Switches & Motors

Overview: When you turn on a switch, it's difficult to really see what's going on. So you're going to make your own from paperclips, brass fasteners, and index cards. And you get to play with real motors, too.

What to Learn: Think of this switch like a train track. When you throw the switches one way, the train (electrons) can race around the track at top speed. When you turn the switch to the OFF position, it's like a bridge collapse for the train – there's no way for the electrons to jump across from the brass fastener to the paper clip. When you switch it to the ON position (both sides), you've rebuilt the bridges for the train (electrons).

Materials

- 2 AA batteries
- AA battery case
- 2 alligator wires
- 1.5-3V DC hobby motor
- 1 index card
- 2 brass fasteners
- 1 large paperclip
- propeller or piece of tape for the motor shaft

You decide if you want to complete Part 3. If that's the case, you'll also find these items set out for you:

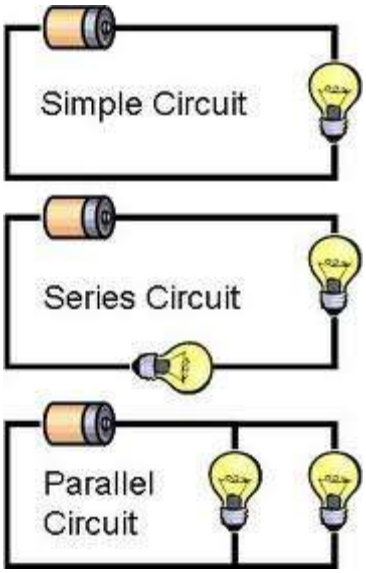
- 6 brass fasteners
- 1 index card
- 2 large paper clips
- 6 alligator clip lead wires

Lab Time

1. Today, we're going to learn how to turn a *motor* on and off by controlling when the electricity goes through the circuit by using a switch. The motors we're using are one of those special electrical components which are not polarized, meaning if you stick it in backward; it will still run… but backward.
2. SPST stands for Single Pole Single Throw, which means that the switch turns on only one circuit at a time. When the switch is engaged, current flows. When it's not, the circuit is broken open and electricity stops. SPST stands for Single Pole, Single Throw, which means that the switch turns on only one circuit at a time. This is a great switch for turning one motor on and off.
3. DPDT stands for Double Pole Double Throw, and you need this kind of switch to handle the circuitry required to make a motor go in reverse. That's in Part 3 of this experiment.
4. There are three different parts to this experiment – you'll be doing Parts 1 & 2 for sure, but Part 3 is totally optional.

Lab Time

Part 1: Making a motor turn.



1. Grab hold of your materials and make the motor turn on. Do you see those two little terminals on the back of the motor? That's where you hook up the alligator wires. It's just like lighting up an LED, only instead of wires, there are tabs.
2. Since these motors spin quickly and the shaft is tiny, add a piece of tape (unless you're using propellers) to the shaft to see the spinning action more clearly.
3. Can you make your motor go in reverse? (Hint: remember the waterwheel?)
4. Can you hook up both the LED and motor at the same time?

Part 2: Switching the motor on and off using a switch. Follow your instructor through these steps:

1. Making the SPST switch:
    a. Open the paperclip into a V-shape.
    b. Stick the brass fastener through the paperclip and through the index card, making sure the smaller loop of the paperclip is on the bottom.
    c. Open the brass fastener up on the other side.
    d. Measure where the second brass fastener needs to go in order to miss the lower loop but hit the larger loop when the paper clip is pressed. Insert the brass fastener at the mark and open it up on the other side. The paper clip should not be touching the second brass fastener yet.
    e. Make sure the brass fasteners aren't touching on the underside of the card, or you'll bypass the switch.
    f. Press down on the upper loop to be sure it touches the brass fastener, and springs back up when you let go. You've just made a NO (normally open) switch, meaning that the switch is open (no current flows) until it's activated. Now let's hook it up in a circuit.
2. Now remove one wire from the motor terminal and replace it with a third alligator wire like we did with the conductivity tester experiment, only this time it's a motor and not an LED. When you touch the two free ends, make sure the motor still runs.
3. Instead of having the alligator clip leads touching each other, connect each one to a brass fastener on the underside of the index card.
4. Press the switch – the motor should turn. Ta-daa!
5. Trace the path the electricity takes with their finger. What did you find out? Write it here:

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Part 3: Making the motor go forward and reverse using a single switch. Follow your instructor's directions:

1. Making the DPDT switch:
    a. We're going to put six brass fasteners on the card, three in each row. Insert the two middle brass fasteners first, each with their own paperclip attached. Open them up on the other side and tape them down on the underside so they are out of reach of other fasteners but can still be attached to alligator clip leads.
    b. Move both the paperclips up and mark the next location for the fasteners. Insert two fasteners, one on each side, and open them up on the underside of the card. Tape into place.
    c. Move the paperclips down and mark the last set of points for the last two fasteners. Insert fasteners, open up, and tape.
    d. Show the kids how to operate the switch and have them practice *before* wiring it up. Both paperclips up means forward, both down is reverse. No contact is off.
    e. Working on the underside of the card: use two alligator clips to make the "X." Connect one alligator clip to a corner (it doesn't matter which) and the other end connects to the fastener in the opposite diagonal corner. If you grab the stems that are peeking out of the tape, it's easier to connect to. Do this for both diagonals.
    f. Connect one alligator clip wire to the negative wire on the battery back and then to one of the middle brass fasteners.
    g. Connect one alligator clip wire to the positive wire on the battery back and then to the other middle brass fastener.
    h. Connect one alligator wire to each motor terminal (you should have two wires connected to your motor). Connect the other ends of the wires to two brass fasteners on one end of the switch (it doesn't matter which), but they must be on the same end.
    i. Test your motor and see how it works! If it doesn't work, remove all the wires and redo steps f-h. If you still have trouble, grab a new set of wires and see if this helps.
2. Trace the path the electricity takes with your finger. What did you find out? Write it here:

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Reading

Do you remember how the yardstick moved around in a circle using a balloon way back in Lesson #6: The Electrostatic Motor? Using static charge attraction, the yardstick followed the balloon around in a circle.

Imagine modifying the experiment so that there was a charged balloon physically attached to the end of the yardstick, so that you could use a positively charged object to attract and pull the yardstick toward you, and then just as the stick was close, you quickly switched to a negatively charged object to push the object away. That's how the electrostatic bottle motor worked in a previous experiment.

Now place those statically charged objects with magnets. You've got a magnet on something which can move in a circle, and another magnet you can flip North-South depending on where the rotating magnet is. That's how a motor works! We're going to actually build a motor using these principles when we get to electromagnetism, and we have to wait a bit before making one because we're going to make a magnet that we can turn on and off for that project, and there's a few more things we need to learn how to do first.

Remember the water analogy? Suppose you add in a valve so you can turn the water on and off through your pipe. What is the valve like in your circuit? It's just like a switch in a circuit, because it interrupts the flow of electricity. There are different kinds of switches, but they all do the same thing: allow you to control when electricity flows through the circuit.

Think of this switch like a train track. When you throw the switches one way, the train (electrons) can race around the track at top speed. When you turn the switch to the OFF position, it's like a bridge collapse for the train – there's no way for the electrons to jump across from the brass fastener to the paper clip. When you switch it to the ON position (both sides), you've rebuilt the bridges for the train (electrons).

Exercises

1. If you want to reverse the spin direction of a motor without using a switch, what can you do?
2. A simple switch can be made out of what kinds of materials?
3. How would you make your SPST switch an NC (normally closed) switch?
4. How did you have to connect your circuit in order for both the LED and motor to work at the same time? Draw it here:
5. Draw a picture of your experiment that explains how the SPST switch works, and show how electricity flows through your circuit:

Extra Credit (for students who have completed Part 3):

6. Draw a picture of your experiment that explains how the DPDT switch works in your circuit and show how to wire up the circuit.

Answers to Exercises: Switches & Motors

1. If you want to reverse the spin direction of a motor without using a switch, what can you do? (Switch the wires on the back of the motor.)
2. A simple switch can be made out of what kinds of materials? (You need to be able to control when it conducts and insulates. Take the two wires (one from the battery and the other from the motor) and touch them together – ON – OFF – ON – OFF. Simplest switch in the world! Air is the insulator and metal is the conductor. But you can also use index cards, paper clips, and brass fasteners.)
3. How would you make your SPST switch an NC (normally closed) switch? (Leave the paperclip in its normal shape (don't bend into a V) and touch the paperclip to the brass fastener. The motor will run until you move the paperclip away.)
4. How did you have to connect your circuit in order for both the LED and motor to work at the same time? (If they wire it up in series (plus to minus), they'll find it doesn't work. If they hook it up in parallel (plus to plus), then both will work with one battery pack.)
5. Draw a picture of your experiment that explains how the SPST switch works, and show how electricity flows through your circuit.

Extra Credit (for students who have completed Part 3):

6. Draw a picture of your experiment that explains how the DPDT switch works in your circuit and show how to wire up the circuit.