# Physics 1 Lab: Series and Parallel Circuits

#### **Introduction:**

Ohm's law is the most fundamental relationship between the quantities of electric potential (voltage), electric current, and resistance. It is valid for many circuits and allows us to calculate one quantity if we know the value of the other two. Ohm's law states that the current through a circuit is directly proportional to the source voltage and inversely proportional to the resistance in the circuit. For a single circuit element such as a resistor, heating element, or light bulb filament, the voltage drop across the device equals the current through the device multiplied by its resistance. So, in mathematical terms, I = V/R or V = IR. Although the bulb filament's resistance changes when it is lit, if currents are kept fairly constant, resistance will not change and Ohm's Law will be applicable.

When two or more devices are connected in a circuit with a voltage source, they can be arranged in two different ways, a series connection or a parallel connection. In a series circuit, there is only one path for the current to flow; so all parts of a series circuit have the same current. Charges moving through the circuit must pass through one device and then the other device to make a complete path back to the source. In a parallel circuit, each device has a connection to the voltage source, independent of the other device. The current divides, with some passing through each parallel branch. The amount of current each branch gets depends on the resistance of the device in that branch, with smaller resistances experiencing proportionately more current.

In this experiment, we will be using the ammeter to measure current (amperes) and the voltmeter to measure potential (volts). In order to use these instruments properly, a few precautions must be observed.

Analog Meters: Analog meters (those with a pointer and dial) especially must be used properly or inaccurate readings and possible damage to the meter will result.

- Proper polarity must be observed. The positive or red terminal must be connected to the point in the circuit (or on the device) closest to the positive terminal of the voltage source. If the meter deflects in the negative direction (below zero) it is connected backwards. Shut down current to the meter immediately and connect properly.
- Ammeters must be connected in series with other circuit elements so that all current flows through the meter. *Never connect an ammeter in parallel with other devices in the circuit or meter damage will result*. Voltmeters must be placed in parallel with circuit elements whose voltage is to be measured. The circuit does not need to be interrupted to measure voltage. Simply touch the voltmeter probes across the circuit element whose voltage is to be measured.
- Many meters have more than one input connection to allow the meter to be used over a wide range of values. The correct input must be used so that the current or voltage does not exceed the maximum value. If at any time the needle goes beyond the scale, shut down the power and connect to an input with a higher maximum value. When in doubt, use the connection with the highest maximum value, then switch to a lower value, more sensitive input if possible. It is also important to read the proper scale that corresponds to the input being used.

Digital Meters: Digital multimeters (DMM) are usually protected from damage due to polarity and input voltage or current greater than the maximum selected. However, *when used as an ammeter, the meter must be connected in series or the meter will be damaged*. To use the DMM, the black lead is connected to the COM input; the red lead is connected to the input that matches the quantity to be measured (voltage and resistance, low current, or high current). The dial is then rotated to the proper setting for the quantity being measured (dc volts, ac volts, resistance, dc current) and the expected maximum value.

**Purpose:** In this experiment, we will construct series and parallel circuits and investigate their properties. We will measure values of current and potential differences and use Ohm's law to calculate resistance and current. **Apparatus:** Voltage source (6 volt dc power supply or batteries), 2 miniature bulbs and sockets, voltmeter and ammeter or digital multimeters, knife switch, connecting wires

# **Procedure:**

Part one, series circuit: If a battery is being used, 4, 1.5-V D-cells will provide the 6 V needed.

- 1. Connect the series circuit as shown in figure 1, carefully observing meter and power supply polarities. Do not close the switch until the circuit is inspected by your instructor. If you are using an adjustable power supply, turn the control all the way down in the counterclockwise direction, plug it in and turn it on. When your circuit is checked, close the switch and rotate the control knob clockwise until the lights begin to glow. Using the voltmeter, adjust the power supply output until a reading of about 6 V is obtained. Record this reading to the limit of the precision of the meter. If you are using batteries, simply close the switch, measure the voltage of the battery and record (under source voltage) in the data table.
- 2. Record the reading of the ammeter in the data table.
- 3. Measure the voltage across each bulb in the circuit and record in the data table.

4. While the bulbs are still lit, carefully disconnect one of the bulbs from the circuit. Observe what happens to the other bulb and the ammeter reading and record your observations.

<u>Part two: parallel circuit.</u> If a battery is being used, remove two cells from the battery. Two, 1.5-V D-cells will provide the 3 V needed for this part of the experiment.

- 1. Connect the parallel circuit as shown in figure 2, again observing polarity for meters and power supply. Again, have the circuit checked by the instructor before closing the switch. If you are using the adjustable power supply, turn the control fully counterclockwise. When the circuit is checked, begin slowly rotating the control clockwise until the bulbs begin to glow. Check the output voltage with the voltmeter until it measures about 3 volts. Record the exact value indicated on the meter. If you are using batteries, be sure to remove two of the cells so that the battery is now composed of 2 D-cells. Close the switch, measure the voltage of the battery and record (under source voltage) in the data table.
- 2. Record the reading of the ammeter in the data table.
- 3. Measure the voltage across each bulb in the circuit and record in the data table.
- 4. While the bulbs are still lit, carefully disconnect one of the bulbs from the circuit. Observe what happens to the other bulb and the ammeter reading and record your observations.
- 5. Turn off the power supply or remove the batteries from the box and disconnect the connecting wires.
- 6. Remove all connecting wires from the bulb sockets. Using the multimeter as an ohmmeter, measure the resistance of the bulbs in the sockets and record as the Measured Resistance in the data table.
- 7. Return all equipment to the proper place and clean up your area.



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#### Data Table:

Circuit Type	Ammeter	Bulb #1	Bulb #2	Battery	Measured Unlit	
	Current	Voltage	Voltage	Voltage	Resistance	
Series					Bulb #1	Bulb #2
Parallel						

#### Calculations Table:

Series	Circuit	Parallel Circuit		
Calculated Resistance	Calculated Resistance	Calculated Current	Calculated Current	
Bulb #1	Bulb #2	Bulb #1	Bulb #2	

**Observations:** Describe what happened when one bulb was unscrewed from its socket in both the series and the parallel circuits. Explain why each observation occurred.

Series: \_\_\_\_\_

Parallel: \_\_\_\_\_

### Questions and Calculations:

- 1. Calculate the resistance of each bulb using Ohm's law and the measured values of bulb voltage and current in the *series* circuit. Show your work and place the result in the calculations table.
- 2. Calculate the current through each bulb in the *parallel* circuit using Ohm's law, the measured voltages from the *parallel* circuit and the bulb resistances calculated in the previous question. Show your work and place the result in the calculations table
- 3. Add the two bulb voltages in the *series* circuit and compare the total with the source voltage.

- 4. Predict the voltage across one of the series bulbs if the source voltage were doubled.
- 5. What would be the voltage across any one bulb if three identical bulbs were connected in a *series* circuit using your source voltage?
- 6. Compare the source voltage to the voltage across each bulb in the *parallel* circuit.

- 7. What would be the voltage across any one bulb if three identical bulbs were connected in a *parallel* circuit using your source voltage?
- 8. Predict the voltage across the parallel bulbs if the source voltage is doubled.
- 9. Compare the current measured on the ammeter in the *parallel* circuit with the sum of the calculated branch currents from question two.
- 10. Predict the current through any one bulb if three identical bulbs were connected in parallel with your source voltage.
- 11. Compare the values of the measured bulb resistances with the calculated resistances. Explain why they are so different.
- 12. Using your data and your answers to the questions, draw a conclusion that relates (a) the sum of the voltage drops in a series circuit to the source voltage and (b) the sum of branch currents to the source current in a parallel circuit.