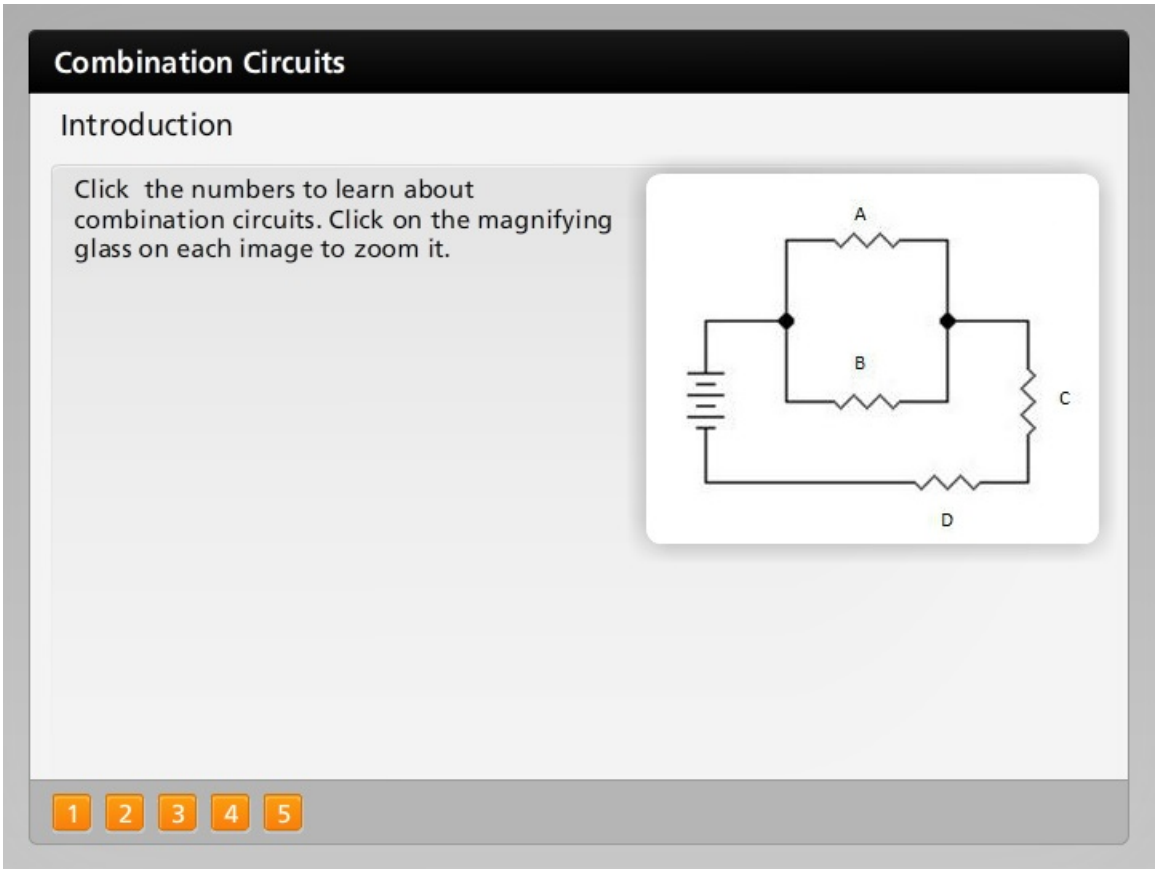
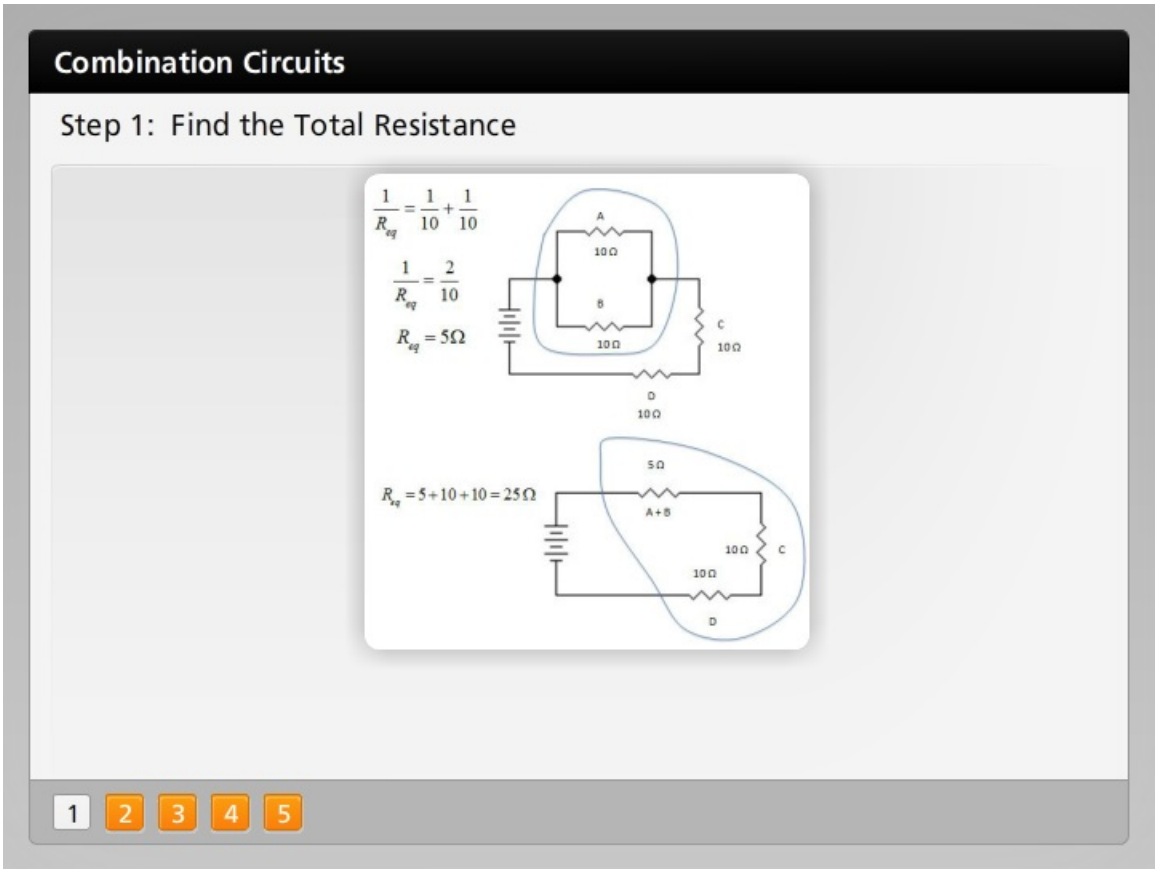
Module 7: Electricity - Currents and Circuits
Topic 5 Content: Combination Circuits

Introduction



Click the numbers to learn about combination circuits. Click on the magnifying glass on each image to zoom it.

Step 1: Find the Total Resistance



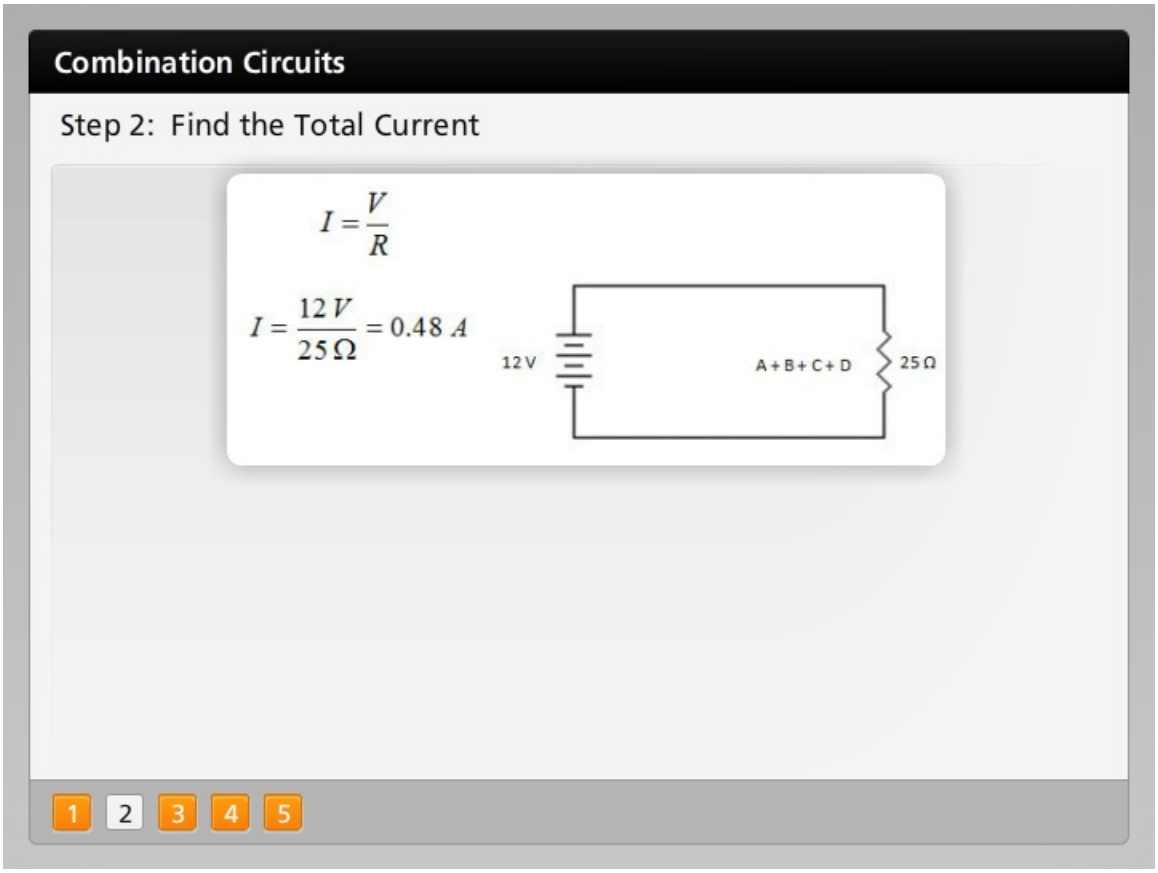
To illustrate this process, let's look at an example. In this example circuit, four identical resistors, each with a resistance of ten ohms, are connected to a battery with a potential difference of twelve volts.

In this example, we will use equivalent resistance to simplify the circuit. We will start by finding two resistors that are either in series or in parallel with each other and using the rules we learned in the previous topic to replace them with an equivalent resistance.

For this circuit, let's assume all of the resistors have the same resistance of ten ohms. In this circuit, A and B are in parallel with each other. What equivalent resistance can you replace them with? We can replace the circled part of the circuit with one five ohm resistor.

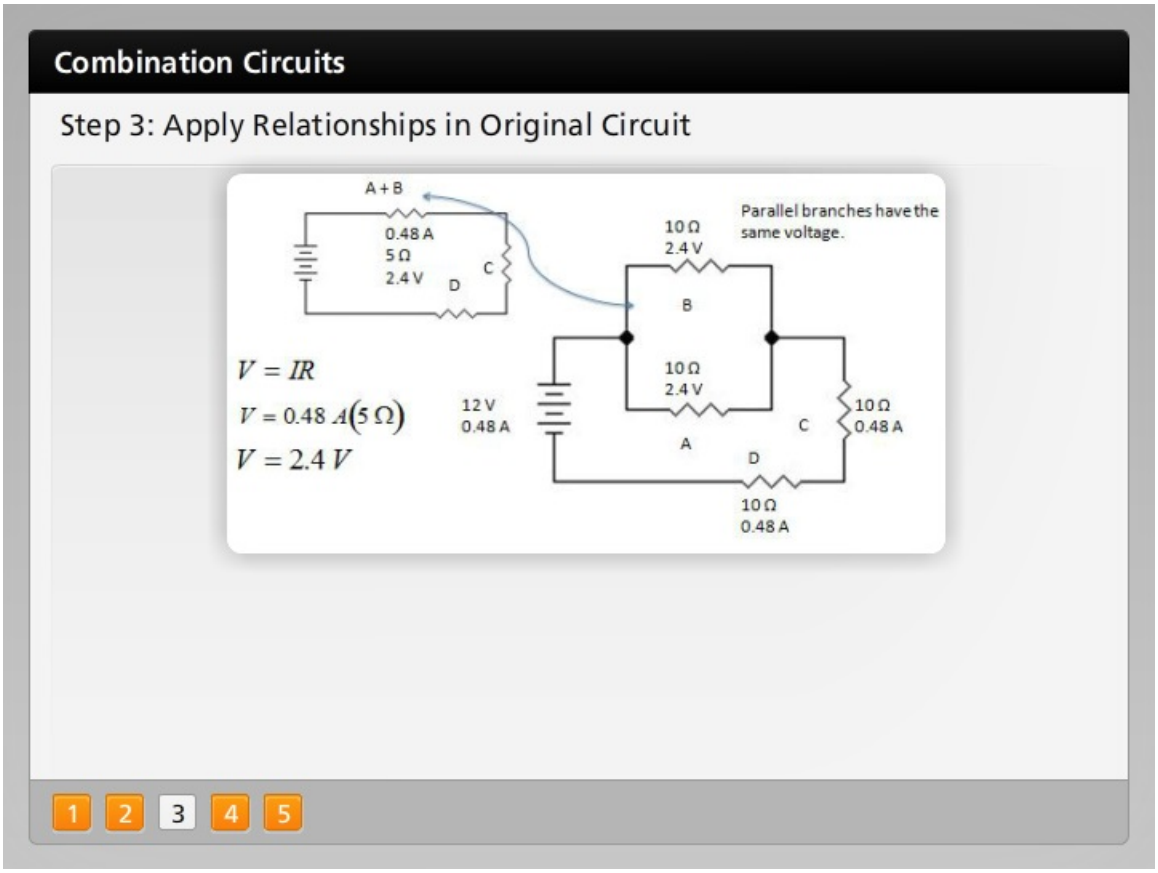
Now you can combine the three resistors that are left because they are in series. The equivalent resistance of two ten ohm resistors and a five ohm resistor in series is twenty five ohms. This is the total resistance of this circuit.

Step 2: Find the Total Current



Now the circuit has been simplified to one resistor with a resistance equal to the total resistance of the original circuit. You can find the current delivered by the battery by using Ohm's Law. Let's use a battery voltage of 12 volts for this circuit. The insect sees the vulture over the rabbit, or I equals V over R. For this circuit, the current is zero point four eight amps. Now that you know the total current for the circuit you can use your knowledge of series and parallel connections to figure out what is going on in the rest of the circuit.

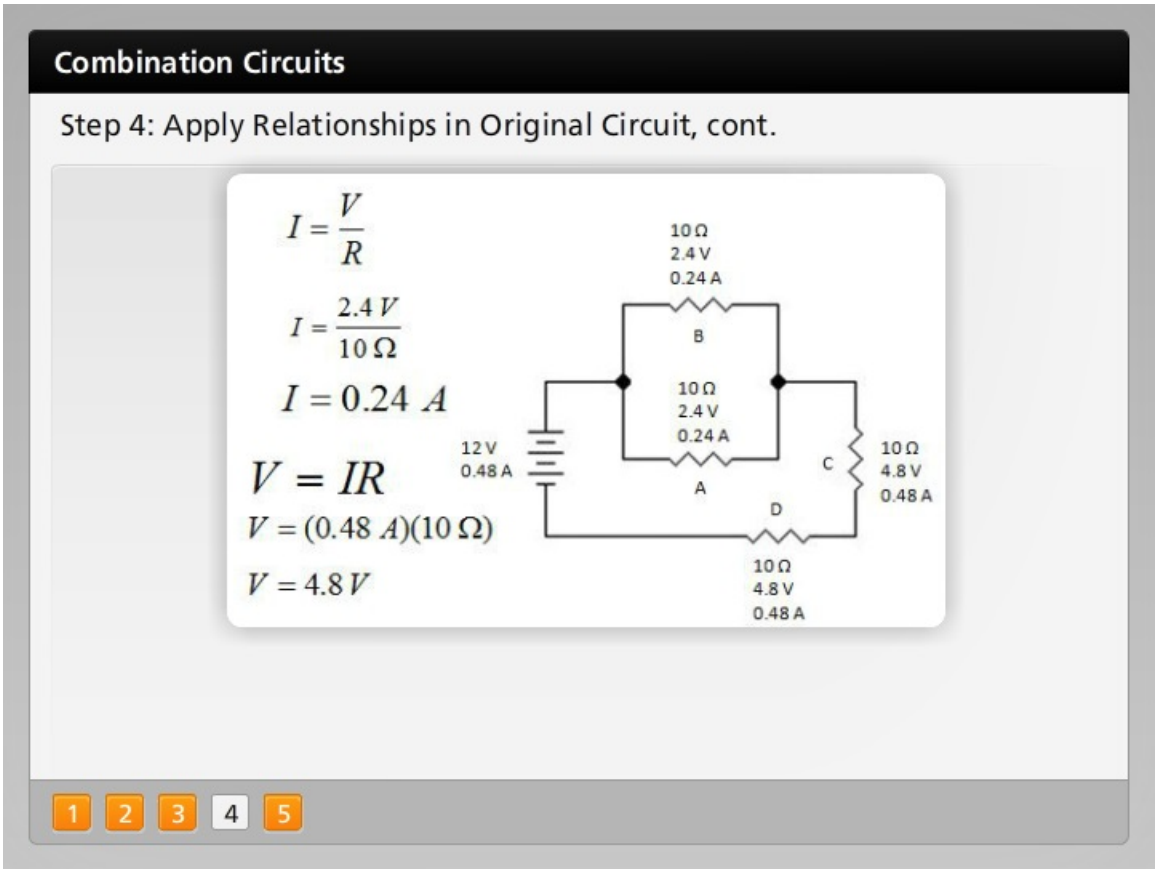
Step 3: Apply Relationships in Original Circuit



Go back to the original diagram. You now know how much current is leaving the battery, zero point four eight amps. Resistors C and D are in series with the battery, so they have the same current as the battery.

Remember that we replaced resistors A and B with an equivalent 5 ohm resistor. The equivalent five ohm resistor will have a current of zero point four eight ohms. Using Ohm's Law solved for voltage, V equals I R. Substituting appropriate values, the voltage across the five ohm equivalent resistor is two point four volts. Since the two ten ohm resistors that the five ohm equivalent resistor represents are in parallel, they have the same voltage. So the voltage across resistors A and B is two point four volts.

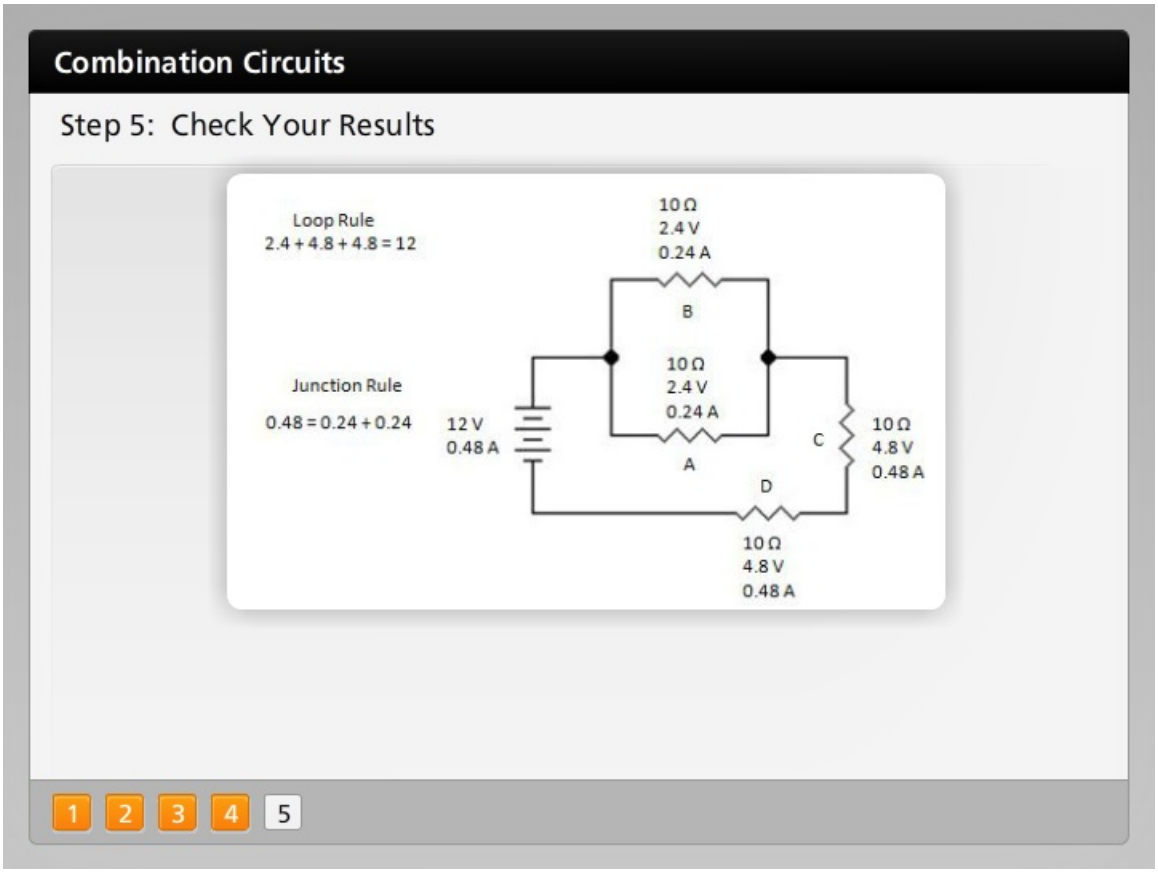
Step 4: Apply Relationships in Original Circuit, cont.



Now you can use Ohm's Law to find the current through resistors A and B. I equals V over R. Substituting values, we see that the current is zero point two four amps. You probably noticed that half of the current is going through each of the parallel branches. This happens because the two branches have equal resistances. If the resistances were different, the currents would be different also. However, the voltage of parallel branches are always the same even if the resistances are different.

The only thing left to find is the voltage drops of the two remaining resistors. Using Ohm's Law, V equals I R. Substituting appropriate values, we see that the voltage drop of each remaining resistor is four point eight volts.

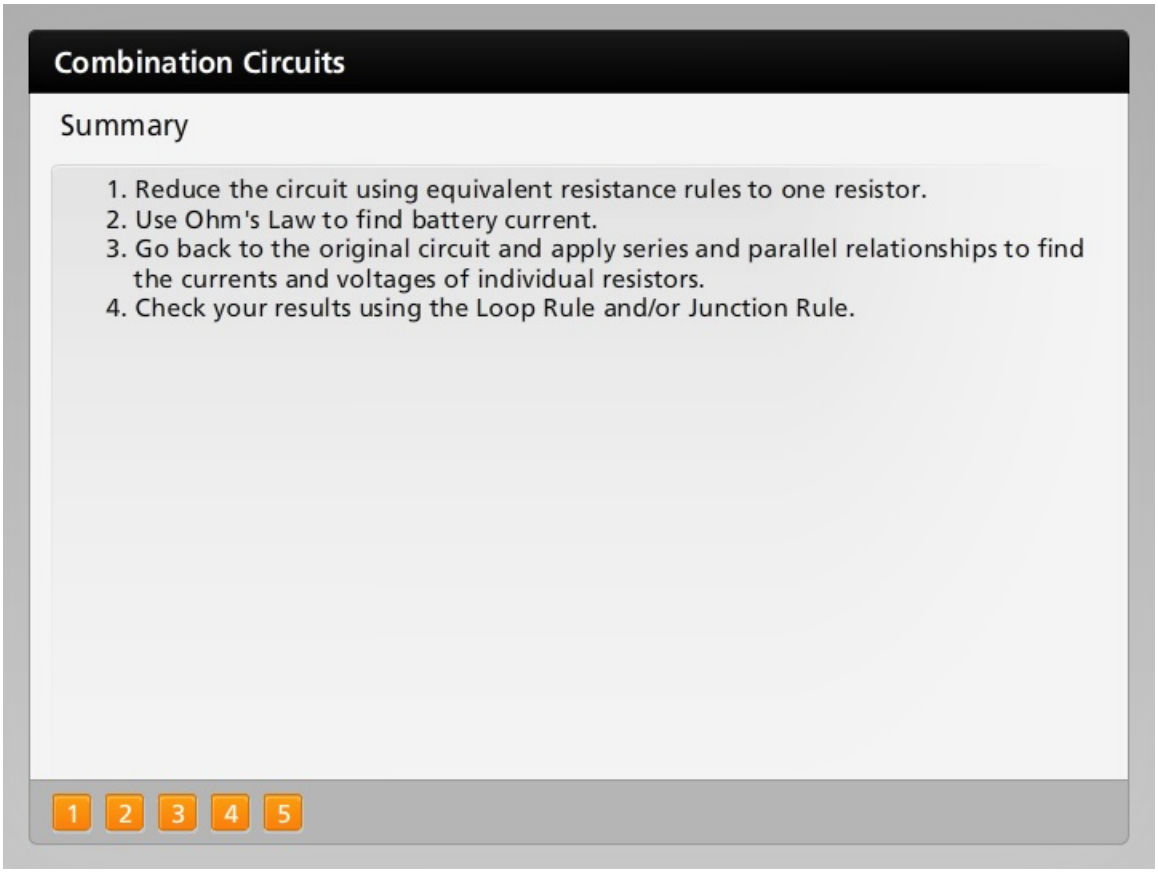
Step 5: Check Your Results



We can check our work by adding the voltage drops around the loop and comparing to the voltage of the battery. This is Kirchoff's Loop Rule. Tracing the path of one electron, two point four volts is lost through resistor A, then four point eight volts through C and four point eight through D. The voltage drops add up to twelve volts, the voltage of the battery. Or you could trace the path through B, C and D and the result would be the same. An electron cannot go through both A and B, it must choose one branch.

Another way to check your work is to look at the currents at a junction and see if Kirchoff's Junction Rule is obeyed. For example, at the first junction, zero point four eight amps goes into the junction from the battery and zero point two four amps go through resistor A plus zero point two four amps goes through resistor B. Since the same amount enters and leaves the junction, the junction rule checks out.

Summary



1. Reduce the circuit using equivalent resistance rules to one resistor.
2. Use Ohm's Law to find battery current.
3. Go back to the original circuit and apply series and parallel relationships to find the currents and voltages of individual resistors.
4. Check your results using the Loop Rule and/or Junction Rule.

In summary, you have learned how to apply the procedures for analyzing simple circuits to more complicated ones. There are four basic steps. First, reduce the circuit using equivalent resistance to one resistor. Second, use Ohm's Law to find the battery current. Third, go back to the original circuit and apply your knowledge of series and parallel relationships to find the currents and voltages of individual resistors. And fourth, check your results using the loop rule and the junction rule.