Equivalent Resistance in Series Circuits

We've seen that every circuit needs a source, a path, and a load. The load is usually a resistor of some type. However, if there's more than one resistor, then we have to look at exactly how those resistors are connected together. They can be combined in series or in parallel.

How the resistors are connected determines the total resistance of the circuit and the way in which the current and voltage are distributed around the circuit. In this video, we're going to look at resistors connected in series. This means that they're all connected on the same wire in the circuit, like you see in this diagram, with resistors, R1, R2, and R3.

Looking at this diagram, you can see that there is only one possible path that electrons can take through this circuit. So the same amount of current flows through each resistor. Thus, the current through resistor 1 is the same as the current through resistor 2, same as resistor 3, and so on. This is true for all series circuits.

In order to find this current value, we have to begin by finding the total resistance of the circuit, called the equivalent resistance. When resistors are connected in series, the equivalent resistance is just equal to the sum of the individual resistances. So for this circuit, that would be the sum of R1, R2, and R3.

Like we saw before, because there's only one possible path for the electrical current to take, the current is constant through all series resistors. However, voltage across each resistor in the circuit may be different. As soon as we have solved for the current running through the circuit, we can then find the voltage values using ohm's law, V equals IR. To see how this works, let's go over to the whiteboard and look at an example problem.

The question reads, in the series circuit shown below, R1 equals 15 ohms, R2 equals 30 ohms, and R3 equals 45 ohms. The voltage for the battery is 45 volts. A, what is the equivalent resistance of the circuit? B, how much current flows through the circuit? And C, what is the voltage across each resistor?

Let's start with part a, which is asking about equivalent resistance. In a series circuit, equivalent resistance is just equal to the sum of the individual resistance values. So in this case, that's going to be R1, which is 15 ohms, plus R2, which is 30 ohms, plus R3, which is 45 ohms. Add those together, and we find that the equivalent resistance value for this series circuit is 90 ohms.

Now we can use this value to help us solve part b. Part b asks how much current flows through the circuit. So let's give ourselves a little bit of space here. And we're going to apply Ohm's law to solve this one. Ohm's law, recall, says that V equals I times R. Voltage equals current times resistance.

We know the voltage across this circuit is 45 volts. The current is what we're trying to solve for. And the equivalent resistance of this circuit is 90 ohms. If we divide both sides of this equation by 90 ohms, we find that the current running through the circuit is 0.5 amps.

The last part of the question asks, what is the voltage across each resistor? And we're going to have to calculate these values individually. So let's scroll down and give ourselves a little bit of space here.

The voltage across resistor 1, that we'll call V1, we can use Ohm's law. And we know that that's going to be equal to the current running through it, which we just solved as 0.5 amps, times the resistance value, which was given to us as 15 ohms. Multiply those together, and you find that the voltage across resistor one is 7.5 volts.

Resistor 2 we're going to do the same way. Voltage across resistor 2 is equal to current, which is the same value of 0.5 amps, times the resistance of resistor 2, which is given to us as 30 ohms. Again, multiplying these values together, we find that the voltage across resistor 2 is 15 volts.

And last, let's find the voltage across resistor 3, we'll call V3. That's going to be equal to the current, which is also 0.5 amps, times the resistance, which, in this case, is 45 ohms. Multiplying those values together, we find the voltage across resistor 3 is 22.5 volts.

Now, when we add these three values together, the voltage drops across each of the resistors, what we get is something interesting. We can say VTOTAL is equal to 7.5 volts plus 15 volts plus 22.5 volts. We find that the total drop in voltage across the three resistors is equal to 45 volts, the same as the voltage of the battery that was supplying the power.