Name, Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Series and Parallel Circuits

*This activity is designed to be run with the* ***PhET circuit construction kit****, (NOT the “virtual lab” version) available online. The* ۞ *symbol indicates you should check in with an instructor.*

1. Simple Circuit- One Resistor
   1. ۞ Construct a simple circuit that contains the following components: Light bulb, 10-V battery, and an ammeter.
      1. Make sure that the components are in series; that is, you can trace a charge traveling through the entire circuit from the positive end of the battery to the negative end.
      2. Right-click the battery and the light bulb, and check the “Show Value” box.
      3. Call your instructor to check your setup.
   2. Use the voltmeter to confirm that the voltage of the battery is, in fact, 10 volts. If it is not 10 volts, change it by right-clicking the battery and using the keyboard to enter in 10V.
   3. Record the current flowing through the circuit by reading the ammeter value:

Itotal = \_\_\_\_\_\_\_\_\_

* 1. \*\*Use V=IR to predict the resistance of the light bulb, and record the answer below.

Rbulb = \_\_\_\_\_\_\_\_\_\_

* 1. Confirm this resistance by right-clicking on the light bulb and then clicking the “Change Resistance” button. You should see the resistance listed on the screen.
  2. ۞ \*\* Was the equation V = IR verified here? Why or why not?

1. Simple ***Series*** Circuit- Two Resistors
   1. Add another light bulb in series to the simple circuit above. Right-click the light bulb to make sure it is also a 10-Ω light bulb.
   2. Confirm that the battery is still producing a 10-volt potential difference using the voltmeter.
   3. Determine the current flowing through the circuit by recording the ammeter reading below:

Itotal = \_\_\_\_\_\_\_\_\_\_

* 1. \*\*Using V=IR, calculate the *total resistance of the circuit,* and record this value below. Show your work.

Rtotal = \_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. \*\*Add a third light bulb to the circuit by connecting it in series to the others. Repeat steps b🡪d and calculate the *total resistance* of the 3 bulbs, and record this resistance. This is called the ***equivalent resistance*** of the circuit.

Req = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. \*\*You should notice a trend developing for resistors that are connected in series. Based on this trend, predict the equivalent resistance of a series of 5 light bulbs, **4 with a resistance of 10 Ω and the 5th with a resistance of 20 Ω**. Confirm your prediction by building this circuit.

Answer: Req = \_\_\_\_\_\_\_\_\_\_\_\_

* 1. ۞ Now, for a final definition of equivalent resistance: given a series of resistors R1, R2, R3, R4…etc., write a formula that determines the total equivalent resistance Req. Check in with instructor.

1. Simple ***Series*** Circuit: Voltages & Currents of Components
   1. Next, return to a 3-bulb setup and change the resistances of the light bulbs until you have: one 10-Ω bulb, one 20-Ω bulb, and one 30-Ω bulb, all connected in series. Also, **remove the ammeter.**
   2. Using the rule developed from part 2(f) above, calculate the equivalent resistance of the 3 bulbs, and record this resistance

here: Req = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. Use the voltmeter to determine the voltages across each of the three light bulbs. Record these voltages below in the appropriate spots.

V10Ω = \_\_\_\_\_\_\_\_\_ V20Ω = \_\_\_\_\_\_\_\_\_ V30Ω = \_\_\_\_\_\_\_\_\_

* 1. \*\*How are these voltages related to the **total** voltage across the battery?
  2. ۞ \*\* What can be said, in general, about the relationship between **the voltages of components** that are connected in series, andthe **total voltage** across the terminals of the battery?
  3. \*\*Predict the current flowing through the circuit by using V=IR. Use Req for the circuit as your R, and use the voltage of the battery for V. Record your current prediction below:

I = \_\_\_\_\_\_\_\_\_\_\_\_

* 1. Put the ammeter back into the circuit, and check your prediction.
  2. Use the “non-contact ammeter” from the menu to check the current at various places around the circuit. Are there any changes?
  3. What can be said, in general, about the current values at different places within a series circuit?

1. Simple ***Parallel*** Circuit: Two Resistors
   1. ۞ Clear the screen and set up a simple circuit identical to the setup from part 1. Make sure the battery is a 10-Volt battery. Then, connect a second 10-Ω light bulb in ***parallel*** to the first bulb. This means that the circuit splits for the 2 bulbs. Check in with instructor.
   2. \*\*Use the voltmeter to measure the voltages across each bulb. How do these 2 voltages compare to each other? How do they compare to the voltage across the battery terminals?
   3. \*\*Increase the resistance of one bulb to 100 Ω, then repeat step 4(b). Did the voltages change significantly? How?
   4. \*\*What can be said, in general, about the voltages for components that are connected in parallel to each other?
   5. Reset both resistances to 10 Ω. Using the ammeter reading, and the known voltage of the battery, use V=IR to calculate the equivalent resistance of the circuit.

Req = \_\_\_\_\_\_\_\_\_\_\_\_

* 1. Change one bulb from 10 Ω to 20 Ω, and repeat step 4(e).

Req = \_\_\_\_\_\_\_\_\_\_\_\_

* 1. Change the 20 Ω bulb to 30 Ω, and repeat 4(e).

Req = \_\_\_\_\_\_\_\_\_\_\_\_

* 1. Try to determine the pattern developing. How is the equivalent resistance related to the values of the resistors used in a parallel circuit? Ask your instructor or look in your textbook for the correct formula for parallel circuits.
  2. ۞ Using the formula given to you by your instructor, predict the equivalent resistance of **3** 10-Ω bulbs that are connected in a parallel circuit. Check with instructor.
  3. After showing your prediction to your instructor, confirm your prediction by setting up a 3-bulb circuit on the computer and using the same technique from 4(e).

1. Simple ***Parallel*** Circuit: Voltages & Current of Components
   1. Construct a 3-bulb parallel circuit, and change the resistances of the light bulbs until you have: one 10-Ω bulb, one 20-Ω bulb, and one 30-Ω bulb.
   2. Using the rule developed above, calculate the equivalent resistance of the 3 bulbs in parallel, and record this resistance

here: Req = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. Use the voltmeter to determine the voltages across each of the three light bulbs. Record these voltages below in the appropriate spots.

V10Ω = \_\_\_\_\_\_\_\_\_ V20Ω = \_\_\_\_\_\_\_\_\_ V30Ω = \_\_\_\_\_\_\_\_\_

* 1. \*\*How are these voltages related to the **total** voltage across the battery?
  2. ۞ \*\* What can be said, in general, about the relationship between **the voltages of components** that are connected in parallel, andthe **total voltage** across the battery?
  3. Knowing the equivalent resistance and the battery voltage, calculate the total current in the circuit using V=IR. Write your answer below, showing your work.

Total Current = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. Drag the “non-contact ammeter” from the menu, and place it on one of the wires directly connected to the battery. Confirm that the current is what you predicted.
  2. Knowing the voltage across each resistor, you can calculate the current for each one. Do so, and write your answers below. Show your work.

I10Ω = \_\_\_\_\_\_\_\_\_ I20Ω = \_\_\_\_\_\_\_\_\_ I30Ω = \_\_\_\_\_\_\_\_\_

* 1. Place the non-contact ammeter on each of the three wires connected to a single bulb, and check your answers for each current calculation.
  2. ۞How do these individual currents compare to the total current in the circuit? Why does this make sense?

1. Practice Problems
   1. Series Circuits
      1. Sketch a **series** circuit that contains the following: A 9.0-V battery, 2 20-Ω resistors, and an Ammeter.
      2. What is the equivalent resistance of this circuit? (show work)
      3. What reading would the ammeter show?
      4. What is the voltage across each resistor?
   2. Parallel Circuits
      1. Sketch a **parallel** circuit that contains the following: a 9.0-V battery, 3 15-Ω light bulbs in parallel.
      2. Calculate Req for this circuit.
      3. Calculate the current flowing through one of the bulbs.