

Direction of Current Flow

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In the first lesson titled “Electricity” there is a section on the direction of current flow. You should first review that section before continuing with this lesson.

In a later lesson we will study alternating current (AC). For now you should just remember that alternating current changes direction of current flow. For example, the AC supplied to your house by the electric company is 60 cycles, which means it changes direction of flow 120 times each second. In this lesson we will be concerned only with direct current (DC), which does not alternate in direction of flow.

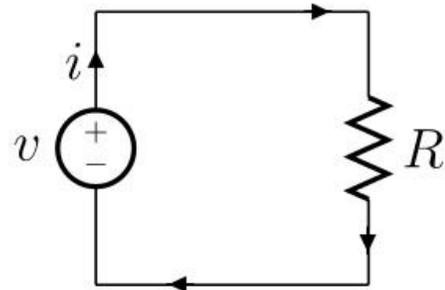


Figure 1 schematic of a simple circuit with current flow direction marked

Figure 1 is a schematic drawing of a simple circuit with a power source (marked with a v) and a load (a

resistor marked R). Notice that the power source is marked with plus and minus signs, indicating the polarity of the source. Also remember that current flows from the positive pole of the source, through the circuit, to the negative pole of the source. The schematic in Figure 1 indicates the direction of current flow with arrows and includes the letter (i) next to one of the arrows. We have said before that v represents voltage (*i.e.* power source),

but have not said anything before about the letter (i), which represents the current of the circuit.

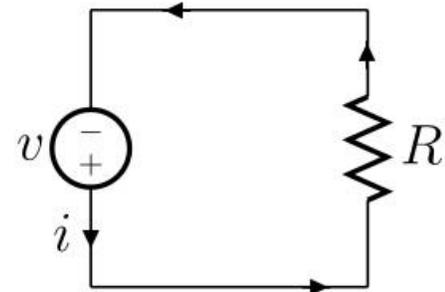
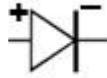


Figure 2 schematic of a simple circuit with current flow in the opposite direction

In Figure 2 the polarity of the power source has been inverted (the plus is now at the bottom). This change in the way we connect the power source to the circuit results in a change of direction of the current flow. However, this should not be confused with alternating current. A circuit powered by direct current flows only in one direction. The direction changes only if we connect the wires differently to the power source. In contrast, AC current changes direction many times each second without any change in the connection of the wires to the power source.

In the activities for this lesson you will be exploring direction of current flow using a light emitting diode (LED) and a DC motor. You will learn more about LEDs in another lesson. For now I will provide a brief description. A diode is a semiconductor that allows current flow only in one direction. When current flows through an LED, it gives off light (thus the name light emitting diode). We can use this property of an LED to visually determine the direction of current flow in a circuit. If we connect the LED to the power source with the proper polarity, then current will flow and the LED will glow. However, when we

reverse the wire connections to a battery, current will not flow through the LED and it will not glow. Therefore, we can use an LED to determine the direction of current flow.



This is the symbol for a diode . It is an arrow and a line perpendicular to the wire line. I have added plus and minus signs so that you will know how the diode should be connected to a battery to allow current to flow. The arrow part of the symbol represents the direction of allowed current flow. The perpendicular line can be thought of as a block to current flow. Current flowing in the direction opposite the arrow is blocked by the diode. The plus side of the diode is named the **anode** and the minus side is the **cathode**. To make it easy to identify the anode and cathode of the LED you will use, I have attached a red wire to the anode and a black wire to the cathode. In DC circuits it is common to use the color red for wires that connect to the positive terminal of the power source and black for wires that connect to the negative terminal of the power source.

LEDs have some peculiar properties that we must account for if we want to use them properly in a circuit. The red LED that you will use requires about 2.0 volts to operate properly. Now here we have a problem in our circuit board because our battery supply includes two voltages: 1.5 and 3.0. The 1.5 volts is not enough to make the LED glow, even if connected properly to the battery. On the other hand, the 3.0 volts causes a current flow of about 88 milliamps through the LED. That is also a problem because this particular LED is rated for a maximum continuous current of 30 milliamps. If we run the LED on 3.0 volts, it will burn out (my testing showed that it will survive for 10 minutes, but it will still burn out much sooner than the expected life of the LED).

In order to protect the LED, I have included a resistor on your circuit board. The resistor reduces the voltage that is applied to the LED to a safe level. The resistor and LED are already connected in series on the circuit board (the cathode of the LED is connected to one side of the resistor). All you need to do is connect one battery wire to the red LED wire and the other battery wire to the open end of the resistor. The current must flow through the LED and resistor in series in order for the resistor to protect the LED. Here is an example of a good reason for applying a series circuit in an electronics design.

In the previous lesson on switches you learned that a DC motor can be made to spin clockwise or counterclockwise, depending on the direction of current flow through the motor. In this lesson you will use a DC motor to explore the direction of current flow. Without knowing the exact design of the interior of the motor, it is not possible to predict which direction the current must flow to make the motor turn in a particular direction. However, by reversing the wire connections to the motor you can see that the motor turns in the opposite direction.

(your activities begin on the next page)

Module 1, Activity C – Direction of Flow

Turn to page 65 in your Robotics Notebook. In this activity you will complete steps one and two. However, you will be using a circuit board for the activities and should follow the directions below instead of the directions for steps one and two in the notebook.

Step 1 – build a circuit with the battery pack of your circuit board and a DC motor. The DC motor provided is the exact kind that you will use to build your line following robot. You will notice that the two wires connected to the motor have different colors (green and black). The colors are not meant to indicate the positive and negative terminals of the motor. However, the different colors allow you to easily record in your notebook exactly how the motor was connected to the battery pack. The battery pack has two red wires and one black wire. The red wires connect to the plus side of the batteries and the black wire to the minus. One red wire provides 3.0 volts, the other red wire provides 1.5 volts.

It is time now to connect the battery wires to the motor wires. Make sure that you do not create a short circuit. All electrical current must flow through the motor. There must not be a path from the plus side to the minus side of the battery that contains only wires. When the motor begins to rotate, record in your notebook the direction of rotation (clockwise or counterclockwise). Also record in your notebook the way you connected the battery wires to the motor wires (which color motor wire is connected to which color battery wire). You should also try applying 1.5 and 3.0 volts to the motor. Do the different voltages result in different rotation speeds? If so, which voltage results in faster rotation of the motor? Record your observations in your notebook. Now experiment to see if you can make the motor rotate in the opposite direction. Record in your notebook the wire connections required to reverse the rotation direction.

Step 2 – using the 3 volt red wire and black wire from the battery pack, connect one to the red wire of the LED and the other wire to the open end of the resistor. Record in your notebook how you made the connections (where did you connect each battery wire). Is the LED glowing? Record your observation in your notebook. Now exchange the two battery wire connections. Is the LED glowing? Record your observations in your notebook. Try the same experiment now using one light bulb to compare results with the LED. Does the light bulb respond differently to the connections you tried, compared to the LED? Record your observations in your notebook.

Module 1, Activity D – Forward and Reverse Design Team

Turn to page 66 of your notebook. Read the design challenge. In this case you already have a DPDT switch on the circuit board so you do not need to design the switch. However, you must design the wiring to use with the switch. Draw the battery pack, switch, motor and the wiring in the space provided on page 66. This will be your design. Engineers make a design first before they actually build a test circuit (test circuit = prototype). You are doing the same thing in this activity.

Module 1, Activity E – Forward and Reverse Build Team

Turn to page 67 of your notebook. Using your design from Activity D, connect the wiring to the DPDT switch, battery pack and the motor. The switch should be in the open position while you are completing the wiring. Make sure you avoid creating a short circuit. Before closing the switch, have your advisor check your design. After your design is checked, test your circuit. Can you change the direction of rotation of the motor with just one switch motion? Record your observations on page 67 of your notebook. If your circuit does not operate properly, try to determine why. Try rewiring the circuit if you find an error. Record your activity in the notebook. Answer the questions on page 67 of your notebook (ignore the question about the Es-Car Go or Sea Hunt ROV).