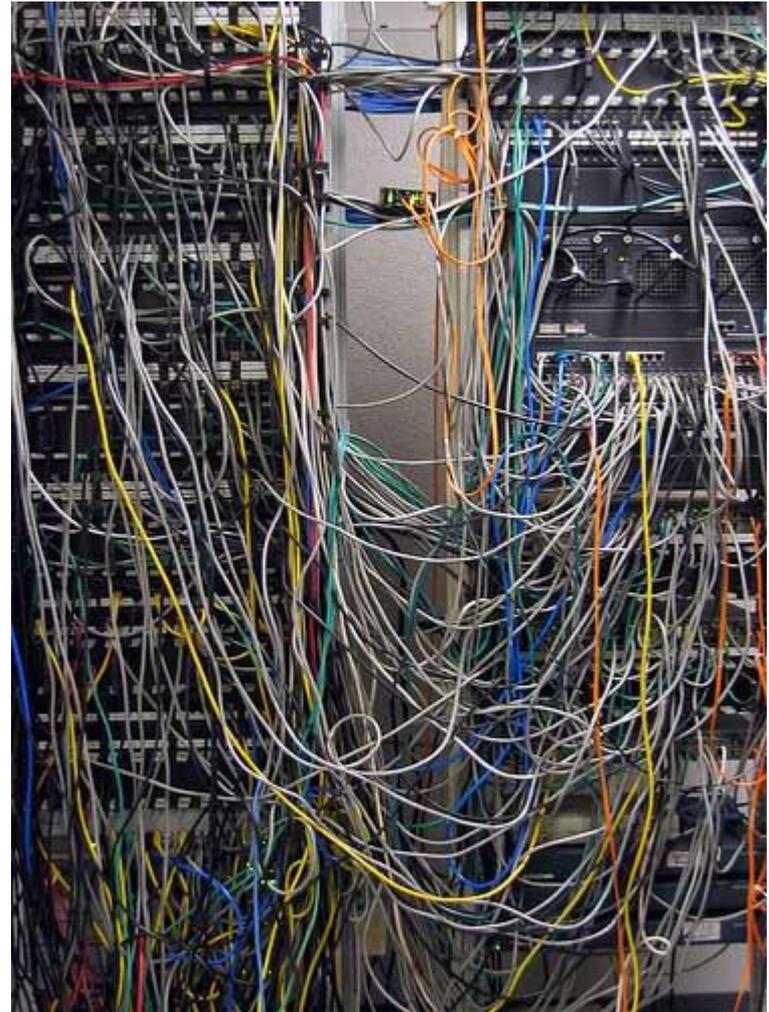


Electric Circuits

1st year physics laboratories

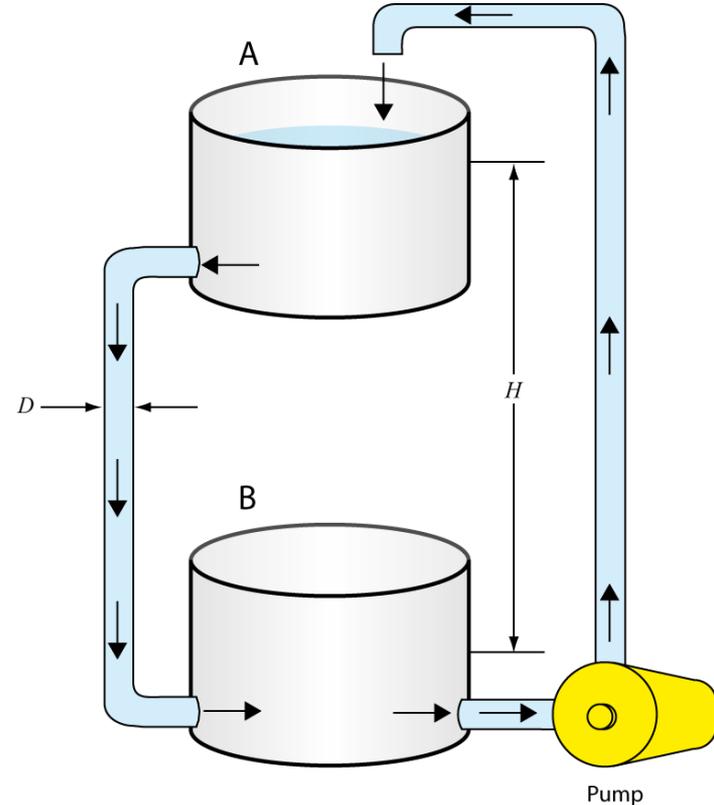
University of Ottawa

<https://uottawa.brightspace.com/d2l/home>



INTRODUCTION

- An electrical circuit consists of a closed loop with a number of different elements through which electric current passes.
- Important variables are voltage (V), current (I), resistance (R), and conductance (C).
- Consider the water pump analogy to understand voltage.



CURRENT, VOLTAGE, and OHM'S LAW

- **Conductivity and resistivity:**

- Conductivity is defined as $\sigma = (\ell/A)C$, ℓ is length , A is area.
- Resistivity is $\rho = 1/\sigma$
- Resistance, R , of an element is its ability to limit current flow.

- **Ohm's Law: $\Delta V = RI$**

- Defines the relationship between electric potential, current, and resistance.
- A plot of voltage vs current in a circuit will have a slope equal to the resistance.

KIRCHOFF'S RULES

- The Junction Rule (conservation of charge)
 - The sum of the currents entering any junction must equal the sum of the currents leaving that junction.
- The Loop Rule (conservation of energy)
 - The sum of the voltage changes across each element around any closed circuit loop must be zero.
- Consider the circuit on the following slide...

SAMPLE CIRCUIT

- Consider point c where the current splits. We have (from the junction rule):

$$I_1 = I_2 + I_3$$

- Consider the loop that goes through R_1 and R_2 . We go through the power source and pick up ΔV_0 then pass through the two resistors dropping the voltage to 0:

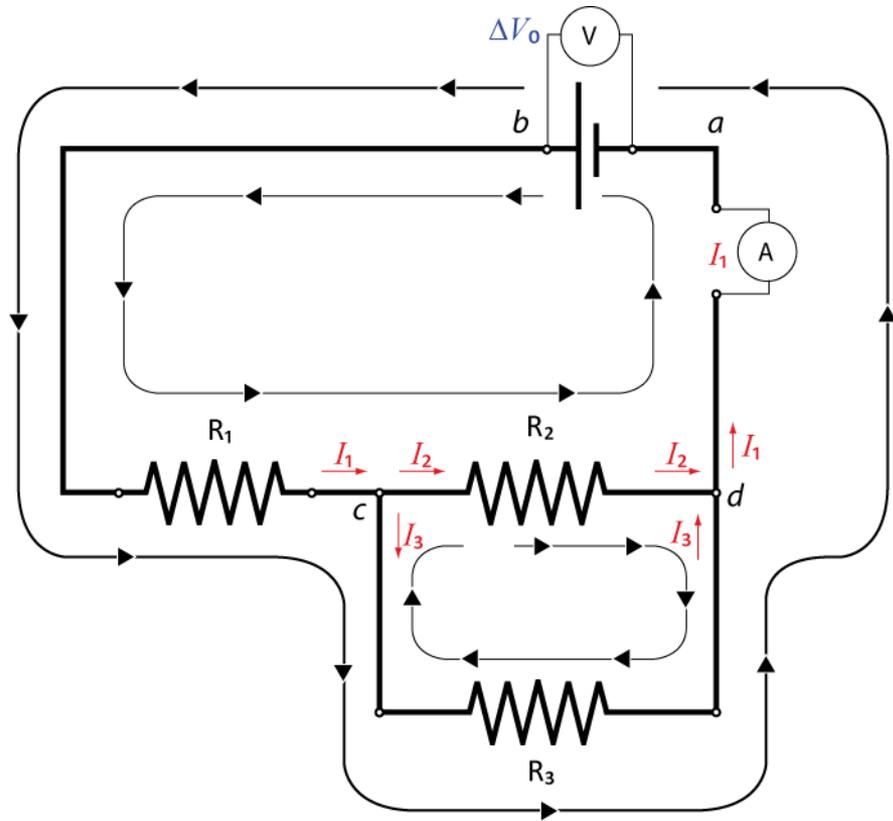
$$\Delta V_0 - \Delta V_1 - \Delta V_2 = 0$$

$$\Delta V_0 - R_1 I_1 - R_2 I_2 = 0$$

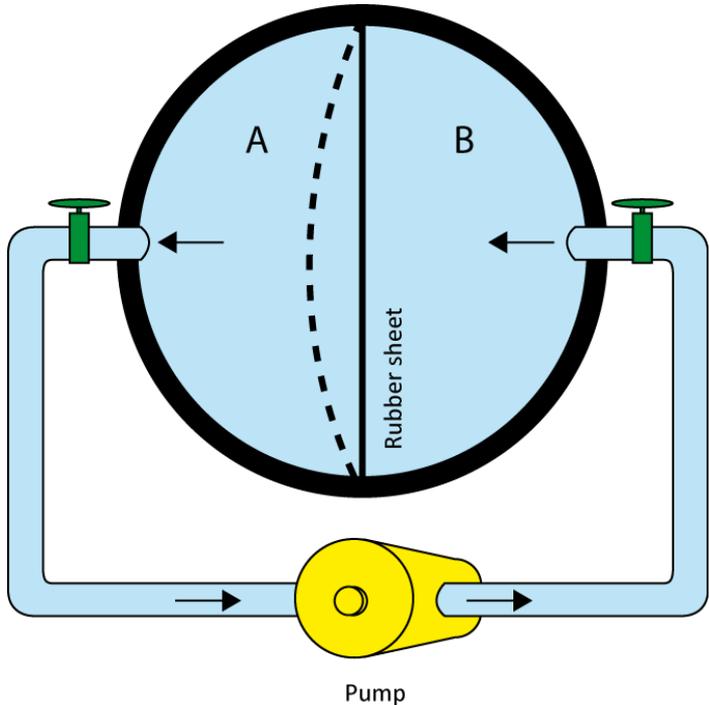
Consider the small loop that goes through R_2 and R_3 . A test charge will drop through R_2 and rise through R_3 therefore we have:

$$-\Delta V_2 + \Delta V_3 = 0$$

$$-R_2 I_2 + R_3 I_3 = 0$$



CAPACITORS IN CIRCUITS



- A capacitor is used to store electrical energy in a circuit.
- A simple analogy can be seen in the figure of the hollow sphere divided into two equal volumes.
 - Water is moved from volume A to B and elastic energy is stored in the rubber sheet due to the work done on the water.
 - The energy in the rubber is analogous to the stored electric potential energy in a capacitor.

OBJECTIVES

- 1) Measuring a **resistance value** using colour code and Ohmmeter
- 2) Verify **Ohm's law** using a simple circuit on a breadboard
- 3) Investigate simple circuits with **resistors in series and parallel.**
- 4) Review **Kirchoff's rules** for circuit analysis.
- 5) Investigate simple circuits with **combinations of capacitors.**

TUTORIALS!

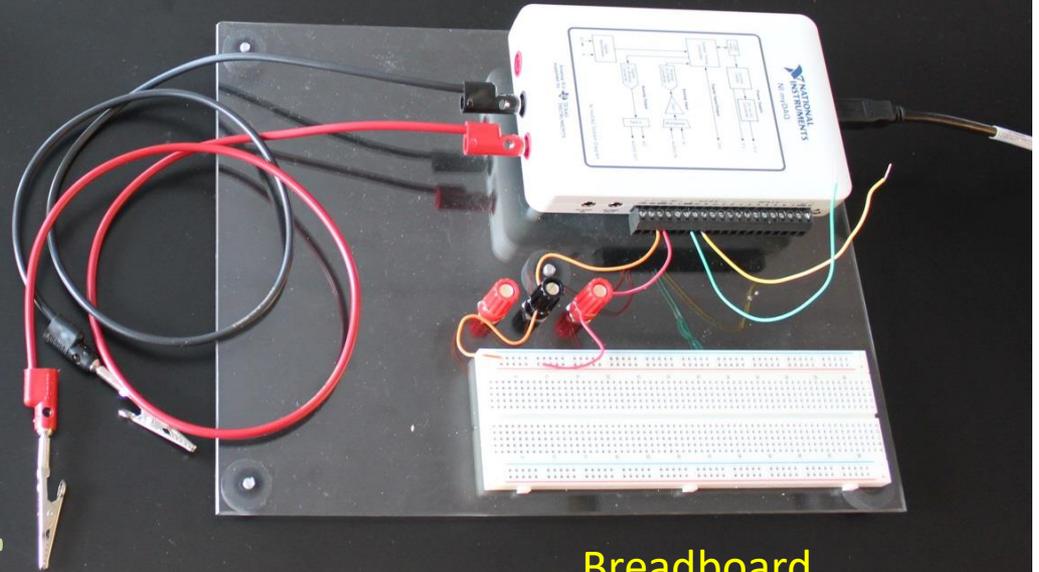
- You should have read the following tutorials before coming to the lab session:
 - Building circuits
 - Using a multimeter
- The tutorials contain vital information on how to manipulate the electronics you will be using in the lab today to investigate simple circuits!



Fluke
multimeter

myDAQ:

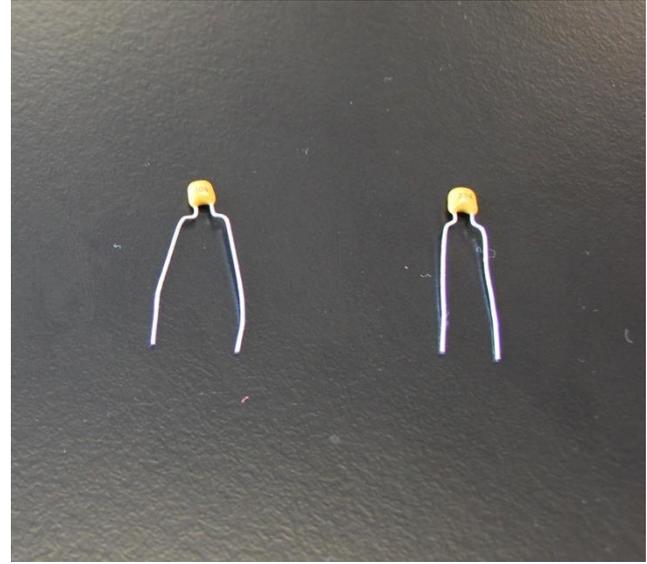
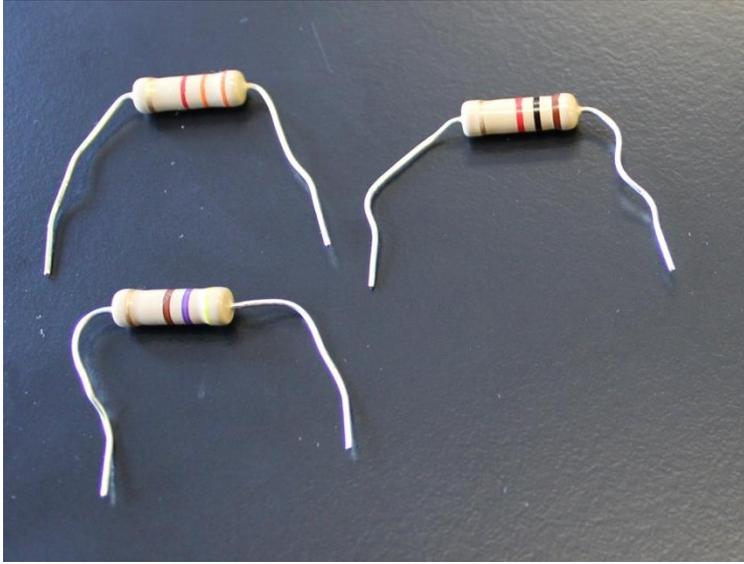
- Multimeter
- Power supply



Breadboard

EQUIPMENT

RESISTORS AND CAPACITORS



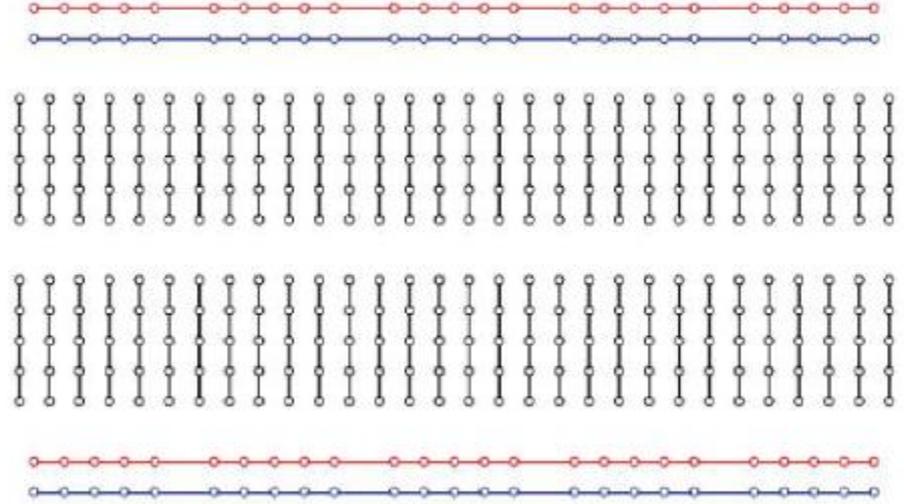
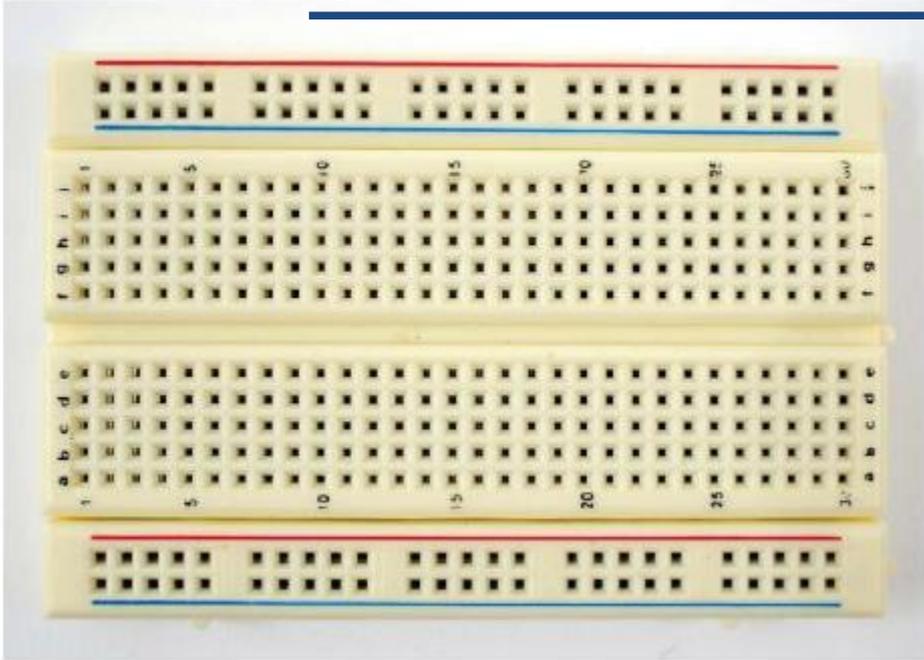
- The resistors have a colour code on them that gives their rated resistance and uncertainty.
- The capacitors use a 3 digit code – the first two numbers are the value and third number is the multiplier times pF: 543 means $54 \times 1000 \text{ pF} = 54 \text{ nF}$.

RESISTOR COLOUR CHART

- Example:
1- Red (2)
2- Black (0)
3- Orange (10^3)
4- Gold (5%)
- Resistance value:
 $20 \times 10^3 \Omega \pm 5\%$
(20 ± 1) k Ω
- You will use this chart to complete **PART 1**.

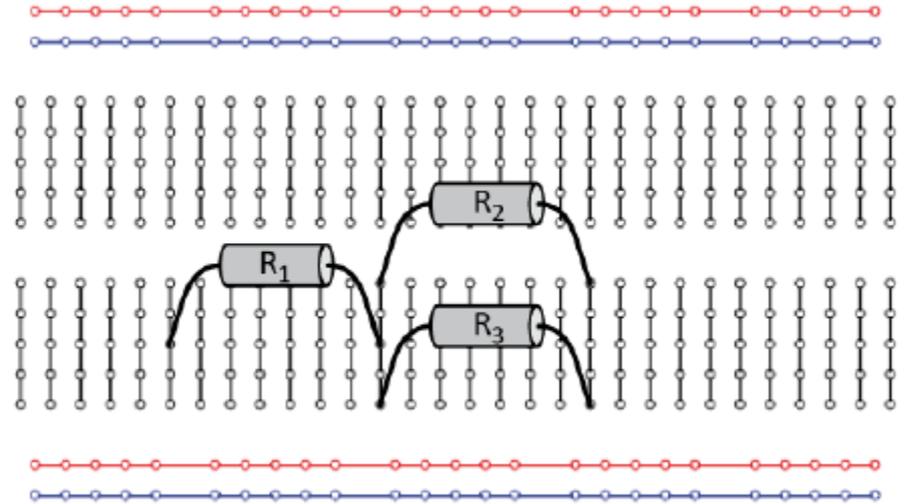
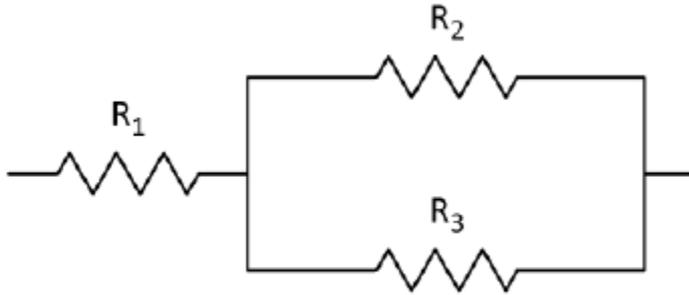
	1 st band	2 nd band	3 rd band	4 th band
	1 st significant figure	2 nd significant figure	Multiplier	Tolerance
Silver	-	-	10^{-2}	10%
Gold	-	-	10^{-1}	5%
Black	-	0	1	-
Brown	1	1	10	1%
Red	2	2	10^2	2%
Orange	3	3	10^3	-
Yellow	4	4	10^4	-
Green	5	5	10^5	0.5%
Blue	6	6	10^6	0.25%
Violet	7	7	10^7	0.1%
Grey	8	8	10^8	-
White	9	9	10^9	-

USING THE BREADBOARD



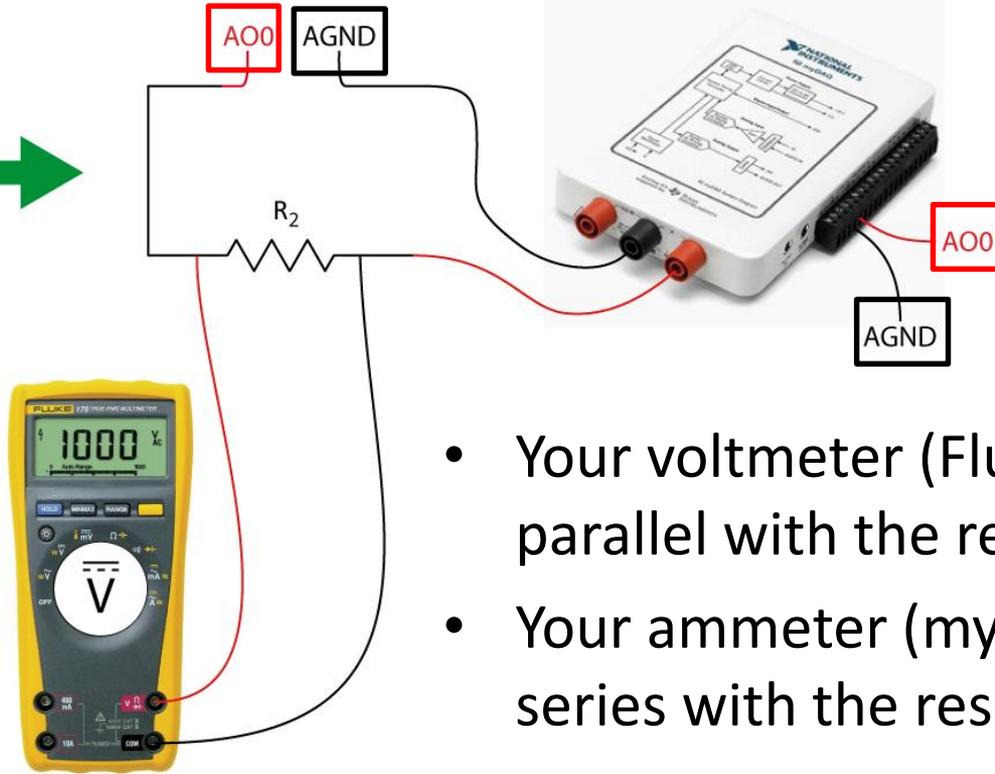
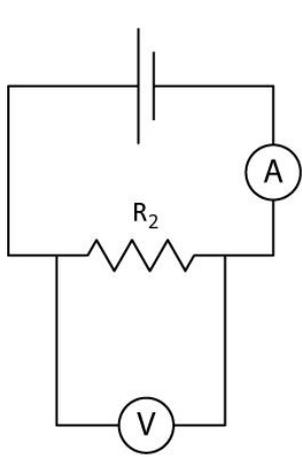
- On the left is a sample of the type of breadboard you will be using.
- On the right is the hidden connection pattern of the pins in the board.

BUILDING A CIRCUIT FROM A DIAGRAM



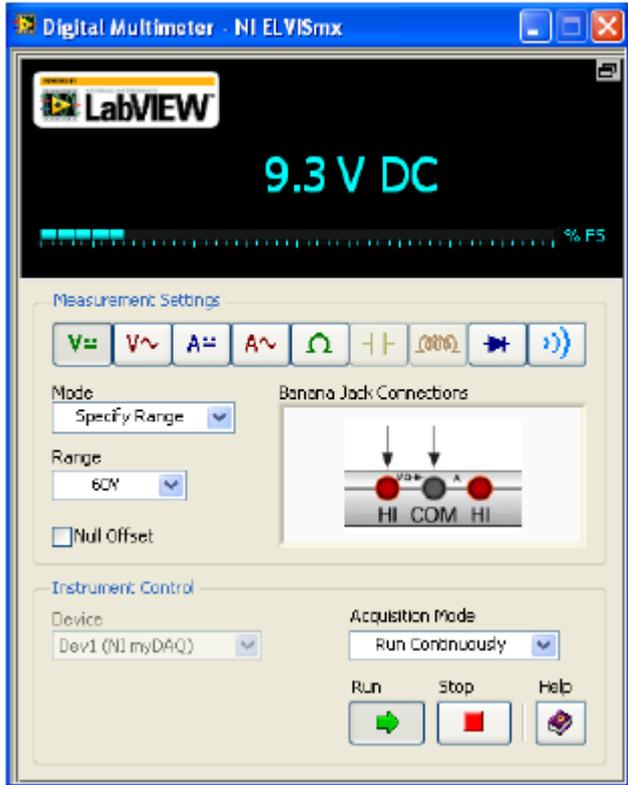
- On the left is the circuit diagram of a combination of resistors in series and parallel.
- On the right is an example of how you can connect the resistors using the hidden connection pattern.

SETTING UP VOLTMETER AND AMMETER



- Your voltmeter (Fluke) will be in parallel with the resistor.
- Your ammeter (myDAQ) will be in series with the resistor.
- You will build this circuit in **PART 2** to verify Ohm's law.

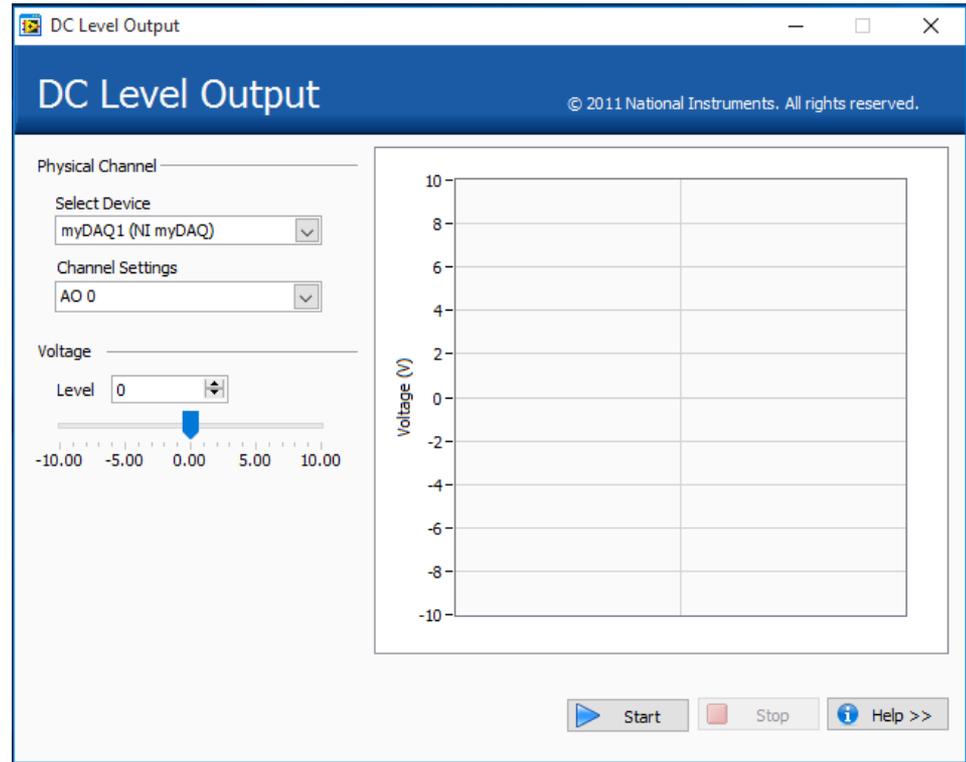
myDAQ DIGITAL MULTIMETER



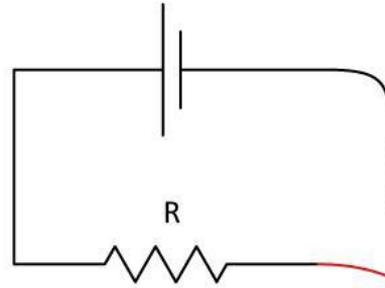
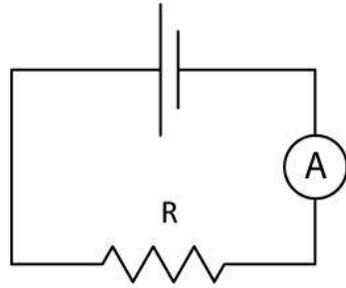
- The digital multimeter program is located in the NI Elvis folder on your desktop.
- You can use the software to measure voltage, current and resistance.
- The range can be specified or leave it on auto mode so that the software will determine your range for you.
- Depending on what variable you are measuring, you might need to change the position of the banana cable.

DC LEVEL POWER SUPPLY PROGRAM

- The DC Level Power Supply program is located in the NIElvis folder on your desktop.
- The correct channels for output (myDAQ AO 0) should be selected then click the “Start” button.
- You can change the voltage output in as necessary (range is 0 – 5 V) (“hit Enter”).
- The voltage output is shown on the graph.



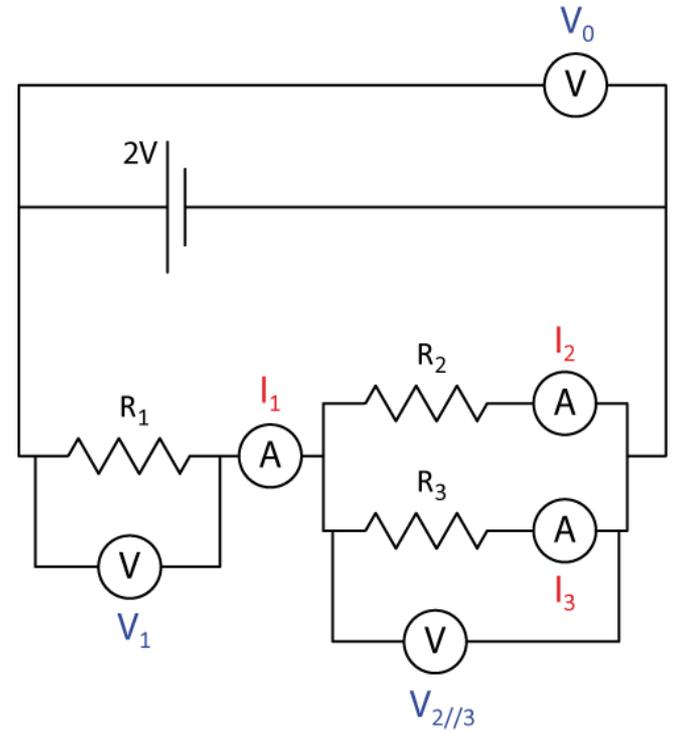
UNCERTAINTIES ON METER READINGS



- Example: You want to use your myDAQ to read the current in a circuit.
 - Your ammeter has a reading of **0.057 A** (set on the 1.000 A range).
 - From the specs. of your myDAQ, the accuracy is **$\pm (0.5\% + 2 \text{ mA})$** .
 - The % is the percentage of your value and the 2 mA is the constant you add to the percentage.
 - $\rightarrow \pm (0.5\% + 2 \text{ mA}) = \pm (0.005 \times 0.057 + 0.002) \text{ A} = \pm 0.002285 \text{ A}$
 - Therefore your final reading is **$I = (0.057 \pm 0.002) \text{ A}$**

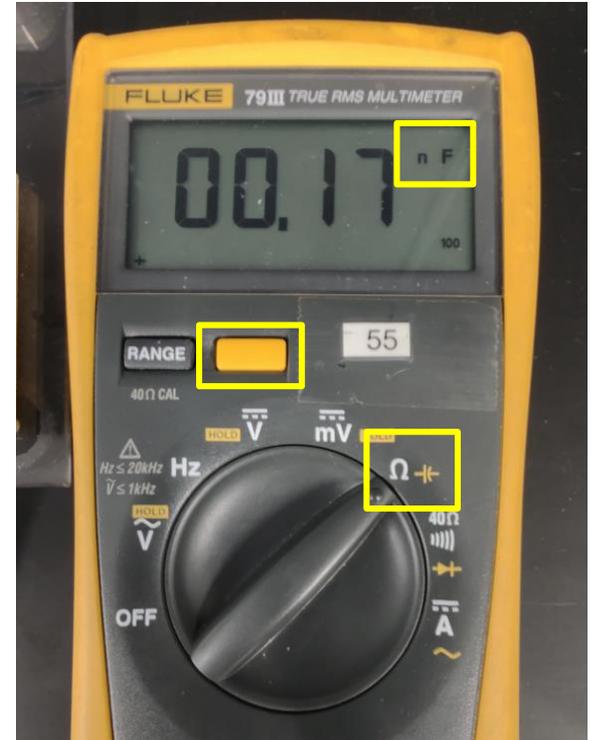
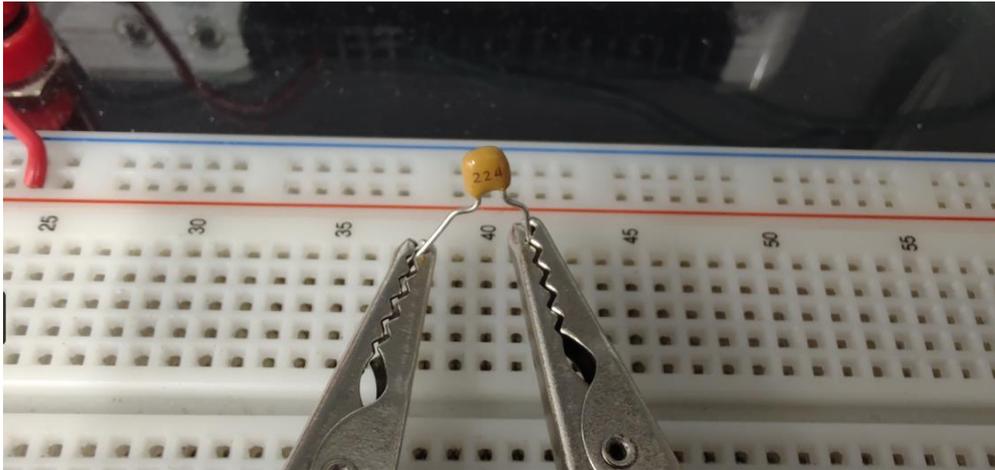
A CIRCUIT WITH SEVERAL RESISTORS

- In **PART 3** you will measure the effective resistance of various combinations of resistors in series and parallel.
- In **PART 4** you will verify Kirchoff's rules using the circuit shown on the right along with your voltmeter (FLUKE) and ammeter (myDAQ) to measure the voltage and current at different sections.



MEASURING CAPACITANCE (PART 5)

- The Fluke multimeter can measure capacitance. Choose the resistance setting (Ω) then press the second function button. The multimeter will switch to measuring capacitance in Farads (F).



CLEAN UP

- Turn off the computer and **don't forget to take your USB key.**
- Turn off the Fluke multimeter. Disassemble your circuit and put back the three resistors and the two capacitors in your wire kit box.
- Please recycle scrap paper and throw away any garbage. Please leave your station as clean as you can.
- Push back the monitor, keyboard, and mouse. Please push your chair back under the table.
- Thank you!

DUE DATE



The report is due in 1 week before 5pm.

Please submit the report to the dropbox in STM 3rd floor.

PRE-LAB

Don't forget to do your pre-lab for the next experiment!