**Lab 1 – DC Circuits on a Breadboard**

**Objectives**

-To learn how to use a digital Multi-Meter (DMM)

-To wire up various circuits on a breadboard, connect them to a DC source and measure voltage across the various components and currents in the circuit

-To learn about Voltage Dividers

-To learn about Voltage Droop

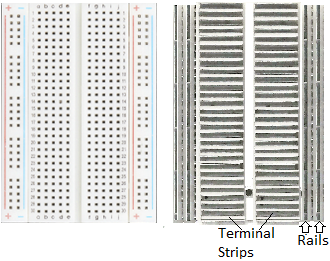
**Equipment**

Measuring Equipment: Digital Multi-Meters, Powered Breadboard with 0 -12 V variable DC source, jumper wires, jumper cables with alligator clips, cables with banana plugs

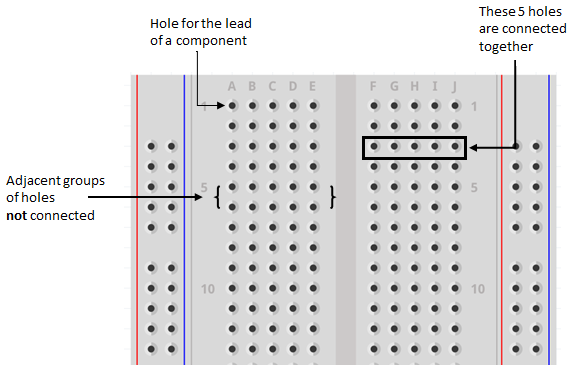
Resistors: One 5k Ohm; Two 10k Ohm; One 100 kOhm

**Introduction**

In this lab you will be building basic electric circuits on a prototyping board or breadboard. A breadboard consists of a perforated plastic block with numerous conducting points under the perforations (or holes). A typical breadboard is shown in the figure 1a below. The figure in the middle shows the underside of the breadboard and figure 1c is just a schematic. Notice that you have sections with rows of metal strips and sections with vertical metal strips. Half the holes in one row are connected together; the holes in one row to the left (or right) of the notch (indicated by a straight line in the schematic) are interconnected. All the holes in one vertical strip are connected together. The rows of metal strips are commonly known as ‘terminal strips’ and the vertical strips are typically known as a ‘bus’ or rails. Electrical components such as resistors, capacitors, transistors, etc. are typically connected to the holes in the terminal strip section and power sources and ground points are usually connected to the bus. Power is then brought to the electrical components via jumper wires. If you were to connect a power source with a specific voltage (say 5 Volts) to one of the holes on a bus then every hole on that particular bus will be at practically 5 V since as mentioned above all the holes on one bus are connected together. The same holds true on the terminal strips.



*Figure 1a-Breadboard Figure 1b - Breadboard underside*



*Figure 1d-Breadboard*

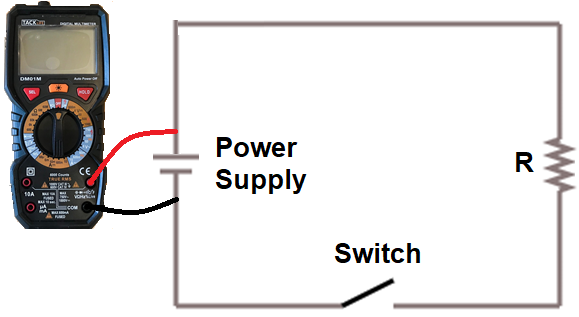
Some breadboards (powered) also come with a built in power source that allows you to vary the voltage up to a maximum amount.

In the Electronics lab this semester you will be making voltage, current or resistance measurements and it is important that you know how to make these measurements using a digital multi-meter (DMM).

A typical DMM is shown below.

**Measuring DC Voltage**

The DMM measures the potential difference (i.e.- voltage) between any two points in a circuit. To make a measurement across any electrical component in a circuit, the DMM needs to be connected to the device in parallel as shown in the diagram below. In this example, the circuit has been setup to measure the voltage across the battery. Make sure the red cable lead is connected to the terminal labeled ‘VΩmA’ and the black lead is connected to the terminal labeled ‘COM’. If your DMM does not have an auto ranging feature then you need to set the dial on the meter to the proper range. So if you set the dial to ‘6V’, the largest voltage that you can measure on that setting is 6V. Important Tip: To make the most accurate measurement you should set the dial to the lowest possible range. Also be sure the dial is set to DC Voltage ( ) not to AC Voltage (V~)



*Figure 2: Measuring Voltage with a Multimeter*

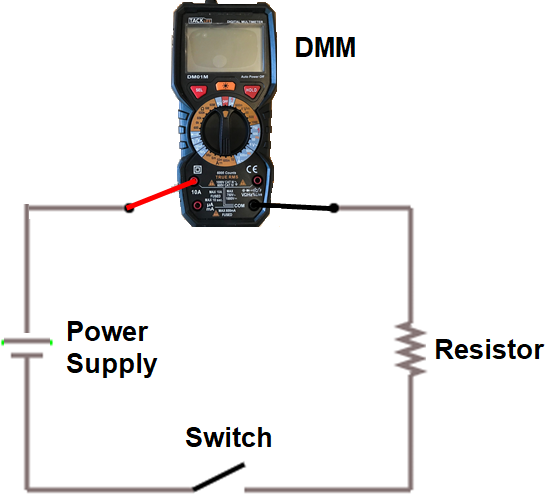
**Measuring DC Current**

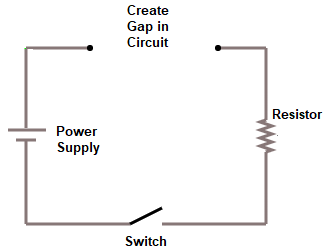
To use the DMM as a DC current meter, press the function button marked ****or set the dial to ****and select the proper range with the dial. The larger the number that you set the dial to, the larger the current that you’ll be able to measure at that setting. The black cable lead needs to be connected to the ‘COM’ jack of the DMM and the red cable lead needs to be connected to either:

(1) the jack marked “mA” for low current measurements, or

(2) the jack marked “10A” for high current measurements.

To measure the current in a circuit, the DMM needs to be connected in series with the electrical device. The following diagram shows how to connect the DMM to measure current. In the circuit below, if you wanted to measure the current going into the light bulb, you need to first create a gap in the circuit and then insert the meter so that it is in *series* with the bulb.

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*Figure 3: Measuring Current with a Multimeter*

**Measuring Resistance**

The resistance of an Ohmic device can be measured directly with a DMM. Simply connect the ends of a component such as a resistor to cables plugged into the ‘V-mA- jack and ‘COM’ jack of the DMM. Turn the dial on the DMM to ‘’ and select the proper range (i.e.- the smallest range that gives you a reading). In this configuration, the DMM applies a small DC voltage to the electrical component and measures the current that flows through the device. From this data and the definition of resistance (R= V/I), the resistance of the device is determined. **Important:** In order for the DMM to measure the correct resistance, the electrical component must NOT be connected to any circuit.



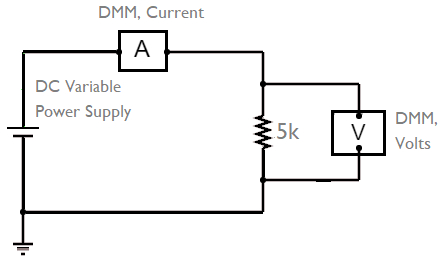
*Figure 4: Measuring Resistance with a Multimeter*

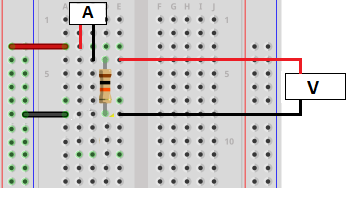
**Activity 1 – Voltage vs Current for a Resistor**

1. List the color code for the resistor and determine its numerical value.

2. Measure the resistance of the resistor with the DMM.

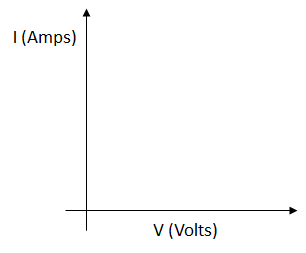
3. Build the following circuit on the breadboard. Wire up the circuit first and then connect the DMM’s to make current and voltage measurements. Use a DC variable power voltage supply (up to 10V at least).





*Figure 5: Wiring up a circuit on a breadboard*

4. Sketch the table below in your notebook and plot the current vs voltage graph in Excel.

**Table1**

|  |  |  |
| --- | --- | --- |
| Set Voltage (V) | Measured Current (I) | Calculate and confirm, I= V/R |
| 1.0 |  |  |
| 2.0 |  |  |
| 3.0 |  |  |
| 4.0 |  |  |
| 5.0 |  |  |

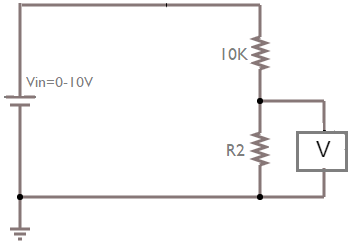
Don’t forget to record the instrument error (see Appendix).

**Question:** Does the resistor obey Ohm’s law? Explain.

**Activity 2 - Voltage Divider Circuit**

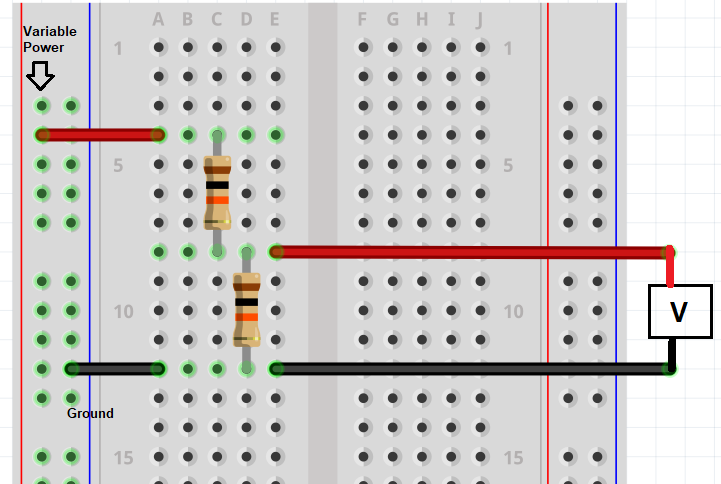
Construct the following circuit; first use R2= 10k and then repeat for R2 = 5 k.

Use to calculate Vout

 T**able2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Set Voltage (Vin) | Vout | | Vout (Calculated) | |
| 2.0 |  |  |  |  |
| 4.0 |  |  |  |  |
| 6.0 |  |  |  |  |
| 8.0 |  |  |  |  |
| 10.0 |  |  |  |  |

*Figure 6: Voltage Divider Schematic*

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*Figure 7: Voltage Divider on a Breadboard*

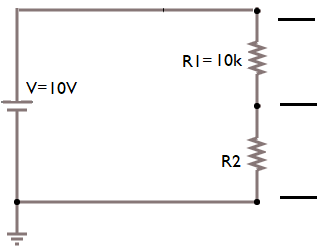
**Question:** A voltage divider is advertised to deliver across R2, did it work?

**Activity 3 – Measuring Electric Potential**

**Measuring Electric Potential at Various Points in a Voltage Divider circuit**

Electric Potential at a specific point (Voltage w.r.t ground) in a circuit is measured by connecting the black cable lead from the ‘COM’ jack of your DMM to electrical ground and connecting the red cable lead to the point of interest in your circuit. The black cable lead does not move in these types of measurements and it is always connected to ground.

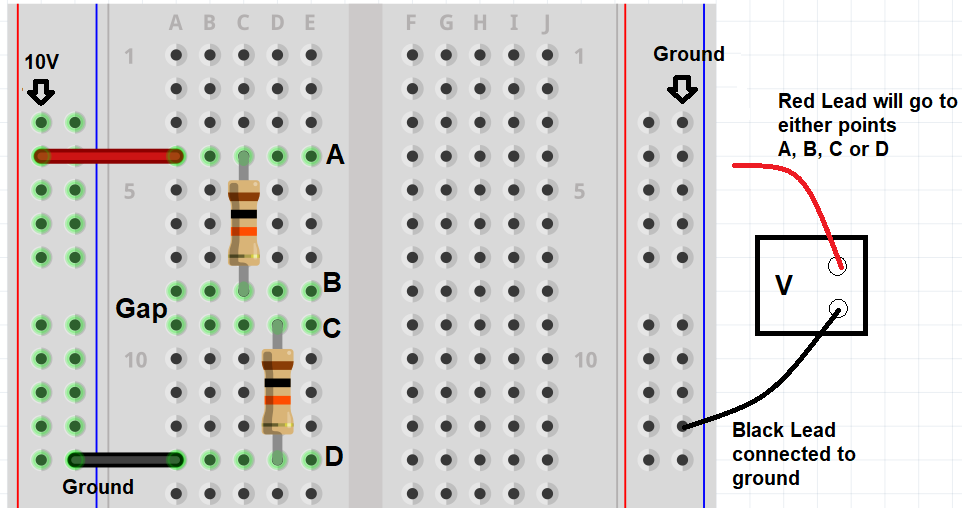
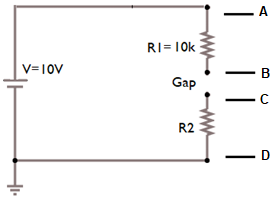
Use a value of 10 k ohms for R1 and 5k ohms for R2. Set the power supply to 10 Volts. Measure the electrical potential at the indicated points in the circuit and record the values.



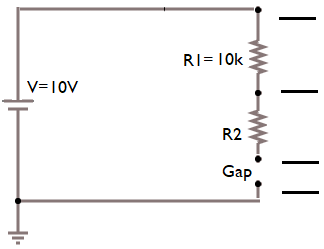
*Figure 7: Measuring Electric Potential*

**Measuring Electric Potential in Open Circuits**

Create a gap in the circuit above as shown below and measure the potential at the indicated points and record the values. Make sure that the power supply is set to 10 V.

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*Figure 8: Measuring electric potential in open circuits*



*Figure 9: Measuring electric potential in open circuits*

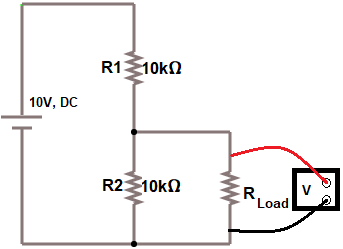
**Activity 4 - Voltage Droop (Optional)**

With a well defined ability to deliver known voltages, Vout , across R2 you can build a voltage divider to run, say a 5 V motor, from your 10 V source. We call the device you want to run the load and specify it as RLoad. Let's model RLoad as a 100 K-ohm device first and then as a 10 K-ohm device and then see what happens to our well designed voltage that we wanted.

1.First, what should Vout be according to our formula?

2. Construct the circuit below. First wire up a circuit with a 100 k load and measure Vout across that load and record this value in the table. Next, replace the 100 k load with a 10 k load, measure Vout across this load, and record.

|  |  |  |
| --- | --- | --- |
| Vin | RLoad | Vout |
| 10 V | 100 k |  |
| 10 V | 10 k |  |



*Figure 10: Voltage Divider with a Load*

**Question:** How does Vout with a load compare with Vout with no load in the circuit? Does the resistance of that load make a difference with respect to Vout?

Comment: As you should see, some loads cause Vout to drop, this voltage drop is called *droop* due to the load. **IMPORTANT:** Unplug all of the equipment before you leave. Wipe down the plastic surfaces with a paper towel and some alcohol. Put all of the electronic components away, put breadboards, and multimeters in the appropiate drawers.