UMass ECE 210 – Fall 2023

Lab 2: Breadboarding simple circuits with resistors

GOALS:

- Learn about lab equipment:
  - Breadboard – create simple circuits with resistors
  - Power Supply – apply voltage to a breadboard circuit
  - Multimeter – measure voltage, current and resistance

- Learn about Ohm's Law:
  - Voltage divider with resistors in series
  - Current divider with resistors in parallel

DATA required for Lab report (get instructor check off before leaving):

TABLE 1 – Measurements of resistors in Series	Instructor check:	
TABLE 2 – Measurements of resistors in Parallel	Instructor check:	
Experimental setup - Circuit diagrams/Schematics/Pictures	Instructor check:	

Lab report (Due in 1 week):

1. Introduce concepts and justification for experiment.
   a. Voltage, current, voltage dividers, series vs. parallel etc.
2. Describe your experimental setup in a diagram for each plot
   a. Label all equipment, voltages, currents (with direction).
3. Present measurements with plots that are clearly labeled
4. Analysis for each plot – How well does data match prediction?
5. Conclusion – Summary of concepts and supporting data and ways to improve data

You will need to RECORD all of your data independently.

Failure to record your data properly or take notes about your procedures will leave you **unable** to write your lab report.

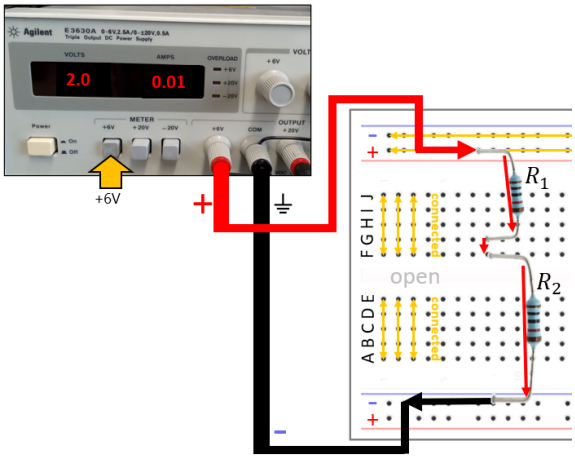
TAKE CAREFUL NOTES and RECORD everything!

Intro to power supply, multimeter, breadboard:

We will create simple circuits with a breadboard and measure them carefully to become familiar with the benchtop equipment in the lab. We'll use the power supply to apply voltage to the breadboard and the breadboard to hold and connect two resistors in a circuit. First in series and then in parallel. In series the resistors create a voltage divider, while in parallel they create a current divider.

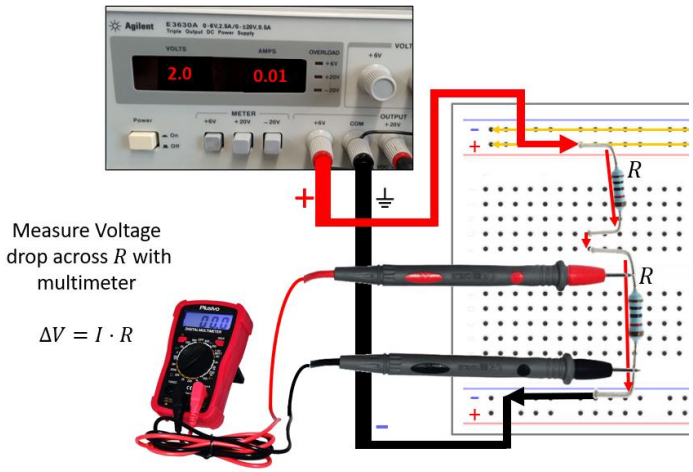
Resistors in series:

1. Get two resistors with the same resistance from the front of the room.
2. RECORD what resistors you select. (Any values ~2kΩ should work)
3. Insert them into the breadboard so that the voltage from the power supply must pass through both resistors to get to ground.
4. Apply 6V from the power supply to the resistors using the power rails on the outside edges of the breadboard.
5. RECORD exactly what voltage you apply with the power supply.



The bread board is split into two sides. (A → E connected, F → J connected, but not to each other)

6. Measure and RECORD the **voltage** across one resistor using the multimeter.



Voltage Divider:

$$V_{power} = I \cdot (2R)$$

$$I = \frac{V_{power}}{2} \cdot \frac{1}{R}$$

$$\boldsymbol{\Delta V_R = I \cdot R}$$

$$= \left(\frac{V_{power}}{2} \cdot \frac{1}{R}\right) \cdot R$$

Measuring Voltage with multimeter:

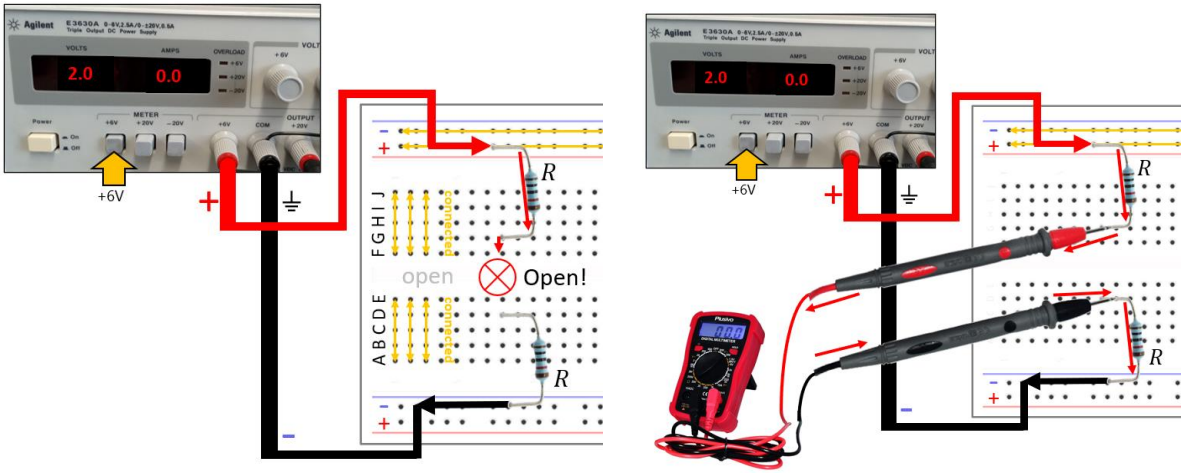
1) Rotate dial to measure 20 Volts
2) Verify red probe is connected to the V input
3) Verify black probe is connected to the 'COM' input
4) Use the probes to touch the metal on each side of a resistor (follow associated variable convention)
5) Don't forget to RECORD the voltage across the resistor.
6) Note that HOLD must be OFF (press the 'hold' button to toggle)

When the multimeter is set to voltage measurement, it draws very little current from what it is measuring. This is because it presents a very high resistance (~10 MegaOhms) to the circuit under test. Relative to the resistors in your circuit the voltmeter looks like an open circuit.

Measuring Current with multimeter:

To measure the current we have to modify the circuit and reconfigure the multimeter to measure current by swapping the red probe input to 'mA' and rotating the dial to DC current measurements (20mA).

To modify the circuit, move a resistor so that the circuit is broken. Then we will complete the circuit with the multimeter.



1. Measure the voltage across the same resistor as before and verify there is no voltage drop.
2. Reconfigure input plugs to measure current and rotate dial to measure 20mA
3. Measure and RECORD the current by using your probes to complete the circuit (if you opened the circuit between the two resistors, use the probes to close it there)

When the multimeter is set to current measurements, it now presents a very low resistance ($R_{sense} = 10\ \Omega$) or 'input impedance' to the circuit under test, acting like a short circuit.

Calculating the Current:

Use Ohm's Law to calculate the current expected in your circuit.
Verify your measurements match your calculations. They should be EXACT.

Measured Current: _____ [mA]

Calculated Current: _____ [mA]

Measuring Resistance with multimeter:

To get even more precise results we will MEASURE the resistance of the resistors.

1. Remove each resistor from the circuit
   (if you leave it in the circuit you will measure the circuit, NOT the component)
2. Rotate the dial on your multimeter to measure resistance
   (Set the dial to the lowest resistance range that will still measure your resistor)
3. Measure and RECORD the resistance of each resistor

Measured Resistance of 1st resistor: _____ [ ]
Measured Resistance of 2nd resistor : _____[ ]

Labeled Resistance of 1st resistor: _____ [ ]
Labeled Resistance of 2nd resistor : _____ [ ]

Recalculate the expected current in your circuit using these measured resistances and measured voltage applied to the circuit.

Calculated Current with measured resistance and voltages: _____ [mA]

Is it within 1%? Yes / No

ALL electrical measurements in these labs will be almost EXACT!

IF you find errors, you have not measured something or there is a broken connection.

(99% of the time the problem is a loose or bad connection/cable)

The rest of the time diodes/transistors and op-amps had too much voltage applied and burned.

Resistors in Parallel:

Repeat the procedure with the same two resistors but now wire them in parallel.
This creates a current divider.

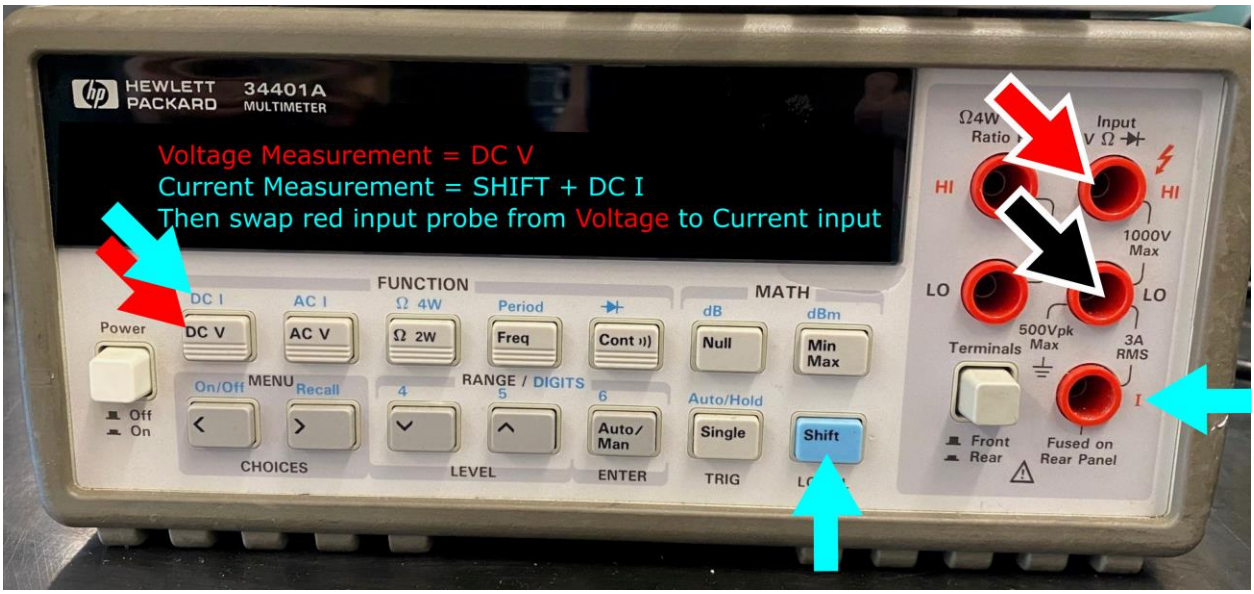
1. Draw the new circuit diagram for two resistors in parallel.
2. Draw how you could wire this circuit in a breadboard.
3. Create the circuit on your breadboard
4. Measure and RECORD the applied voltage from the power supply
5. Measure and RECORD the voltage across the resistors
6. Measure and RECORD the current through each resistor
7. Calculate and RECORD the expected current through the circuit.
8. Calculate and RECORD the power dissipated through the circuit.

Precision Multimeter:

The portable and handheld digital multimeter is convenient but has limited precision.
Next use the bench multimeter (HP 34401A) to measure your parallel circuit.
Check your measurements again and note any differences you find in your lab report.

REMEMBER – You need to swap the probe inputs for Voltage and Current!

Now you should expect to get less than 1% error for all measurements.



LAB REPORT DUE NEXT WEEK

Start outlining report. Do you have all the data you need?
Do you need to take pictures of your setup?

Lab Report 2 – Rubric

To practice your technical writing skills, you will write a concise (short) lab report which is a self-contained document, introducing important concepts with citations to a few sources, motivating your experiment, presenting your experimental setup and your experimental results (PLOTS, TABLES etc.) and analyzing your results to verify the concepts you introduced were confirmed within the precision of your measurements.

Lab reports should focus on proving to the reader that you made the measurements accurately and precisely. Meaning you will need to take pictures of your circuit and setup and present data in well labeled figures that are easy to interpret towards your conclusions.

2,000-word limit 1 report/group

Focus on presenting your data clearly with well labeled plots. You can use any plotting software.

		Points	**Grade**
	Introduce and define concepts (with citations)	5	
	Motivation for experiment	5	
1	Experimental Diagram (drawing + PICTURE with labels)	5	
	TABLE – Measurements of resistors in series	5	
	Analysis (remember to show your work for calculations)	5	
2	Experimental Diagram (drawing + PICTURE with labels)	5	
	TABLE – Measurements of resistors in parallel	5	
	Analysis (remember to show your work for calculations)	5	
	Conclusion	5	
		45	