Lab 1: Voltage, Current, and Resistors

Note: This first lab has a number (maybe *too large* a number) of little experiments. Don't worry if you are unable to complete all of them today.

1 Multimeters: Resistance

(a) The color code chart for resistors is available on your bench. You probably won't memorize the whole code, but you should remember the meaning of the third (multiplier) band: brown resistors are in the $100\,\Omega$ range, red resistors are in the $k\Omega$ range, orange in the $10\,k\Omega$ range, and yellow in the $100\,k\Omega$ range. Typical resistors are rated for $1/4\,W$ ($= 0.25\,W = 250\,mW$).

What is the smallest $1/4\,W$ resistor that can safely drop $5\,V$, and what is its color code?

(b) Read the three loose resistors on the sticky note on your bench by color and write down their values. For each resistor, which is rated for $250\,mW$, what is the maximum voltage you can place across it before it will get dangerously hot?

Color code	Resistance Value	Power rating	Max safe voltage
		250 mW	
		250 mW	
		250 mW	

(c) Using a multimeter, measure the resistance values (you will have to attach appropriate leads).

Do they agree with the nominal values within $\pm 5\%$?

(d) How does the multimeter measure resistance? (Hint: note that the leads are connected the same way as for a voltage measurement.)

Under what conditions will this measurement fail?

(e) Switch to the continuity-check mode of the multimeter by moving the dial to the diode symbol. This is an arrow with a bar at the end.

Use the continuity-check mode to draw a diagram of the connections inside the breadboard (use the separate empty strip for this). Which rows and columns are connected? Check your diagram with the lab staff.

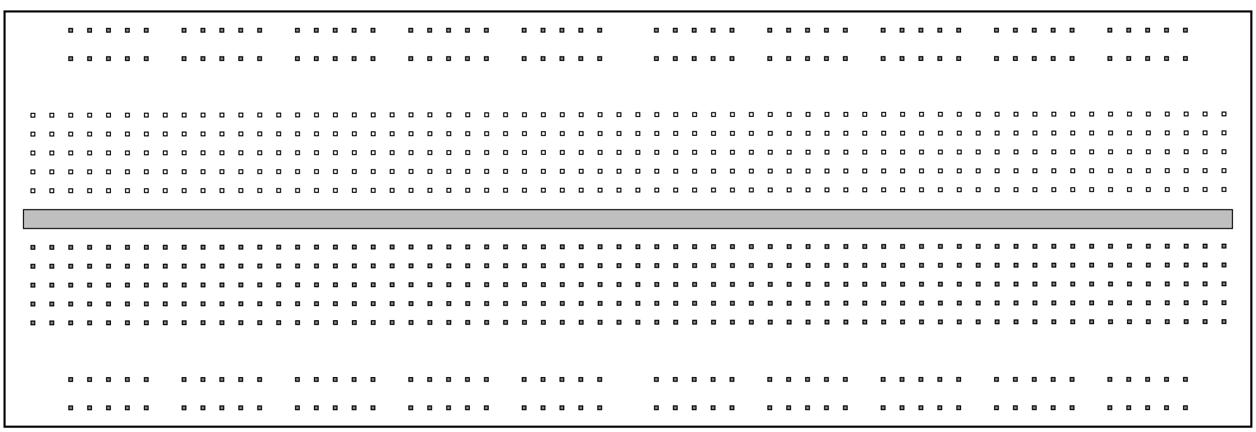


Figure 1: Draw the internal connections on this empty "solderless breadboard."

2 Reading Circuits

(a) Determine why two of the light bulbs do not light when the protoboard is switched on. You can use the multimeter, but make your investigation non-destructive (i.e., don't disconnect the circuit).

Bulb 2:

Bulb 3:

(b) Draw a full diagram of the circuit including what you have learned, then check it with one of the lab staff.

3 Multimeters: Current

(a) Explain why an ideal current meter has no resistance, while an ideal voltage meter has infinite resistance.

(b) Use a second DMM to measure the resistance of a DMM when set on its 2 mA (2000 μA) dc current range.

What would the voltage drop across the DMM be, if a "full-scale" current (i.e., 2 mA) were flowing through it? (this is known as the "voltage burden.")

(c) Hypothetically — *DON'T TRY IT!!* — What would happen if the DMM, set to measure current, were connected from $+5\,\mathrm{V}$ to ground?

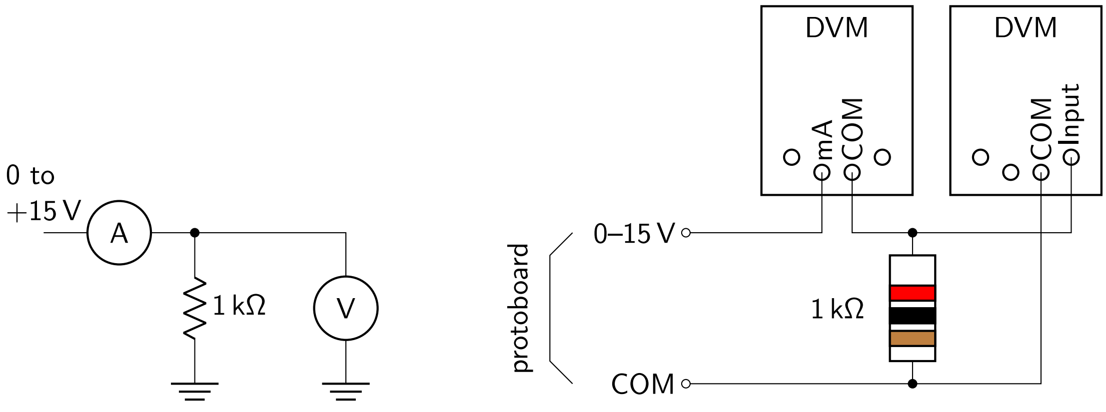
(d) Remove bulb 1 from the circuit, measure its resistance with the DMM, then predict the current through it when the circuit is powered. Reconnect bulb 1.

(e) Draw how you will connect the multimeter as a current meter to measure the current through bulb 1, then check this with the lab staff before proceeding to make the measurement.

(f) Measure the current through bulb 1. Did your measurement match your prediction? Why or why not?

4 Ohm's Law

(a) Rig up the circuit shown in Figure 2, using a pair of DMMs so that you can measure both voltage and current at the same time. Then, using the variable positive supply voltage (yellow wired, top rail) to drive the circuit, plot a set of measurements of current versus voltage on the handy graph paper of Figure 3.



A. (schematic) B. (pictorial)

Figure 2: Simple circuit to learn about voltage, current, multimeters, and Ohm's law.

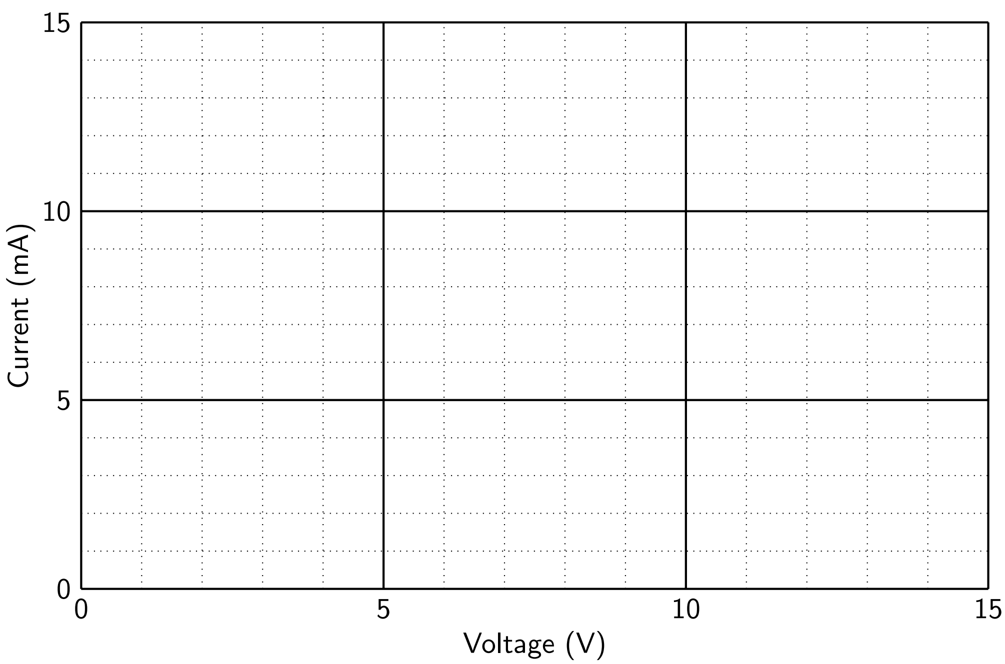


Figure 3: Graph paper for 1 kΩ resistor measurements.

(b) What would be wrong if you put the current meter on the low side of the resistor, as in Figure 4 below?

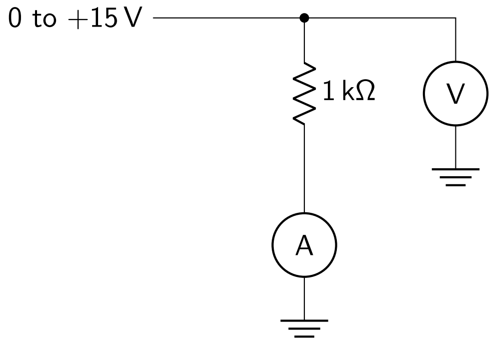


Figure 4: What's wrong with this innocent variation on the circuit of Fig. 2?

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5 A Nonlinear Device: Light Bulb

The light bulb in measurement 3 behaved "non-Ohmic," and here we'll explore this a bit more.

(a) Rig up a 10 kΩ pot (potentiometer) as shown in Figure 5A.

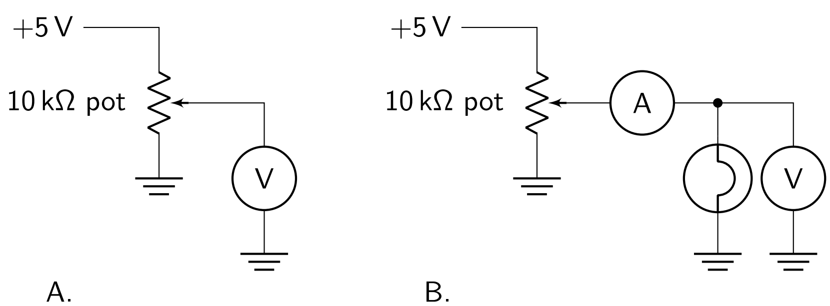

Figure 5: A. Potentiometer ("pot") used as variable voltage divider. B. Circuit to investigate I vs V of a small incandescent bulb.

Be careful not to connect the center wire to either +5 V or to ground! Explain why not.

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(b) Turn the power on, and satisfy yourself that it lets you create a voltage between 0 and 5 V.

(c) Now rig up the circuit of Figure 5B, and plot a set of measurements of current versus voltage on the custom graph paper of Figure 6.

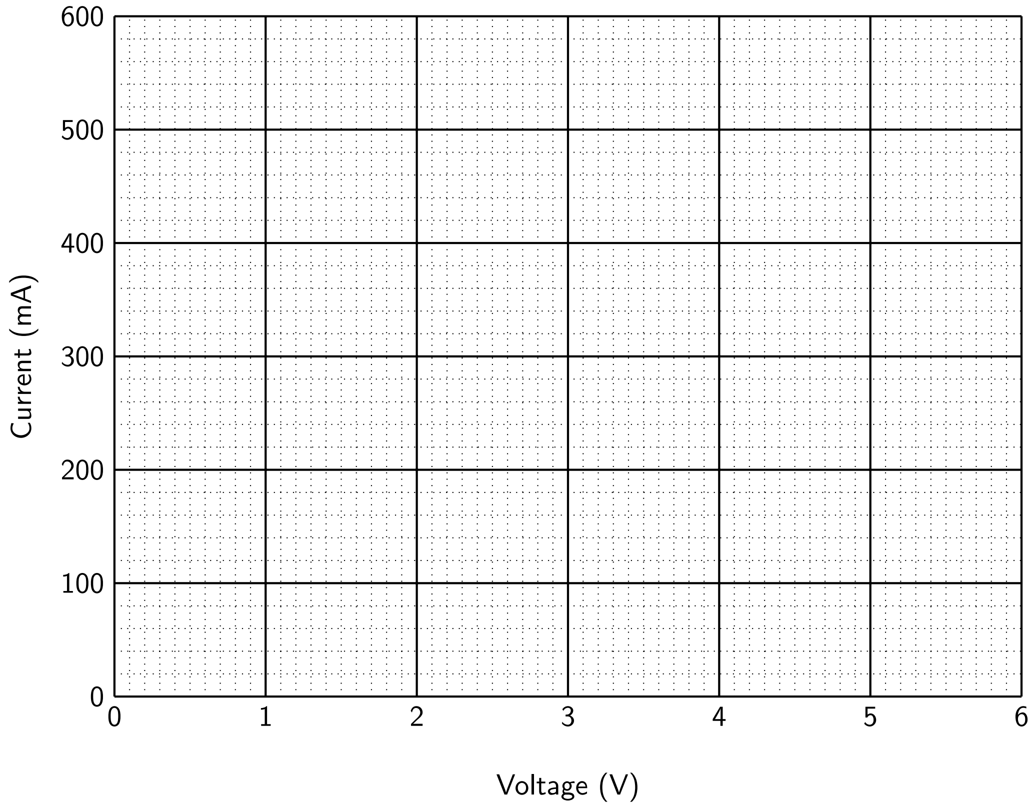

Figure 6: Graph paper for 5 V bulb I vs V measurements.

6 Time Permitting: An Important Nonlinear Device: The Diode

We don't use light bulbs much anymore (LEDs have taken over the job of making light), but we *do* use a 2-terminal device called a *diode*. The ideal diode is an electronic "one-way valve" — it conducts in one direction, but not the other way around. Now that you've got a low-voltage I vs V tester working, let's see what a diode does.

(a) Replace the bulb in your Figure 5B with a diode, and (important!) add a $100\,\Omega$ resistor in series; thus the circuit of Figure 7.

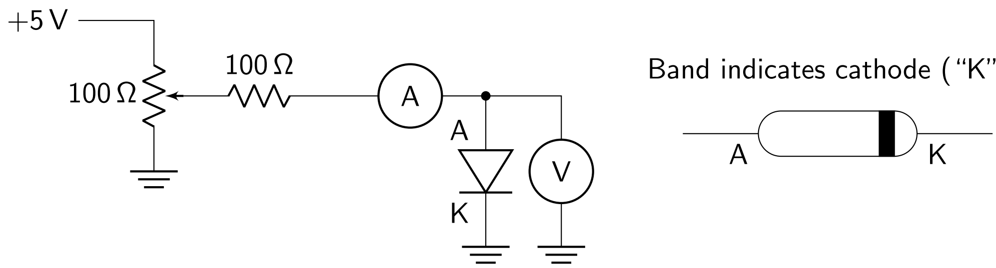

Figure 7: Circuit to investigate I vs V of a diode.

(b) Before you turn on the juice, explain why the resistor is needed, and check with lab staff.

(c) Now power the circuit and plot I vs V on the custom graph paper of Figure 8.

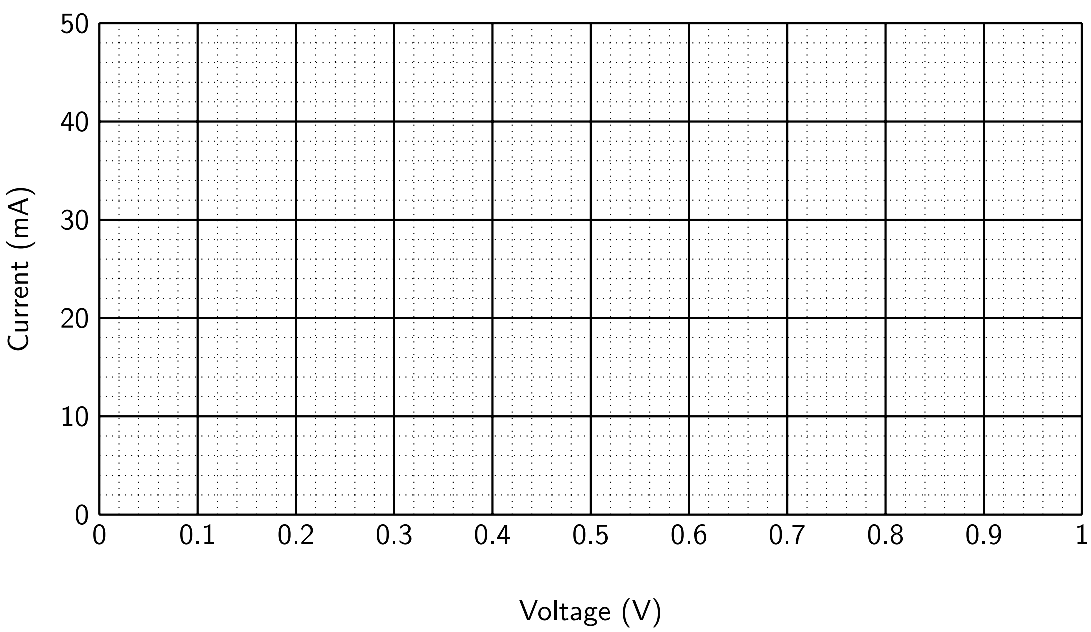

Figure 8: Graph paper for diode I vs V measurements.

(d) In the region 0 V to 0.4 V, does the diode behave like a very small or a very large resistor? What about in the region 0.6 V–0.8 V?

(e) Now reverse the diode and observe I vs V.