Background
The flow of charges through a circuit is best illustrated by actually constructing such circuits, and analyzing them using concepts covered in class.

Objectives
To construct and analyze the behavior of several circuits.

Equipment
This lab will be done using a PhET simulation found at
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html.

Procedure

Part A. Series and Parallel Circuits

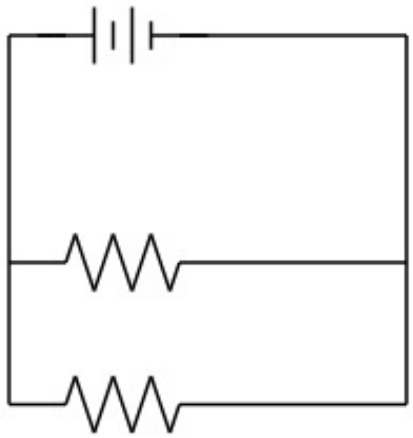
1.) Use the PhET program found at
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html
When you open the program, use the Lab link to construct *both* of the following simple circuits

- Two lightbulbs in series (no switch necessary), connected to a battery.
- Two lightbulbs in parallel (no switch necessary), connected to a battery.

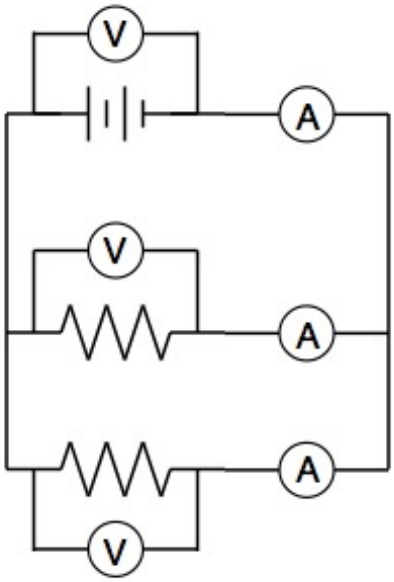
See further instructions below.

An example of the sketches that should accompany the circuits is shown below.

Basic parallel circuit.



Parallel circuit with voltmeter and ammeter placements indicated.



For both of these circuits, you'll need to:

a. Build the circuit and demonstrate (to someone, anyone!) that it works.

b. Draw a schematic diagram of the circuit using the appropriate symbols.

c. Use a multimeter to determine:
   i. the current flowing through each device in the circuit, and

ii. the potential difference (voltage) over the battery and the light/motor

d. Identify on your schematic diagram
   i. the current flowing through each device in the circuit, and

   ii. the potential before and after each device in the circuit.

e. Identify what happens in each circuit when you unscrew one of the light bulbs (this is the same as disconnecting one of the leads in the branch)

f. Create a circuit with a single lightbulb across a battery.

a.) Put an ammeter in the circuit to record the current through the lightbulb and an ammeter in the circuit to record the current being drawn from the battery (i.e., one next to each element). Also, put voltmeters across the lightbulb and the battery. Record the meter readings.
b.) Put a second lightbulb in parallel with the first and record the meter readings.
c.) Disconnect the second lightbulb. Click on the Advanced setting to the right on the page. Increase the Battery Resistance to 5 ohms. Record the meter readings.
d.) Leaving the Battery Resistance at 5 ohms, add the second lightbulb back into the circuit. Record the meter readings.
e.) What can you conclude from what you have observed doing all of this?

Questions

Part A. For the Series Circuit

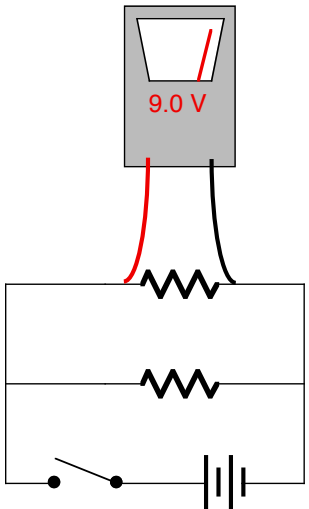
1. What was the relationship between the potential difference measured across the battery, and the potential differences across the two lights in the circuit?
2. What was the relationship between the current drawn from the battery and through the two lights in the circuit?
3. What happened when you unscrewed one of the light bulbs in the circuit? What did the behavior of the light bulbs reveal about the flow of current through the circuit in that case?

Part B. For the Parallel Circuit

1. What was the relationship between the potential difference measured across the battery, and the potential differences across the two lights in the circuit?
2. What was the relationship between the current drawn from the battery and through the two lights in the circuit?
3. What happened when you unscrewed one of the light bulbs in the circuit? What did the behavior of the light bulbs reveal about the flow of current through the circuit in that case?

Part C: Circuit Boxes

1. To give you the opportunity to think your way through an unknown circuit, three lightbulbs and two switches have been connected in a mysterious way and presented in a video you will watch. There is a technique to do this kind of analysis, though, so a first video has been provided at https://youtu.be/VO1mhdIrKcU that demystifies the process. View it first (I would suggest you look at it at 1.25x as I seem to be speaking very slowly). Once done:
2. Look at the video https://youtu.be/J9IR0f83DPM and draw the circuit (called Circuit 1) that is associated with the situation. When done:
3. Look at the video https://youtu.be/hdewmA3pUOE and draw the circuit (called Circuit 2) that is associated with the situation.



Supplementary notes on Using a Multimeter (Read for general knowledge)

Part A. Measuring Change in Potential / Voltage

To measure a change in potential over / across a device (resistor, battery, light bulb, motor, capacitor, etc.):

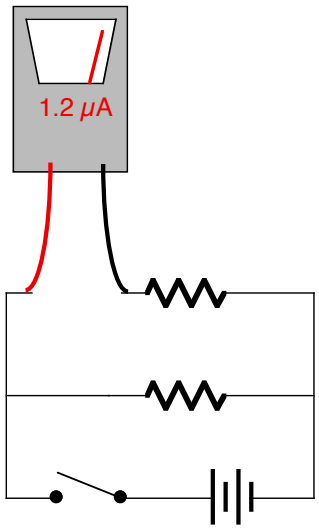
1. Place the red (positive) lead in the + jack.
2. Place the black (negative, common, ground) lead in the - jack.
3. Turn the multimeter on (if it has a power switch).
4. Set the multimeter initially to its appropriate Voltage setting. If you're not sure what the potential is that you might be measuring, use a higher setting, and adjust it downwards as necessary once the circuit is operating.
5. Place the red lead from the Voltmeter at the high potential end of the device, and the black lead from the Voltmeter on the other side of the device, at the low potential end. (See diagram.)
6. Read the potential difference across the device on the meter.

Part B. Measuring Current through a circuit

NOTE: It is *extremely* easy to destroy a meter when trying to measure current! Follow these instructions carefully, and have the instructor check your setup before you apply power!

To measure current flow *through* a circuit:

1. Place the red (positive) lead in the + jack.
2. Place the black (negative, common, ground) lead in the - jack.
3. Turn the multimeter on (if it has a power switch).
4. Set the multimeter initially to its appropriate Current setting. If you're not sure what the current is that you might be measuring, use the highest setting, and adjust it downwards as necessary once the circuit is operating.
5. **Disconnect the circuit where you want to measure current.** Then place the red lead from the Ammeter at the high potential wire, and the black lead from the Ammeter at the low potential wire. The ammeter acts to complete the circuit. (See diagram.)
6. Read the current through this part of the circuit on the meter.



Additional Notes