

Using a Multimeter

The multimeter can measure voltage, current, and resistance. You insert the leads into the meter in different ways depending on what you want to measure. In all cases, you put the black lead in the jack marked “COM” (because it is “common” to all three measurements, I suppose). The jack you use for the red lead depends on whether you want to measure voltage or resistance (in which case you put the red lead in the jack marked “V/ Ω ”) or current (in which case you put the red lead in the jack marked “A”). There are also other differences in how you use the multimeter, depending on whether you want to measure voltage, current, or resistance.

Equipment Needed

1. a multimeter
2. a battery
3. lab bench voltage supply
4. a resistor
5. 2 wires with banana plug ends

1 Measuring Voltage

1. Plug the black and red leads into the meter in the way appropriate for measuring voltage (black in “COM”, red in “V/ Ω ”).
2. Set the dial on the meter. If you want to measure DC voltage (like that provided by a battery), use one of the settings in the group marked “DCV”. If you want to measure AC voltage (like that provided by a

wall outlet), use one of the settings in the group marked “ACV”. In either case, pick the lowest setting that will be higher than the voltage you expect to measure (for example, if you expect to measure about 12 V, pick the 20 V setting). If you have no idea what the voltage will be, pick the largest setting. You can lower it later if you need to.

- Practice by measuring the voltage of a battery. Connect the red lead to the protruding end of the battery (the top) and the black lead to the recessed end (the bottom). Record this voltage along with the setting of the dial that you used.

Battery voltage	
Multimeter setting	

- What happens if you use a dial setting that is too low? Try it and write down what happens below.

- What happens if you use a dial setting that is too high? Try it and

write down what happens below.

6. Go back to the correct setting now and reverse the leads (black lead to battery top, red to battery bottom). Record the result below.

Battery voltage (leads reversed)	
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7. You can measure the voltage across any circuit element (battery, resistor, capacitor) by touching the leads to either side of that circuit element. If you get a positive result, the electric potential is higher on the side with the red lead. If you get a negative result, the electric potential is higher on the side with the black lead.

Usually, you will measure the voltage across a circuit element in a circuit that is “live” (has current flowing). If the currents and voltages are low (like with batteries), there is no danger in touching the wires and exposed metal of the meter leads. Even so, it’s best to avoid doing this, since your body has some resistance and can mess up a sensitive measurement.

Caution: If the voltages are high (like with a wall outlet of 120 V), do NOT touch the exposed metal portions of the meter leads. You can get an electric shock.

8. As another example, we will measure the voltage produced by the 0–16 V DC supply at the end of the lab bench. Put the red lead of the

meter in the red supply jack and the black lead of the meter in the black supply jack. You can use the knob to control the supply voltage. Turn the knob to achieve a voltage as close to 6 V as possible. Record the voltage you measure below.

Voltage from DC supply	
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We will use this voltage to supply a circuit later on.

9. What setting would you use to measure the voltage of a wall outlet? (Remember, the wall outlet is AC voltage.) Try it. Keep your hands away from the exposed metal.

Multimeter setting	
Wall outlet voltage	

2 Measuring Resistance

1. Plug the black and red leads into the meter in the way appropriate for measuring resistance (black in “COM”, red in “V/ Ω ”).
2. Set the dial on the meter. Use one of the settings in the group marked “OHM”. Pick the lowest setting that will be higher than the resistance you expect to measure (for example, if you expect to measure about 470 Ω , pick the 2 K setting). If you have no idea what the resistance will be, pick the largest setting. You can lower it later if you need to.
3. Practice by measuring the resistance of a resistor. Connect one end of the resistor to the red lead of the meter and the other end to the black lead.

Resistance (measured)	
Multimeter setting	

4. Compare by reading the stripes on the resistor to determine its resistance.

Resistance (from stripes)	
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5. When measuring resistance, it doesn't matter which end gets the red lead and which gets the black lead. Confirm this by reversing the leads.

3 Measuring Current

Electric current is the flow of electric charge. We measure current in Amperes (or Amps, abbreviated "A"). An Ampere is a Coulomb per second. Electric current can arise from the flow of negative charge or the flow of positive charge. In most situations, negative charge flowing in one direction has the same effect as positive charge flowing in the opposite direction. For this reason, we follow a convention in describing electric current. We define the direction of electric current to be the direction that positive charge would flow if it were creating the current. So, if positive charges really are flowing, then the direction of the electric current is the same as the direction of motion of the positive charges. On the other hand, if negative charges are flowing, then the direction of the electric current is the opposite of the direction of motion of the negative charges.

1. Before we can measure electric current, we must have a circuit in which current is flowing. A circuit is made of circuit elements (things like voltage sources, batteries, and capacitors) connected by wires. The symbols for some circuit elements are given in Table 1.

We will build the circuit shown in Figure 1. To build this circuit, we will use the DC supply at the end of the lab bench (the approximately 6 V we measured earlier) and the resistor from the previous section. Connect the high potential (red) side of the DC supply to the resistor with a wire. We will call this Wire A. Connect the low potential (black) side of the DC supply to the other end of the resistor with a second wire, which we will call Wire B. The resistor does not have an orientation, so it does not matter which side of the resistor gets connected to the high potential side of the DC supply.

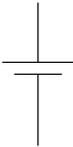
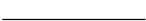
	<p>Battery or DC Voltage Source. The long bar is the high potential, or positive side of the battery.</p>
	<p>Wire</p>
	<p>Resistor</p>

Table 1: Symbols for some circuit elements.

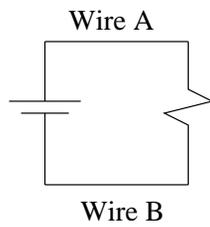


Figure 1: A simple circuit.

2. Plug the black and red leads into the meter in the way appropriate for measuring current (black in “COM”, red in “A”).
3. Set the dial on the meter. If you want to measure DC current (like that provided by a battery), use one of the settings in the group marked “DCA”. If you want to measure AC current (like that provided by a wall outlet), use one of the settings in the group marked “ACA”. In either case, pick the lowest setting that will be higher than the current you expect to measure (for example, if you expect to measure about 200 mA, pick the 2 A setting). If you have no idea what the current will be, pick the largest setting. You can lower it later if you need to.

Important: Please try to connect the multimeter to the circuit correctly when measuring current. If you connect it incorrectly, you will likely blow the fuse inside the multimeter. The fuses are an irritation to replace. So, when measuring current, it is best to connect all of the wires with the multimeter turned off and have your professor or your teaching assistant check your wiring before turning the meter on.

4. Now we will measure the current through Wire A. We do this by *replacing* Wire A with the current meter, as shown in Figure 2. Remove Wire A, connect the red lead of the current meter to the high potential side of the DC supply, and connect the black lead of the current meter to the resistor. The current meter is doing the job that Wire A did before, namely allowing current to flow from the DC supply to the resistor. The only difference is that the current meter is a “smart” wire that detects how much current is flowing through it.

Record your measurement of current through Wire A.

Current through Wire A	
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5. Reverse the leads of the current meter, connecting the black lead of the current meter to the high potential side of the DC supply, and the red lead of the current meter to the resistor. Again record your measurement of current through Wire A.

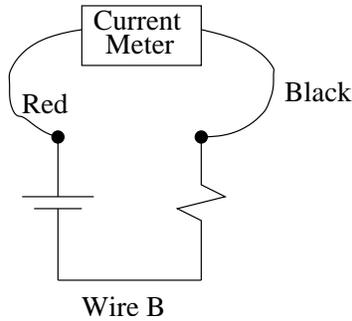


Figure 2: To measure the current through Wire A, *replace* Wire A with the current meter.

Current through Wire A (leads reversed)	
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The current meter can tell you which way the current is flowing, as well as how much current is flowing. The current meter will show a positive number if current is flowing in through the red lead and out through the black lead.

- Next we will measure the current through Wire B. We do this by *replacing* Wire B with the current meter, as shown in Figure 3. The current meter is doing the job that Wire B did before, namely allowing current to flow from the resistor back to the DC supply. The only difference is that the current meter is a “smart” wire that detects how much current is flowing through it.

Record your measurement of current through Wire B.

Current through Wire B	
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- Draw arrows on the circuit diagram in Figure 4 to indicate the direction in which current is flowing through Wire A and through Wire B.
- In light of your measurements of current through Wire A and Wire B, do you think that current is used up by the resistor? Give some reasoning for your answer.

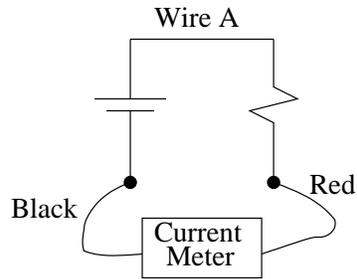


Figure 3: To measure the current through Wire B, *replace* Wire B with the current meter.

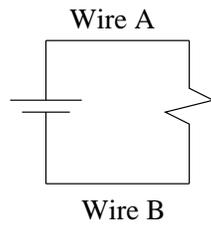


Figure 4: Simple circuit. Indicate the direction in which current is flowing through Wire A, through Wire B, and through the resistor.

9. How much current do you think flows through the resistor? Give some reasoning for your answer.

10. Draw an arrow on the circuit diagram in Figure 4 to indicate the direction in which current is flowing through the resistor.

4 Measuring Voltage in a Circuit

1. When we measured voltage earlier, we measured the voltage of a battery. We can also measure the voltage across circuit elements (batteries, resistors, capacitors, etc.) that are in a live circuit. Suppose you have already set up a circuit that has current flowing. To measure the voltage across a circuit element, first set the multimeter for measuring voltage (red and black leads in the correct places). Then, place the multimeter leads on either side of the circuit element that you wish to know the voltage across. (We say that the multimeter is *in parallel* with the circuit element across which we are measuring the voltage.) Note how this is different from measuring current.

Measure the voltage across the resistor in the circuit from the previous section. Record the measured value below. On the circuit diagram in Figure 5, indicate which side of the resistor had a higher electric potential by writing “high” on that side. Write “low” by the side of the resistor that had a lower electric potential.

Voltage across resistor	
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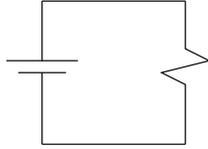


Figure 5: Simple circuit. Indicate which side of the resistor had a higher electric potential and which side of the DC supply had a higher electric potential.

2. Measure the voltage across the DC supply in the circuit. Record the measured value below. On the circuit diagram in Figure 5, indicate which side of the DC supply had a higher electric potential by writing “high” on that side. Write “low” by the side of the DC supply that had a lower electric potential.

Voltage across DC supply	
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5 Voltage and Current in a Resistor

In this section, we want explore the relationship between the voltage *across* a resistor and the current that flows *through* the resistor. We have already discussed how to measure the voltage across a resistor in a circuit, and we have hinted about how to measure the current through a resistor in a circuit. For the measurements in this section, it will be convenient (although not absolutely essential) to use two multimeters—one to measure voltage and the other to measure current.

Let us review how to measure current through a resistor. Find a wire in the circuit that carries the same current that flows through the resistor. *Replace* that wire with the meter, and the meter will tell you how much current is flowing through it (and consequently how much current was flowing through the wire that you removed). We say that the multimeter is *in series* with the circuit element through which we are measuring the current.

Important: Please ask your instructor *before* connecting your meter to your circuit if you are not absolutely sure about connecting your meter properly to measure current. It takes time to

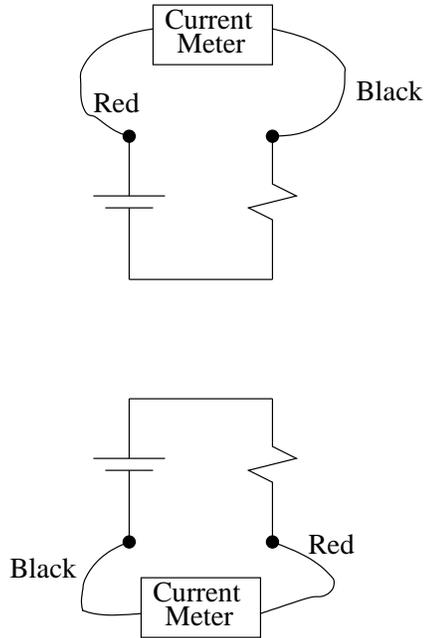
replace the fuses in the multimeter that blow when the meter is connected incorrectly. This would be an unnecessary delay and irritation for all of us. So, in the interest of general happiness and good cheer, please ask before you connect, or connect with the meter off and ask before you turn the meter on.

Figure 6 shows examples of correct and incorrect ways to use the current meter to measure the current flowing through the resistor. In both of the correct ways, we put the current meter *in series with* the resistor.

1. Using one of the “correct” methods, measure the current through the resistor for various values of DC supply voltage.

DC supply voltage	Voltage across resistor	Current through resistor
1 V		
2 V		
3 V		
4 V		
5 V		
6 V		
7 V		
8 V		
9 V		
10 V		

Right ways



Wrong ways

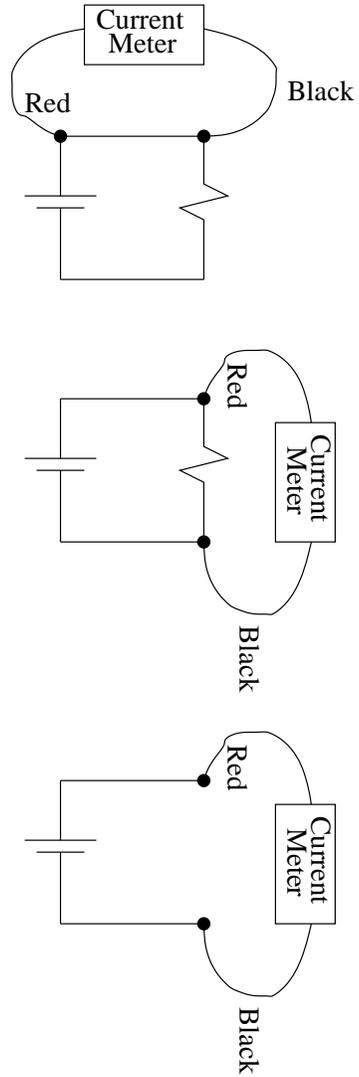
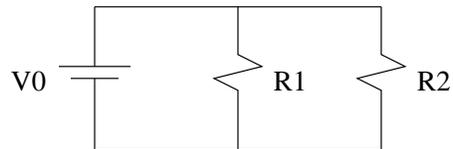


Figure 6: Correct and incorrect ways to measure current through the resistor. The correct way is to put the current meter *in series with* the resistor.

2. What can you say about the relationship between the voltage across a resistor and the current through the resistor?

6 Questions



1. Consider the circuit pictured above. Draw a picture showing how you would connect the multimeter to measure the voltage across resistor R_1 .

2. Draw a picture showing how you would connect the multimeter to measure the current through resistor R1.