Transformation T-STEM 2013
New Directions | New Pathways | New Outcomes

Circuits Activity

Overview
In this activity, students will learn about the differences between series and parallel circuits. Students will calculate the current and resistance of a circuit and its components. The Circuits virtual instrument, VI, will be used in performing and checking calculations as well as building an intuitive sense of the difference between series and parallel circuits.

Objectives
Students will be able to:

- Calculate the current through each component of a circuit
- Calculate the total current and resistance on a circuit

Standards (TEKS)
IPC 6F
Physics 6E

Activity
Components, like light bulbs, can be connected either in a series or parallel circuit. The lights will behave quite differently depending on the type of circuit. The current flowing the circuit and each of its components can be found using Ohm's law, $I = \frac{V}{R}$. Ohm's law is used differently for each type of circuit.

1) Open and run the Circuits virtual instrument, VI.

The VI has four lights that can be connected in series or parallel. The resistance of each can be selected from the controls below the lights. There are controls for setting the battery voltage and the breaking capacity of the fuse. The total current on the circuit is displayed as well.

Series Circuits

Let's get started by focusing on series circuits. In a series circuit, the current flowing through each component (light bulb in our case) is the same as the total current. The voltage drop across any component could be different. The total resistance on the circuit is the sum of all of the components' resistances. That is, $R = R_1 + R_2 + R_3 + R_4$.

2) What is the total resistance on the circuit shown in the VI?
3) If the battery supplies 9 V, use Ohm's law to calculate the current in the circuit.
4) Does your answer equal what is displayed in the VI? If not, check your work.
5) Calculate the total current if the battery is supplying 9 V and each of the four lights has a resistance of 15 Ω. (Hint: Calculate the total resistance first.)
6) Check your answer with the VI.
    a) Set the resistance of each light to 15 Ω.
    b) Check the battery voltage.
    c) Compare your answer with the current displayed on the VI.
7) Calculate the total current if the battery is supplying 9 V and each of the four lights has a resistance of 60 Ω.
8) Check your answer with the VI.

Next, let's take a look at voltage in a series circuit.

9) Solve $I = \frac{V}{R}$ for *V*.
10) What is the voltage drop across any one of the lights?
11) Multiply your answer by 4 to find the total voltage.
12) Does your answer equal the voltage supplied by the battery in the VI?

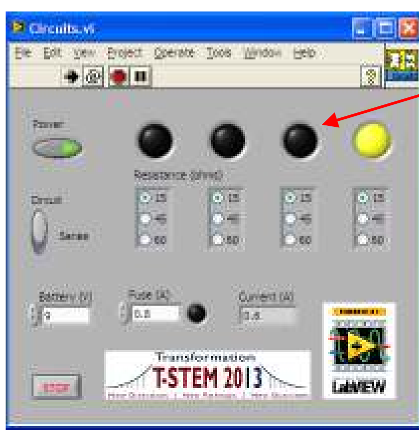
As mentioned above, the voltage drop across each component could be different. The total voltage, supplied by the battery in our case, is the sum of the voltage drops across each component.

13) Calculate the total current if the battery is supplying 9 V, two of the lights have resistances of 30 Ω and the other two have resistances of 45 Ω.
14) Check your work with the VI.
15) Are all of the lights are the same brightness? Explain.
16) Calculate the total voltage.
    a) What is the voltage drop across one of the 45 Ω lights?
    b) What is the voltage drop across one of the 30 Ω lights?
    c) Add up all of the voltage drops.
    d) Does your answer equal the voltage supplied by the battery in the VI?

Since the total resistance in a series circuit is the sum of all of the resistances, let's see what will happen if we remove lights from the circuit.

17) Set the resistance of each of the lights to 15 Ω.
18) In the following table, make note of the current when all four lights are on.
19) Disconnect (turn off) the lights one by one.
    a) Click on the light to remove it from the circuit.
    b) Make note of the current in the table.

Lights (15 Ω)	Current
4	
3	
2	
1	



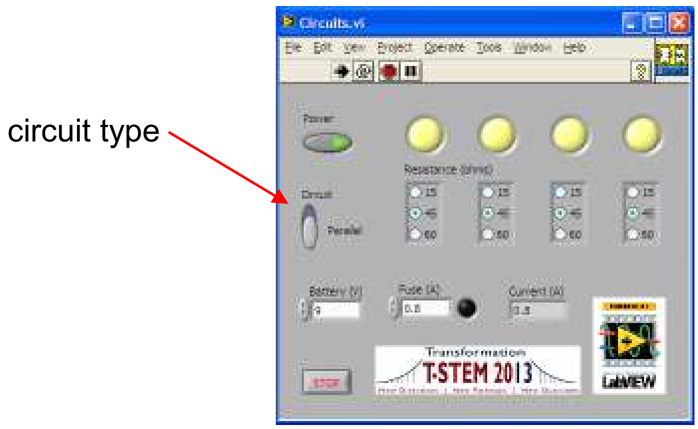
Lights will be black when off.

20) What happens to current as lights are turned off? Does it increase or decrease?
21) If you added more lights to the circuit in a series, would the current increase or decrease?
22) If you added more lights to the circuit in a series, will the lights get dimmer or brighter? Explain.

Parallel Circuits

Parallel circuits operate differently than series circuits. The voltage drop across each component in a parallel circuit is the same. Since the voltage is the same, the current through each component could be different depending on the resistance of the component. The total current in a parallel circuit is sum of the current through each component.

23) Turn all of the lights back on.
24) Set the resistance of each light to 45 Ω.
25) Switch the circuit from series to parallel.



26) Calculate the total current if the battery is supplying 9 V and each of the four lights has a resistance of 45 Ω.
    a) Use Ohm's law to calculate the current flowing through one light.
    b) Multiply by 4 to calculate the total current.
    c) Check with the VI.
    d) Does the total current you calculated equal what is displayed in the VI?
27) Calculate the total current if the battery is supplying 9 V, two of the lights have resistances of 60 Ω and the other two have resistances of 45 Ω.
    a) Calculate the current through one of the 45 Ω lights using Ohm's law.
    b) Calculate the current through one of the 30 Ω lights using Ohm's law.
    c) Add up the currents of all 4 lights.
    d) Check with the VI.
    e) Does the total current you calculated equal what is displayed in the VI?

Since the total current in a parallel circuit is the sum of all of the currents, let's see what will happen if we remove lights from the circuit.

28) Set the resistance of each of the lights to 45 Ω.
29) In the following table, make note of the current when all four lights are on.
30) Disconnect (turn off) the lights one by one.

a) Click on the light to remove it from the circuit.
b) Make note of the current in the table.

Lights (45 Ω)	Current
4	
3	
2	
1	

31) What happens to the total current as lights are turned off? Does it increase or decrease?
32) If you added more lights to the circuit in parallel, would the current increase or decrease?
33) If you added more lights to the circuit in parallel, will each light get dimmer or brighter? Explain.
34) With three lights still off, set the resistance of the light that is on to 15 Ω.
35) How much current is flowing through the one light?
36) Check that the resistance of the other lights is set to 45 Ω.

37) With the fuse set to 0.8 A, can you turn on another light without blowing the fuse?
  a) Turn on one of the 45 Ω lights.
  b) How much current is flowing through the 45 Ω light?
38) Are the two lights the same brightness? Explain.
39) With the fuse set to 0.8 A, can you turn on a third light without blowing the fuse? Explain.
40) Change the breaking capacity of the fuse to 1.0 A.
41) Turn on a third light.
42) Set the resistance of the third light to 60 Ω.

43)How much current is flowing through the 60 Ω light?

The total current in our parallel circuit is the sum of the current through each component. That is,

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}.$$

44)Use this formula to calculate the total current flowing through our parallel circuit of three lights?

If you factored *V* out on the left-hand side of the formula above, you would have

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right).$$

From this, it seems the total resistance on our parallel circuit can be found using

$$\frac{1}{R_{\text{Total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

To find the total resistance, add up the reciprocals of each component's resistance. Then, take the reciprocal of the sum.

45)What is the total resistance on the parallel circuit with the three lights ON?

46)Calculate the total current a different way.

   a) Divide the battery's voltage by this total resistance.
   b) Does your answer equal the total current you calculated above? If not, check your work.

47)Stop the VI. You are done.