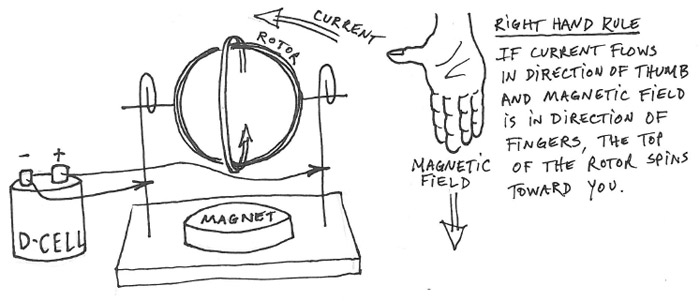
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| **[Electronics Fundamentals: DC Motor](http://www.jameco.com/Jameco/workshop/learning-center/build-dc-motor.html)**  [**Building a DC Motor**](http://www.jameco.com/Jameco/workshop/learning-center/build-dc-motor.html#anchor1) |  |

Providing motion to an electronic design is a key building block for many electronic designs. Motors of all kinds from [servo](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&freeText=servo%20motors&search_type=jamecoall) and [stepper](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&freeText=stepper%20motor&search_type=jamecoall) to hydraulic and pneumatic [motors](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&categoryName=cat_35&subCategoryName=Electromechanical%20%2F%20Motors&category=3515&refine=1&position=1&history=jg44jlow%7CsubCategoryName~Elec) are important fundamentals toward building an electronics education. 

**Background Theory:   
How Does a DC Motor Work?**

Building an electric motor introduces the student to the concept of electromagnetism and how to transform an electromagnetic force into motion. When a wire that carries an electric current is placed in a magnetic field, the wire experiences a force that provides motion for the motor.   
  
The **size of the force**, which determines how fast the motor spins, depends on 1) the amount of current in the wire, 2) the length of the wire, and 3) the strength of the magnetic field.   
  
**Force = Current x Wire Length x Magnetic Field**   
  
The **magnetic field** in this [kit](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2192296&catalogId=10001) is directed into the [magnet](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2111425&catalogId=10001) when the label is facing up. If the **magnet** is turned over, the field is directed outward. In this kit we will orient the magnet with the label up and the magnetic field will direct toward the magnet.   
  
When the wire loop, known as a **rotor** (rotating part of a motor) is still, the loop is vertical to the magnet. The top and bottom sections of the wire act as current carrying sections because they are perpendicular to the vertical force of the magnetic field. So the current only runs horizontally in the top and bottom sections of the loop.   
  
The direction of the force determines which direction the motor spins. Direction of force depends on 1) direction of the current in the wire, and 2) direction of the magnetic field. If the direction of current and the direction of the magnetic field are known, the direction of force could be determined using the [right hand rule](http://en.wikipedia.org/wiki/Right_hand_rule).   
  
To visualize the **right hand rule**, extend your hand in front of you, fingers together, with the thumb and fingers at a right angle to each other. The direction of the magnetic field is your fingers and the direction of current is your thumb. The direction of force, then, is the direction outward from your palm. 

**The Project**

In the project, if the magnetic field is toward the magnet (fingers down) and the battery leads are situated such that the current flows counterclockwise, the rotor will spin topside toward you.   
  
  
You can change the direction of the motor by flipping the magnet over or by switching the battery leads. The force for the bottom of the loop will be in the opposite direction the rotor will rotate away from you.   
  
If left on its own, the rotor would never make a single complete rotation. The rotor would first turn 180 degrees one way, then 180 degrees the other way, and so on without ever completing more than a half turn. This oscillating action might make a good motor for a washing machine, but it wouldn't work for most needs.   
  
In this project you will [strip](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&freeText=stripper&search_type=jamecoall) off then end of half the insulation on one end of the [wire](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&freeText=wire&search_type=jamecoall). When the insulated part of the wire is in contact with the [paper clip](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_il_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=paper%20clip&linkCode=as2&tag=jameco0b-20), the current stops flowing and the rotor's momentum carries the rotor completely around. When the bare wire is in contact with the paper clip, the current flows and the rotor rotates.   
  
Remember, the speed is determined by current, wire length and magnetic field. If any of these attributes are increased, the motor will turn faster. 

**BUILD A DC MOTOR**

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| [**Simple DC Motor Kit**](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2192296&catalogId=10001) (P/N 2192296) [**Simple DC Motor Kit Classroom Pack**](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2192309&catalogId=10001) (P/N 2192309) (enough materials for 20 students)   **Kit Includes:**   |  |  |  | | --- | --- | --- | | **Part No.** | **Qty.** | **Description** | | 2098419 | 1 | [24 AWG magnet wire, 200ft](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2098419&catalogId=10001) | | 2155452 | 1 | [Breadboard, 170 point, 1.9" x 1.3"](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2155452&catalogId=10001) | | 215845 | 1 | [Energizer D-cell battery](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=215845&catalogId=10001) | | 216371 | 1 | [D-cell battery holder with wires](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=216371&catalogId=10001) | | 109031 | 1 | [Round ceramic magnet, 1.23" diameter](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=109031&catalogId=10001) |   **You will need** • 2 metal [paper clips](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_il_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=paper%20clip&linkCode=as2&tag=jameco0b-20) • [Sand paper](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_il_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=sand%20paper&linkCode=as2&tag=jameco0b-20)   **Directions**  1. Cut about three feet of magnet wire using [wire cutters](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&freeText=wire%20cutter&search_type=jamecoall) or [scissors](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_il_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=scissors&linkCode=as2&tag=jameco0b-20).   2. Starting from about two inches in, wind the wire around the battery at least six times to make a coil. Make sure you have two inches left on the other end of the wire. Cut off the excess and remove the battery (See figure 1).   3. Wrap each loose end two or three times around opposite sides of the coil to keep the coil tight. This will create the axis for the coil to spin, so balance is important (See figure 2).   4. With a piece of sand paper, sand off all the insulation on one end only.   5. For the other end of the coil, sand off half of the insulation. This part is easiest if you lay the coil flat on a table and sand outward from the coil to the end of the wire. You should be left with a coil with one lead wire completely sanded and the other lead wire with half of the insulation remaining along its length.   6. Take two paperclips and straighten the outer most loop and stick it in one end of the breadboard. Stick the other paperclip in the opposite end of the breadboard (lengthwise) (See figure 3).   7. Place the magnet on the breadboard between the two paperclips and set the coil in the two loops of the paperclips. You will be able to tell if you need to do a little straightening to make the coil balanced (See figure 4).   8. Insert the battery into the battery holder. Insert the positive wire from the battery into the same row as the right paperclip. Insert the negative wire from the battery into the other paperclip row. See diagram above. Current will run counterclockwise with this orientation. Current will run clockwise if the battery wires are inserted opposite (See figure 5).   9. Give the coil a little flick and it should start spinning. If it is well balanced, it should keep spinning for as long as the battery has power and the contact points remain clean.  **Definitions and Concepts**  • **Rotor:** rotating part of the motor • **DC:** a current in a closed circuit that flows in one direction • **Electromagnetism:** the magnetic field around a conductor (wire) when current passes through it • **Magnet:** an object that has the property of attracting or repelling magnetic materials such as some metals • **Magnetic field:** the area where magnetic forces can be detected • **Motor:** a device that moves an object • **Right hand rule:** a method of using a hand to visualize direction of force in a motor.  **Discussion Questions**  1) What are some ways to reverse the motor's direction of spin? 2) What are some ways to increase the motor's speed? 3) At what point might increasing the number of loops limit the increase in motor speed? |  | diagram  *Figure 1*  diagram  *Figure 2*  diagram  *Figure 3*  diagram  *Figure 4*  diagram  *Figure 5* |