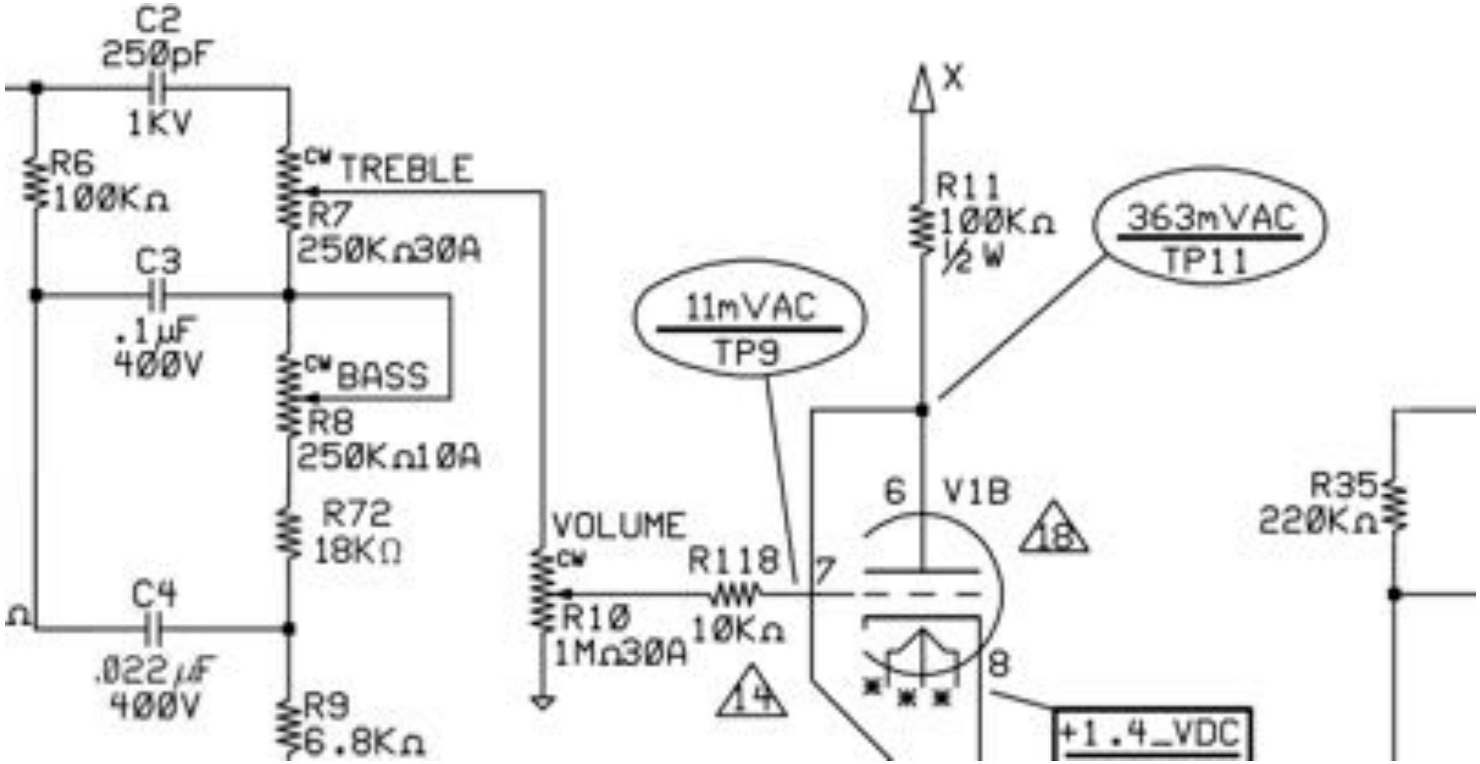
Introduction to Circuits



Prelab

LR Write experiment title, your name and student number at top of the page.

LR **Prelab 1:** Write the objective of this experiment.

LR **Prelab 2:** Write the relevant theory of this experiment.

LR **Prelab 3:** List the apparatus and sketch the setup.

! Have these ready to be checked by lab staff at the door on the day of your lab.

Introduction

All electronic devices begin with the construction of a basic electrical circuit. A circuit consists of an electrical path whereby current flows from a power supply, through components, and back to the negative or neutral of the supply. Conventionally, current flows from positive to negative on a power supply.

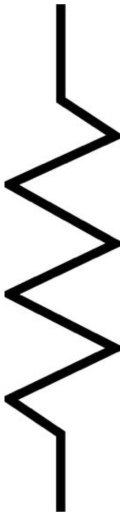
Here, we will start from basic concepts of how to electrically connect simple devices as well as learn how to take measurements of voltage and current.

This process will allow us to better visualize and troubleshoot electric circuits that we will use in future labs and allow us to look at the relationship of voltage and current in electrical components.

Introduction

The basis of all electronics reduce down to controlling, measuring, and manipulating voltages and currents through various electrical components. Resistors, capacitors, LEDs, inductors, just to name a few common components.

Resistors are some of the most basic, as well as the most utilized, electrical components. They are denoted in circuit diagrams as a zigzag line, shown below.

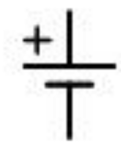


Resistors vary in design based on how much electrical resistance they provide, and the power they may be subjected to in the circuit.

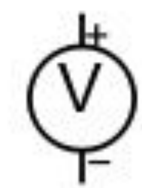
Circuit Diagrams

In electronics, circuit diagrams illustrate how to connect components. We use these as a guide to show where connections are to be made. There are commonly accepted symbols for some other types of components.

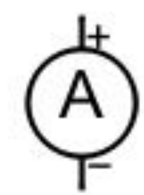
A *DC power supply* is shown at right, indicated with the positive terminal from which we conventionally assign as where the current will flow from.



A *voltmeter* measures voltage and is denoted with circle and a *V.*



An *ammeter* measures current and is denoted with a circle and an *A*.



Introduction

In circuits, resistors provide electrical **resistance** (R) as a way to control **voltage** (V) and **current** (I). Resistors are ohmic components, meaning they obey Ohm's Law, i.e.

$$V = IR\ .$$

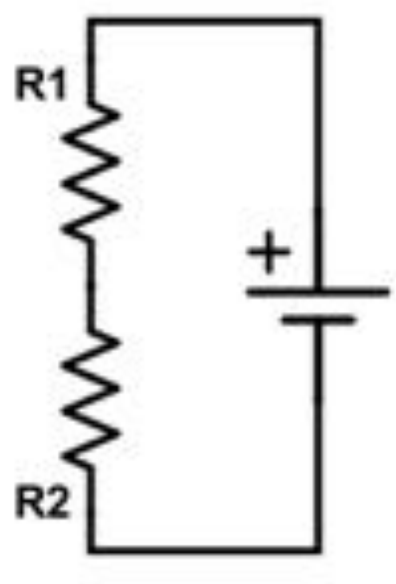
Voltage is measured in volts (V), current in amps (A), and resistance in ohms (Ω). Ohm's law is arguably one of the most utilized relations in electrical circuit analysis.

How we design and build circuits also breaks down in to two types of component connections: **series** and **parallel**.

Series Circuit

In a series circuit, there is single electrical current path between components. Meaning, if you trace wires through the components, there is a single electrical path along the wires for current to travel through both components.

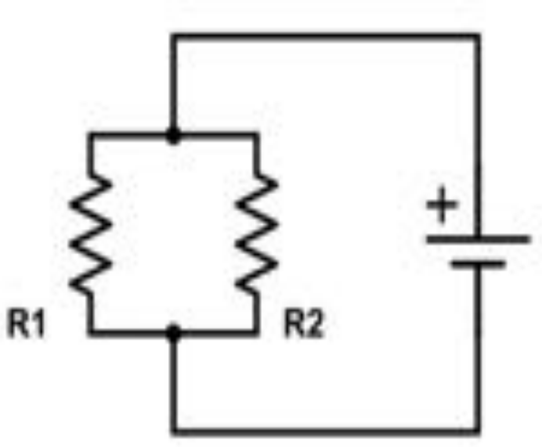
The diagram at the right illustrates a circuit with two resistors connected in series with a power supply.



Parallel Circuit

In a parallel circuit, there are two or more electrical current paths through the components. In this case, both ends of the components are directly connected to each other, meaning that the current will separate, travel through each component, and rejoin.

The diagram to the right shows a circuit with two resistors connected in parallel with a power supply.



Apparatus and setup

You have been provided with the following equipment:

- Power supply
- Resistor box
- 2 Multimeters (DMM)
- 6 electrical leads

Digital Multimeter (DMM)

A digital multimeter (DMM) is a basic tool for any electrical measurement. These devices can be used to measure voltage, current, resistance, and a myriad of other parameters.

We will use this meter as a *voltmeter* (voltage), an *ammeter* (current), and *ohmmeter* (resistance). Each of the settings on the meter indicate the **maximum value** that the setting can measure. So it's important to use the appropriate setting for what is being measured.

The *COM* terminal being the negative (or ground) and $V\Omega mA$ the positive terminal.

Digital Multimeter (DMM)

You select the appropriate setting on the DMM to measure the desired quantity. It's important to only change settings while power supply is off or not connected.

Measures DC voltage from 200 millivolts (mV) to 500 volts (V).

Measures resistance from 200 ohms (Ω) to 2000 kilo-ohms ($k\Omega$).

Measures DC current from 200 microamps (μA) to 200 milliamps (mA).

Digital Multimeter (DMM)

When using the multimeter:

Only adjust the settings on the DMM when power supply is OFF, or not connected.

Altering the setting on the DMM while power is on can damage the meter.

Using the DMM

Using the multimeter (DMM) to measure the voltage and current through the resistor.

Connect leads to the COM (–) and the $V\Omega mA$ (+) of the DMM.

The terminal marked $10ADC$ is only for measuring currents greater than $200mA$ up to $10A$. We won't use this terminal in this experiment.

We generally take the uncertainty to be ± 1 in the last digit.

Using the DMM

If, when measuring a value, your DMM shows a value of 1 on the display, as shown to the right, this means that the quantity measured exceeds the maximum value.

The value you select shows the **maximum value** that setting can measure. The units are also written for each setting. For example, the current is generally measured in milliamps (mA) for our purposes.

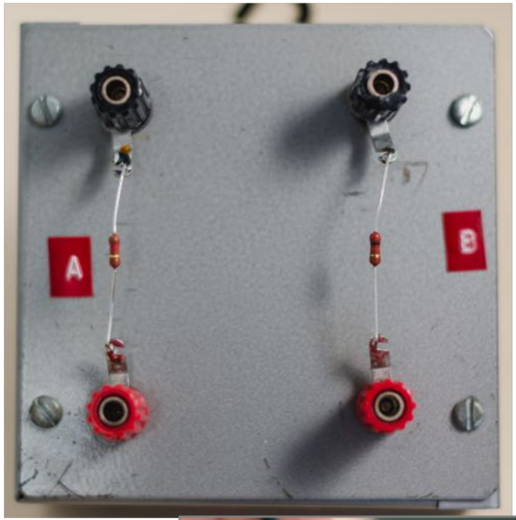
You generally start at the largest selectable value and work your way down.

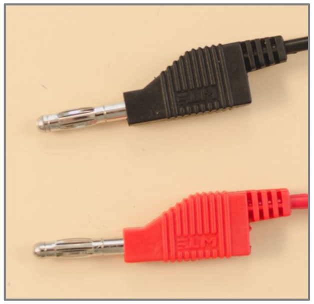
Resistor Box Connections

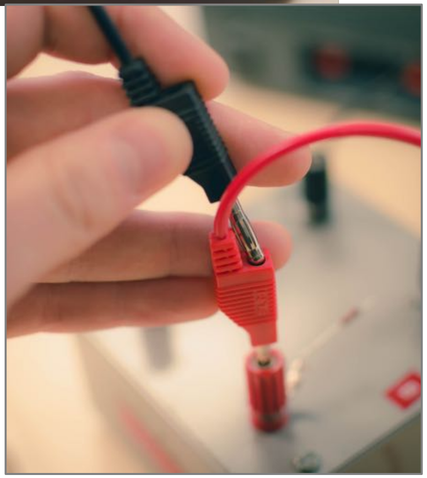
The resistors used in this experiment are those shown at right.

The leads (shown bottom-right) plug directly into the terminals on the resistor boxes and can also “piggyback” into each other when more than one connection at the same point is necessary.

To begin, we need to know the exact resistance values of our resistors.







Resistance Measurement

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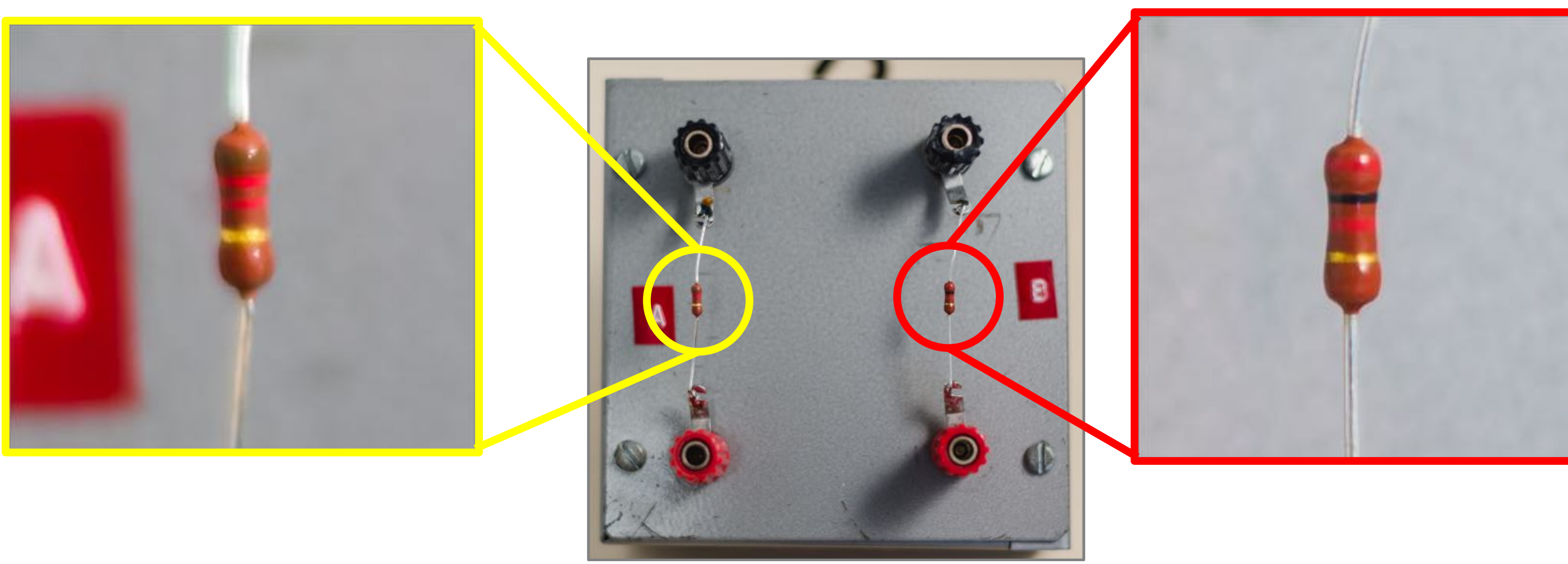
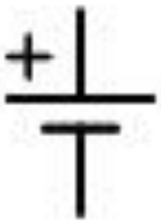
Lab Report 1: Use the DMM to directly measure the resistance of each resistor and record the value with its uncertainty. Switch the DMM to either 2000 or $20k\Omega$ and connect the DMM leads to the terminals of each resistor. Record resistance values as R_A and R_B.



Power Supply Settings

Turn the power supply on and set the **voltage to output $\sim 12V$** by turning the current knob to about halfway and adjusting the voltage knob appropriately. With no circuit connected, there will be no current value displayed.

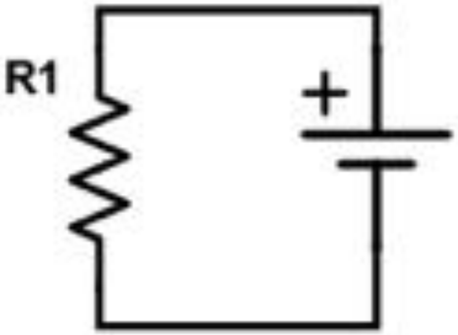


We will flow current through a resistor and measure voltage to determine the current through each resistor.

Simple Circuit

We'll begin by building a very simple circuit and do some basic analysis to understand how to use this equipment.

The circuit diagram for this circuit is as shown to the right. We'll use the power supply to provide the voltage and current through one of the resistors on the resistor box.

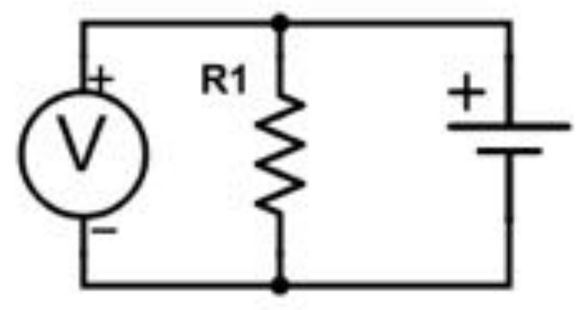


Connect the "+" on the power supply to **one** of the terminals of the resistor box, and connect the other terminal of that resistor back to the "–" **of the supply**. This completes a simple electrical circuit.

Simple Circuit

Switch power supply OFF.
Switch your DMM to $20DCV$ to measure the voltage.
Recall your power supply is set to $\sim 12V$DC.

A **voltmeter** must be connected in **parallel** with the device in which you wish to measure the voltage of. Use the circuit diagram as an aid on how to connect the voltmeter.



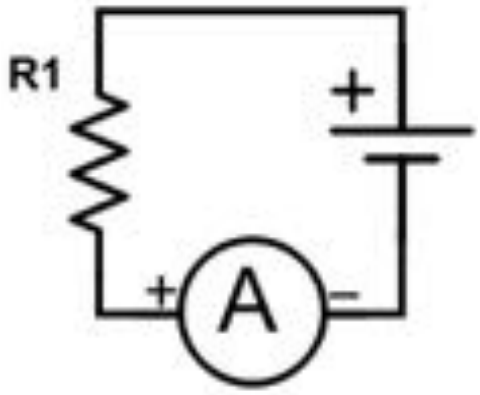
Lab Report 2: With circuit connected, turn on the power supply and measure the voltage across the connected resistor and record this value with uncertainty.

Lab Report 3: Using the measured value of the resistance and the voltage just collected, determine the current flowing through the resistor and its uncertainty.

Simple Circuit

Switch power supply OFF.
Switch your DMM to $200m\ DCA$ to measure the current.
This setting measures current *up to* 200 milliamps.

An **ammeter** must be connected in **series** with the device in which you wish to measure the DC amps of. Refer to the circuit diagram to determine how the meter connects.



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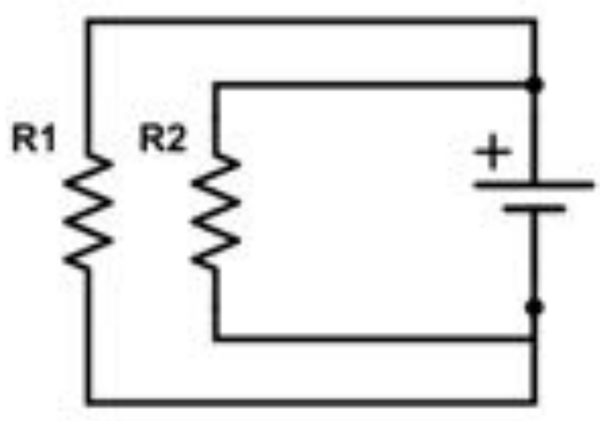
Lab Report 4: With circuit connected, turn on the power supply and measure the current through the same connected resistor and record this value with uncertainty.

LR

Lab Report 5: Compare your measured current value with your calculated value. Do they agree within uncertainty?

Parallel and Series Circuits

We will now investigate using multiple components in circuits.



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Lab Report 6:

Based on the definition of parallel and series, how are these resistors connected? What evidence is there to support your decision?

!

With power supply OFF, use both resistors and the power supply to connect the circuit as shown above.

CP

Have an instructor check your circuit before you continue.

Parallel and Series Circuits

LR **Lab Report 7:** Switch on the power supply and use a DMM to measure the voltage across each resistor and record those values with uncertainty.

LR **Lab Report 8:** Use Ohm's Law to calculate the current flowing through each resistor and its uncertainty.

LR **Lab Report 9:** What can you conclude about the voltage and current in components in this type of circuit?

We will now investigate a different circuit configuration.

Parallel and Series Circuits

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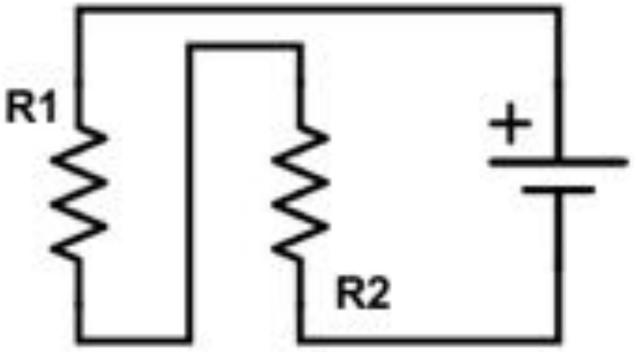
Lab Report 10:

Based on the definition of parallel and series, how are these resistors connected? What evidence is there to support your decision?



With power supply OFF, use both resistors and the power supply to connect the circuit as shown above.

CP

Have an instructor check your circuit before you continue.

Parallel and Series Circuits

LR **Lab Report 11:** Switch on the power supply and use a DMM to measure the voltage across each resistor and record those values with uncertainty.

LR **Lab Report 12:** Calculate the current flowing through each resistor and its uncertainty.

LR **Lab Report 13:** What can you conclude about the voltages and currents for components in these types of circuits?

Summary & Conclusions

LR **Lab Report 14:** Briefly summarize your experiment, in a paragraph or two, and include any experimental results and conclusions.

LR **Lab Report 15:** List any sources of experimental uncertainty and classify them as random or systematic.

Include your prelab, printed data, and all analysis with your report.