Single Battery and Resistor Circuits

Consider a simple circuit made by connecting a resistor to the terminals of a battery. Figure 1 shows three equivalent graphical representations. The physical model on the far left of Figure 1 is an approximation of what the battery, wires and resistors would look if you held them in your hand. The middle image in Figure 1 is a schematic representation of the loop in the physical model. The breadboard model on the far right of Figure 1 represents the same circuit with a more compact notation. Figure 2 identifies the components in the loop and breadboard schematics. Figure 3 adds the current flow direction to the loop and breadboard schematics.

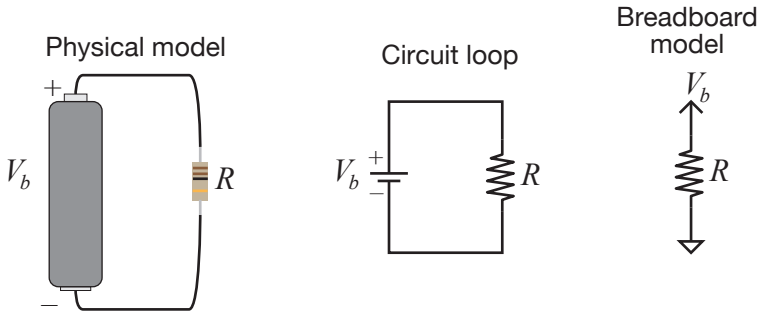

Figure 1 Three representations of a battery connected in series with a resistor

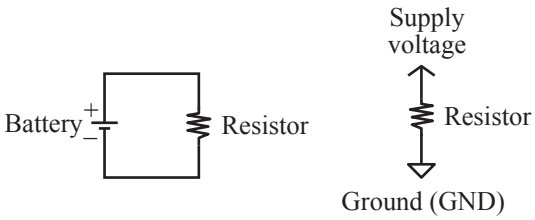

Figure 2 Symbols used in loop and breadboard schematics

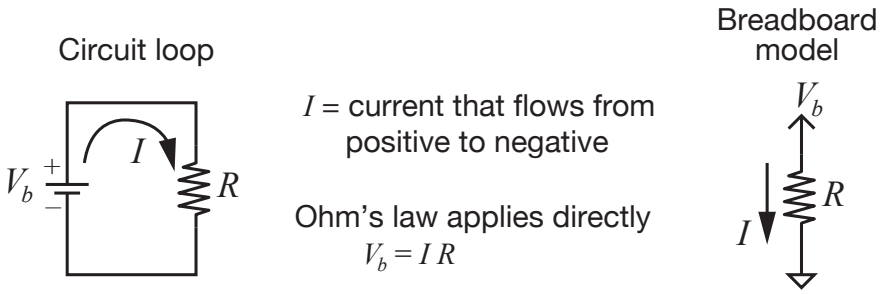

Figure 3 Current flows around the loop. Equivalently, the current flows from the voltage source, V_b, to the ground.

Two Batteries in Series

When two batteries are connected in series, their voltages add. Figure 4 shows three representations of a circuit with two batteries in series. Note that in the circuit loop and breadboard schematics, the equivalent voltage is $2V_b$, in other words, twice the voltage of a single battery.

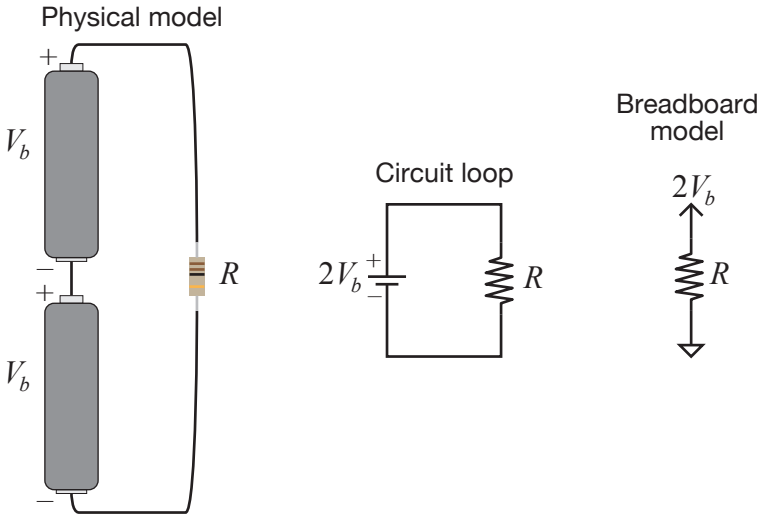

Figure 4 Physical and schematic representations of a simple circuit having its power supplied by two batteries in series.

In-class exercise

1. In the space below, write the expression for Ohm's law that applies to the circuits in Figure 3.

2. If the value of V_b is the same for the circuits in Figure 1 and Figure 4, …
   a. the current for the circuit in Figure 4 is same as the current for the circuit in Figure 1.
   b. the current for the circuit in Figure 4 is less than the current for the circuit in Figure 1.
   c. the current for the circuit in Figure 4 is greater than the current for the circuit in Figure 1.

3. Use formulas to justify your answer to the preceding question.

Two Batteries in Parallel

When two batteries are connected in parallel, as in Figure 5, the voltages across the terminals must be the same. One way to think about the parallel connection is to realize that the wires connecting the positive terminals have to have the same voltage because the wires between them have zero resistance. The same applies to the wires connecting the negative terminals.

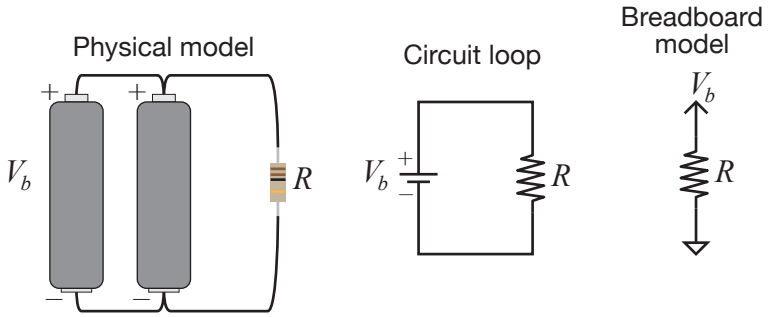

Figure 5 Physical and schematic representations of a simple circuit having its power supplied by two batteries in parallel.

In-class exercise

1. In the space below, write the expression for Ohm's law that applies to the circuits in Figure 5.

2. If the value of V_b is the same for the circuits in Figure 1 and Figure 5, …
   a. the current for the circuit in Figure 5 is same as the current for the circuit in Figure 1.
   b. the current for the circuit in Figure 5 is less than the current for the circuit in Figure 1.
   c. the current for the circuit in Figure 5 is greater than the current for the circuit in Figure 1.

3. Use formulas to justify your answer to the preceding question.

4. In what way does the circuit in Figure 5 behave differently that the circuit in Figure 1?