Physics 251 Laboratory
Introduction to Electronics

Introduction

This lab is designed to familiarize you with electronic components, test equipment, and setting up parallel and series circuits.

Equipment

4 resistors (at least 2 different values)
Decade Resistance Box
2 capacitors (2 different values)
2 'D' Cell Batteries
Alligator clips
Wires
Switch
3 lamps (same size)
3 lamp holders
Multimeter
3 Power Supplies (different)
Inductor coil
Power Strip

Section 1 - Resistance and Resistors

Color	Value
Silver	-2
Gold	-1
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Resistors are electronic components that resist the flow of electricity in a circuit. All materials have some resistance including the wires used to carry electric power to your lamp. Resistance of a material is calculated as $\text{Resistance} = \dfrac{\text{(Resistivity)(Length)}}{\text{Area}} = \dfrac{r L}{A}$. In your book you will find a table (page 804) of resistivities of different materials. Copper is most frequently used for household wiring as it has a low resistivity and is cheaper than silver.

Reading a resistor is much like reading a book, start on the left and read to the right. There are three or four colored bands on each resistor. These colors tell the value of the resistor in ohms according to the chart on the left. The first two bands identify the value of the resistor and the third is the multiplier. The fourth band indicates the tolerance of the resistor. Some circuits require more precise values of resistors than others, but more precise resistors are more expensive.

Value = first band second band x $10^{\text{multiplier}}$
Example: Red, Yellow, Red = $24 \times 10^{2}\Omega$
(Write down the first number, then the second number and multiply by 10 to the third number.)

Tolerance = Gold 5%
Silver 10%
None 20%

From Ohm's law, we know $R = \frac{V}{I}$ and if we know the equivalent resistance of several resistors in a circuit we can calculate an unknown voltage or current in a circuit.

Equivalent Resistance

Series Resistors $R_{eq} = R_1 + R_2 ... + R_n$

Parallel Resistors $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} ... + \frac{1}{R_n}$

Remember to report R_{eq} rather than $1/R_{eq}$

1. Find two different resistors in your box and identify the color sequence and the value and tolerance of each.
2. What would be the equivalent resistance if they were in series?
3. What would be the equivalent resistance if they were in parallel?

Section 2 – Capacitors

Capacitors are devices that store electrical potential energy. They are made by insulating two conductors from each other. One conductor is positively charged and the other negatively charged. The work done to move charge from one plate to the other is stored as potential energy. They are used in electrical circuits to store energy or to absorb sudden changes in power through the circuit much like the springs on a car absorb the bumps in the road. Capacitance is defined as charge divided by the potential difference between the plates, $C = \frac{Q}{V}$. The SI unit of capacitance is one farad, $1F = \frac{C}{V} = \frac{\text{coulomb}}{\text{volt}}$.

Equivalent capacitance

Series capacitors

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ... \frac{1}{C_n}$$

Parallel capacitors

$$C_{eq} = C_1 + C_2 ... + C_n$$

Remember to report C_{eq} rather than $1/C_{eq}$

1. What would be the equivalent capacitance of your capacitors if they were placed in series in a circuit?

2. What would be their equivalent capacitance if they were in parallel?

Section 3 – Inductors

An inductor or "choke" is a coil that produces an EMF when a changing current flows through it. The purpose of an inductor in an electric circuit is to oppose any change in current through the circuit. A transformer uses inductors to raise or lower voltages in alternating current circuits. The potential difference between terminals of an inductor is equal to the inductance times the time rate of change of the current $V = L\frac{di}{dt}$.

Inductance in measured in units of Henrys $H = \frac{V \cdot s}{A}$.

Section 4 – Power Supplies

There are many different types of power supplies. Power output is measured in volts (V). The power outlets in the room supply 110V of alternating current (AC), an alkaline AA battery supplies 1.5V of direct current (DC), cellular phone chargers supply 4.5V DC, and most car batteries supply 12V DC. Many power supplies, especially batteries, have some internal resistance that reduces the actual output voltage. It is important to measure the actual output voltage while the power supply is in the circuit. Battery eliminators, batteries and DC power supplies are all interchangeable in circuit diagrams.

Section 5 – Test Instruments

- An **Ammeter** is used to measure current in a circuit. An ideal ammeter has zero resistance and is placed in **series** with the circuit.
- A **Voltmeter** is used to measure voltages in a circuit. It measures the potential difference between two places in a circuit. An ideal voltmeter has infinite resistance and should be placed in **parallel** in the circuit.
- An **ohmmeter** measures the value of resistance in a circuit or component.
- A **multimeter** is a combination of an ammeter, voltmeter and ohmmeter and measures current, voltage and resistance. Remember, when using the multimeter as an ammeter it must be in series in the circuit and when using it as a voltmeter it must be placed in parallel in the circuit.

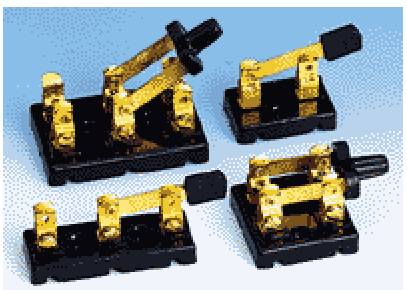
- An **oscilloscope** can also be used to measure voltages and current, but has the advantage of displaying what the wave looks like so you can see what is happening in the circuit.

- A **signal generator** puts out a signal with adjustable frequency and voltage. It is often used in conjunction with an oscilloscope to compare waveforms.

1. What is the measured resistance of the two resistors from part 1?
2. What are the voltages of the batteries?
3. What are the voltages of the power supplies set at their minimum?

Section 6 – Switches

Switches come in many shapes and sizes. The most familiar switches are the ones that turn the lights on and off. All a switch does is complete or break a circuit.



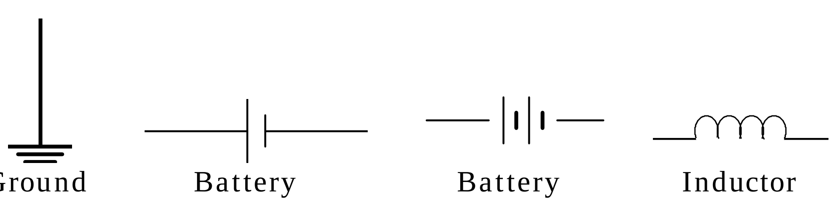
A double pole switch allows the creation of two different configurations for a circuit where throwing the switch changes from one to the other.

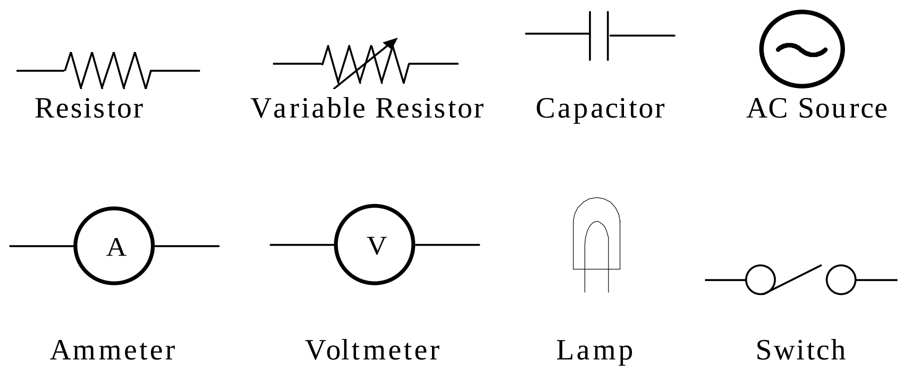
Types of Switches
DPDT – Double pole double throw
SPST – Single pole single throw
DPST – Double pole single throw
SPDT – Single pole double throw

Section 7 – Schematic Drawings

One of the more difficult things in electronics is translating a circuit diagram to an actual circuit. Today we will practice setting up several circuits from diagrams. It is important to remember to make the connections exactly the way they are shown in the diagram including the polarity on the battery or power supply. Many times circuits or measuring instruments are sensitive to where components are located so put them in the exact order listed. The components are shown on circuit diagrams by the standard symbols below.

Schematic Drawing Symbols

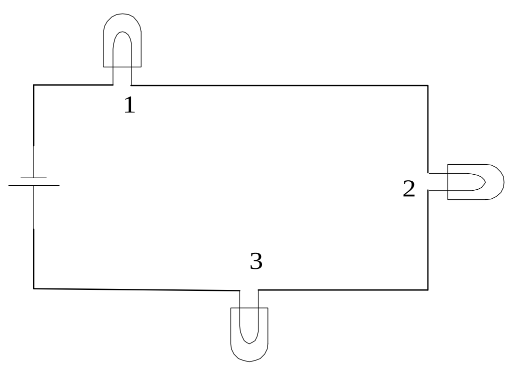




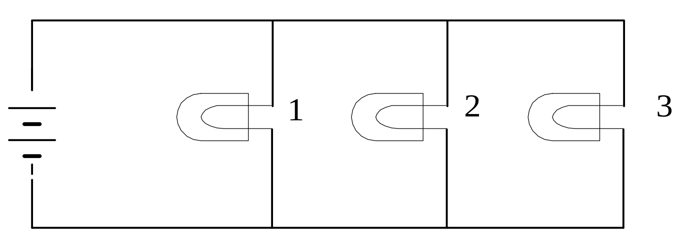
1. Set up the following circuits using the components in your box, wires and alligator clips. Please have them checked by an instructor prior to taking them apart.

2. Think about the difference between series and parallel?

3. Which lamp is the brightest in circuits 1 and 2? Why?

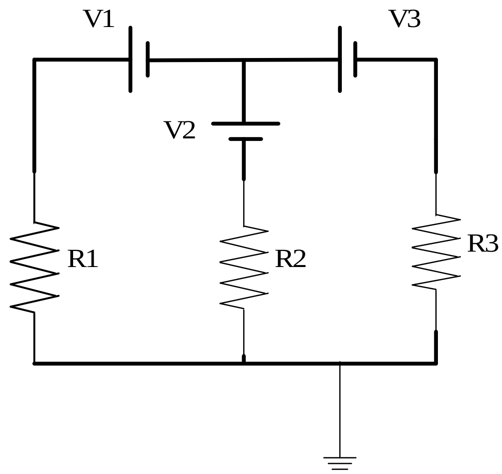


Circuit 1



Circuit 2

Do not plug in the power supplies for this circuit!



Circuit 3

Name ____ Date __________________

Lab Partners ____

Introduction to Electronics
Results

Section 1

1. Find two different resistors in your box and identify the color sequence, the value, and tolerance of each.

Resistor 1

Color 1__________ Color 2_________ Color 3 ________ Color 4 __________

Value _______________ Tolerance _______________

Resistor 2

Color 1________ Color 2_________ Color 3 ________ Color 4 __________

Value _______________ Tolerance _______________

2. What would be the equivalent resistance if they were in series? _________________

3. What would be the equivalent resistance if they were in parallel? _______________

Section 2

Capacitor 1 Value ______________ Capacitor 2 Value ____________

1. What would be the equivalent capacitance of your capacitors if they were placed in series in a circuit? __________________________
2. What would be their equivalent capacitance if they were in parallel?____________

Section 5

1. What is the measured resistance of the two resistors from part 1?

   Resistor 1 __________________ Resistor 2 ________________

   Are they within their stated tolerance?

   Resistor 1 __________________ Resistor 2 ________________

2. What are the voltages of the batteries?

Battery 1 ____________________ Battery 2 ____________________

3. What are the voltages of the power supplies set at their minimum?

PS 1 ________________ PS 2 ____________________ PS 3 _________________

Section 7

1. What is the current through circuit #1 in part 7? ________________________

2. Which lamp receives the most voltage in circuits 1 and 2?

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Overall

1. Have you seen or worked with all of the components we discussed today? If not, which ones were new to you? ____

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2. What was good about this lab and how would you improve it?

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