-life application. For example, if you want to turn on this LED, so we will need to use Ohm's Law right here--V equals IR to do this. And we know the voltage--two volts--and we know the current that is 20 milliamps.

Mujtaba: So if the current is 20 milliamps what would the resistor value be?

Student: 100.

Mujtaba: Exactly. So, now we will use this in a circuit and see if our LED turns on.

So I'll share my camera with you guys and see if this works.

Mujtaba: Can you guys see me now?

Students: Yes. Uh huh.

Mujtaba: So now. Okay, so now what we have is the circuit.

Mujtaba: Can you guys see this circuit?

Students: Yeah. Mmm hmm.

Mujtaba: We will be not worrying about this part of the circuit for now. So the only thing we worry--we worry about is so there is a two volts input right here in this port and we found that a resistor value of 100 ohms will do the job, so this is 100 ohms resistor and we will plug this in from a two volt source in this breadboard, so this is a breadboard.

If you guys have dealt with prototyping electronics you might have used this. It's just a bunch of holes that are connected to each other. So all these five holes in a row

are connected to each other and the columns are not connected so you can use them to essentially make your circuit. So we will be connecting that there and we will be using a red LED. This is an LED, and this one is a red one. And LEDs have two legs, essentially. The longer one is the positive one because they're directional. And if you connect them the opposite way they don't turn on. So the longer leg will go to positive which is connected to the resistor essentially, and then the negative one will go to ground. So we will connect this right here.

Mujtaba: And we will connect the other leg to

Student: I can't see it.

Mujtaba: Oh sorry. Yeah. So we will connect the other leg to ground over here.

Mujtaba: So yeah, so ground right here. So in this breadboard, I've set up this rail at the bottom. So this negative the blue rail is ground and the positive rail is the positive volts that I'll connect the battery to. And I have a voltage divider set up right here that I'll explain in a minute. But this essentially takes my battery which is nine volts--this is a nine volt battery and divides this into essentially the required voltage that I need and that is two volts right here that will go into the resistor. So we will connect this battery now and see if it works.

Mujtaba: Can you guys see?

Mujtaba: There we go. So we will have a closer. I will connect the battery...

Mujtaba: battery pin

Mujtaba: Do you see that?.

Student: Yes.

Mujtaba: The red LED turns on. So this is a real-life application of this.

Mujtaba: So, of Ohm's Law. You can use it to turn on LEDs. You can use it for your personal projects or anything like that. You can buy LEDs, they're very cheap and you can set up the circuitry on your own and make an LED turn on and do a lot of other cool things with it.

Mujtaba: Now, LEDs have--any questions so far?

Student: No.

Mujtaba: Okay, so now LEDs have different current ratings. Essentially, if you're turning on a red one, you need a different current to go through it. And if you're turning on a blue one, you would need a different current to go through it.

Mujtaba: So a blue one, so this one needs 20 milliamps to go through it to turn on.

A blue one will need 30 milliamps to go through it to turn on. Do you guys think if I switch this red LED with a blue one, will it turn on right now?

Student: Probably not.

Mujtaba: Exactly. It will not turn on because because we set up this circuit for a 20 milliamp current, which is lower than the 30 milliamp current and that's why the blue one will not turn on. We can test this and here I have a blue LED. And we can--

Mujtaba: we can plug in the blue LED.

Mujtaba: Okay, now I can plug in the battery and see if it works.

Mujtaba: Oh, battery is connected, but the blue LED does not turn on, or it's very dim.

No, I don't think it's on at all. So, in order to do this--to make the blue LED turn on--what do you guys think the resistor value should be? We know the voltage is two volts. We know the current to be 30 milliamps. What should the resistor value be?

Student: Lower than this one by two thirds.

Mujtaba: Exactly. Something like 67 ohms.

Mujtaba: So, if you plug in that, we can turn on the blue LED.

Mujtaba: So now I will go on to the concept of the voltage divider which essentially is the reason we can take the nine volt battery and connect it to it without burning anything down. And that is essentially when resistors are in series, that is they're connected to each other and they divide the voltage that goes through them. Think of it as having two bubbles in your straw. When you're trying to pull out the bubbles

at the bottom of your boba drink, if you have two bubbles in the straw, you need to suck on it a little harder or essentially the pressure drop across the pipe needs to be higher for both of those bubbles to come up. And that is essentially what happens here. So two resistors in series, divide the voltage across them depending on the resistor value they have.

Mujtaba: So without going to my screen, I can just use paper here.

Mujtaba: So that is

Mujtaba: Can you guys see this?

Students: Yes.

Mujtaba: Okay. So if we have one resistor in series with other resistor and if they're--so, the sum of them the voltage drop across one of them, so say there is a voltage drop across the whole thing, this goes the opposite direction, okay. So the voltage drop across one of them--this is R1, this is R2--will be the resistor value of one over the sum of both of them times the voltage okay?

Mujtaba: So, essentially the voltage drop across one of them will be the resistance of that one over the sum of both of them times the total voltage.

Mujtaba: So, that is essentially what we are using here to do this. So in order to get two volts out of this, what do you guys think the ratio of these resistors is supposed to be? Essentially, this one resistor over the sum of resistances times nine should give us two. And that way we can find two divided by nine should be the ratio of these resistors. And that is essentially the resistor value that I picked--it's random. So you can pick many different combinations that gives you that ratio, which is I think 0.2--0.22. So to get that I chose 1.6 kiloohms resistor and a 5.6 kiloohm resistor. And as you guys can do the math, 1.6 over the sum of both, which is seven point two will be... it's a little odd ratio but it will be 0.22.

So that times nine gives us the two volts that we need. And that is essentially what I'm doing in this circuit right here.

Mujtaba: In here.

Mujtaba: So you guys can see the two yellow resistors. Those two yellow resistors, one of them is 1.6. The one that is horizontal is 1.6. And the other one is 5.6. And 1.6 over the sum of both of them gives us the ratio and that connected to the battery which is the blue and red rail at the bottom.

Mujtaba: Right here.

Mujtaba: This rail is nine volts and that divides it and make to two volts. And that's how we find the two volt from nine volt battery.

Mujtaba: Okay. Any questions

Student: Hmm I have a question.

Mujtaba: Yeah.

Student: Like when we connect something. So, in in the voltage divider, we can add something that has like finite resistance. So, we change effective resistance of one of the resistors in voltage divider. How like how can how do we need to pick resistances of voltage divider by the resistance to make this more--

Mujtaba: Which affects lower? So you are you talking about the two volts that at the end we are getting you want to make that lower?

Student: No. I mean like there are two volts in the voltage voltage divider if you don't connect anything to it, but if you connect something the effective resistance of something we connect and resist. And there's a resistance too, which we connect with the scheme in parallel, changes. And we want to have two volts, exactly two volts.

Mujtaba: That is, that is correct. That is correct. If you connect it in series, it changes the effective voltage drop or the effective resistance and therefore the effective voltage drop across one resistor. But, so the way it is connected to this circuit, and this diagram or in any other situation when you're connecting something, you're usually connected in parallel. So in parallel, the voltage drop stays the same across both of those parallel things. Ideally, that would be the ideal scenario, but in real life, there is a slight drop across the parallel setup because of the losses in the circuitry and all the other things, but in in theory, when you connect things in parallel, the voltage

drop across both of them will stay the same. And that's why the LED circuit is connected in parallel to the 1.6 volts or 1.6 kiloohm resistor and therefore the voltage drop across that resistor stays two volts only.

Student: What would happen if too much current run through, yeah, LED.

Mujtaba: So the LED is essentially a piece of material that has electrons at certain transition states. So the way it emits emit light or emits light is essentially activation of those electrons. And that's how it emits light and it requires certain energy level to cause the activation to happen. If there's too much energy, and most of the commercial ones, they just break. So the LED just breaks and if you put too much current through it, it just breaks and they will not work again, which essentially means that the material whatever they're using in there just melts down or the energy for it is too much. And some of the other cases, if you put too much current through a thin wire, especially when it's it doesn't have a heatsink in any other way. It will just melt down. So in short answer LED just breaks and you will not be able to use it again.

Mujtaba: Yeah. I hope that was clear. You can use it in your own projects. One of the projects I actually made was a clock. I made a clock for my room. I don't have it here right now but it was a clock that was controlled by by an Arduino which is just a microprocessor. And each of the twelve numbers on the clock were LEDs. And it would turn on depending on the hour and the minute of the day it was so you can use a simple calculations like this like ohms law and practice to find the resistor values for the different LEDs that you will be using in that case, the clock for example.