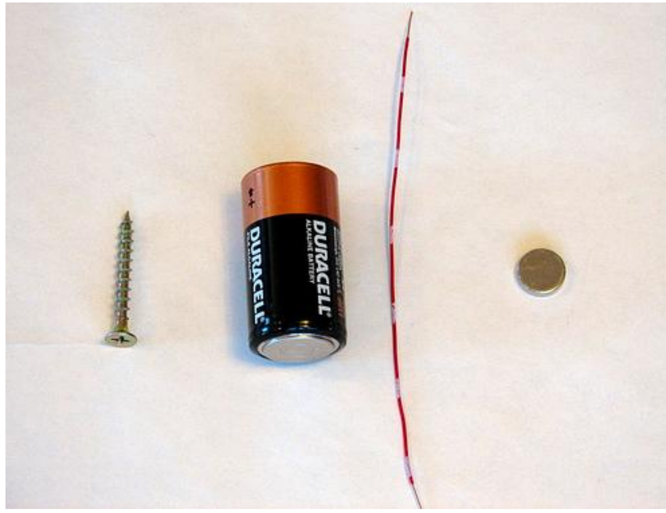
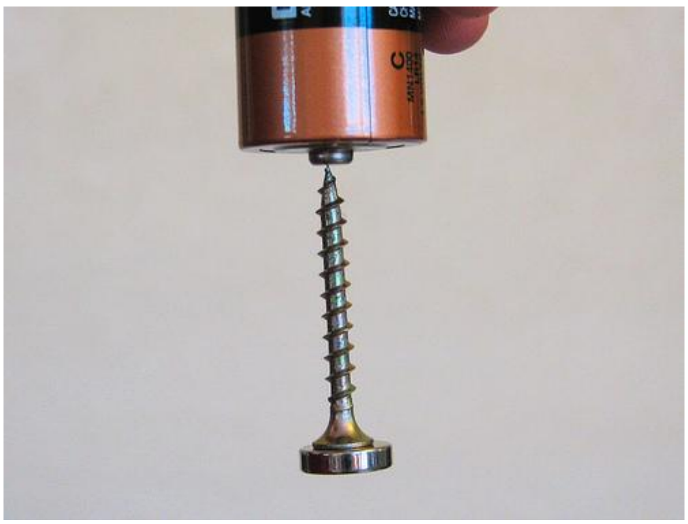
A Simple Motor

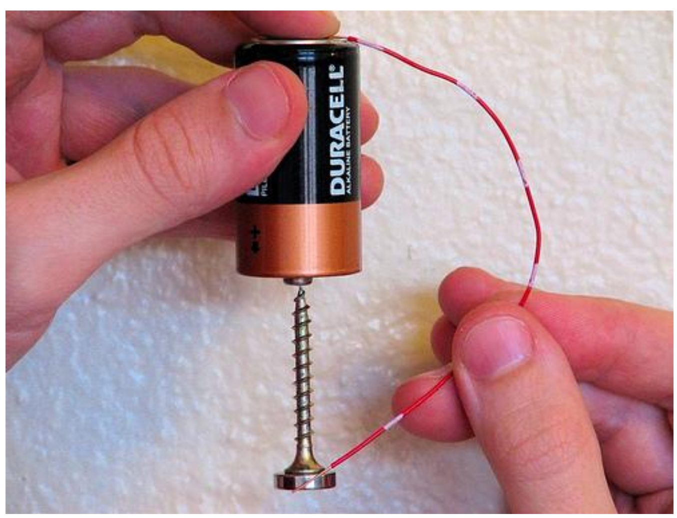
Materials:
one drywall screw
one 1.5 V alkaline battery
six inches of plain copper wire
one small neodymium magnet





Set the screw on the magnet, bend the wire.

Attach the magnet to one end of the battery.



How does this work?

The easy explanation:

When you touch the wire to the side of the magnet you create an electric circuit. A current runs out of the battery, down the screw, through the magnet, the wire and finally to the other end of the battery. The force of the magnet and the electric current flowing through it cause a new force to act on the magnet. this new force drives the magnet to spin very fast! Congratulations! You have must made a homopolar motor!

The "not so" easy explanation:

When you touch the wire to the side of the magnet, you complete an electric circuit. Current flows out of the battery, down the screw, sideways through the magnet to the wire, and through the wire to the other end of the battery. The magnetic field from the magnet is oriented through its flat faces, so it is parallel to the magnet's axis of symmetry. Electric current flows through the magnet (on average) in the direction from the center of the magnet to the edge, so it flows in the radial direction, perpendicular to the magnet's axis of symmetry. If you took physics at some point, it's possible that you'll remember the effect that a magnetic field has on moving electric charges: they experience a force that is perpendicular to both their direction of movement and the magnetic field. Since the field is along the symmetry axis of the magnet and the charges are moving radially outward from that axis, the force is in the tangential direction, and so the magnet begins to spin.

It's called a homopolar motor because you never need to reverse the polarity of any motor component during operation

Paper Circuits

Graphite is an electrical conductor, a graphite pencil can be used to draw conducting lines on paper.

Warning! Do not let both the alligator clips touch the LED without touching the graphite bar. The voltage of the battery will easily burn out the LED if it is directly connected.

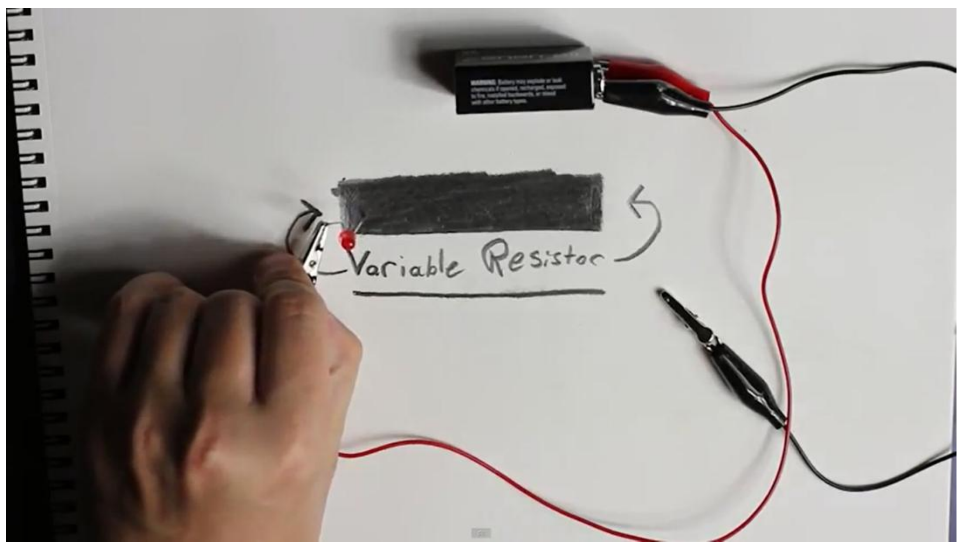
Materials:

Pencil or graphite art stick
Paper or index cards
9 volt battery
Light emitting diode
2 alligator clip leads with wires

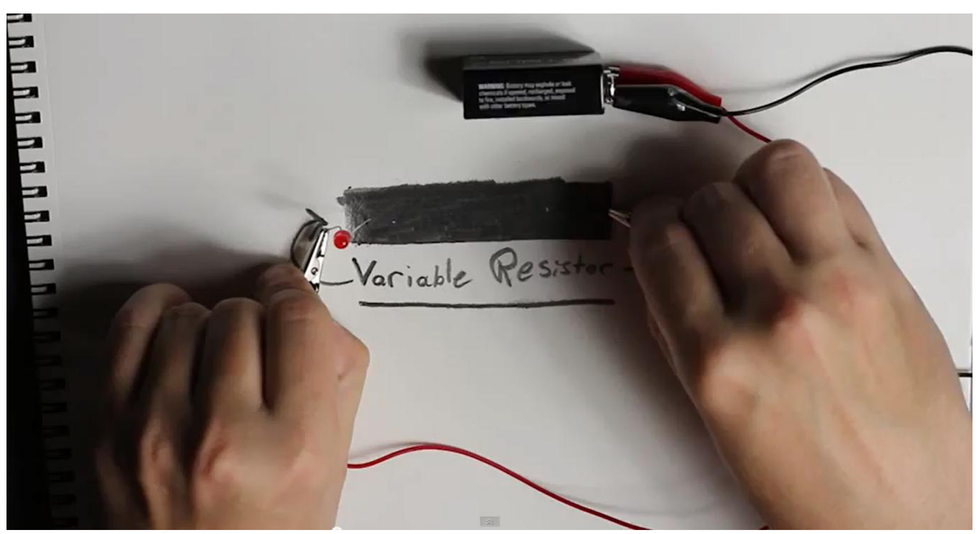
Draw a thick black bar in graphite on your paper.

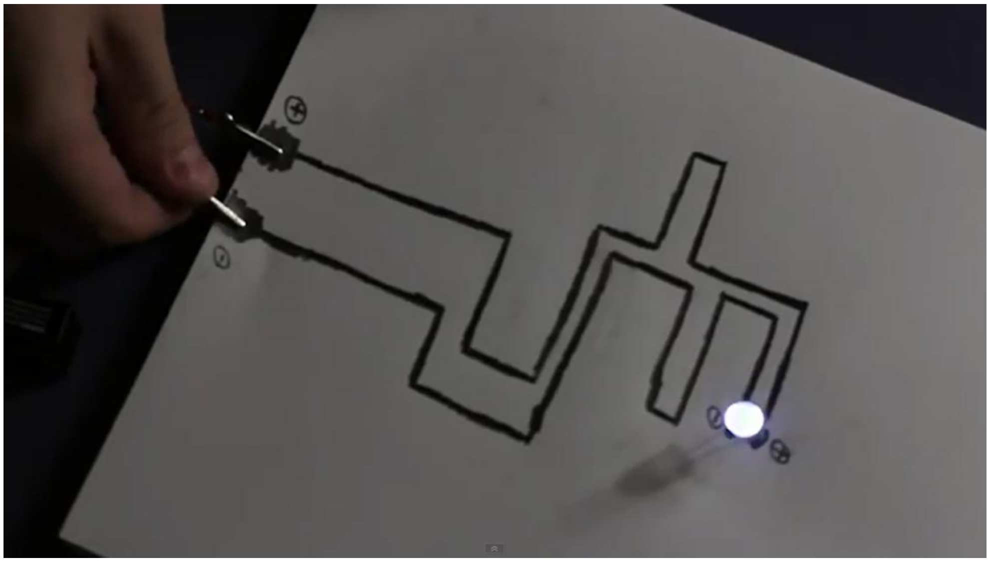
Connect the alligator clips to the battery and connect the negative terminal to the shortest leg of the LED.

The longest leg of the LED will be in contact with the graphite bar.



Place the extra alligator clip onto the end of the graphite bar and watch the LED light up. Slide this clip back and forth on the bar to watch the LED glow brighter!





Draw your own circuit

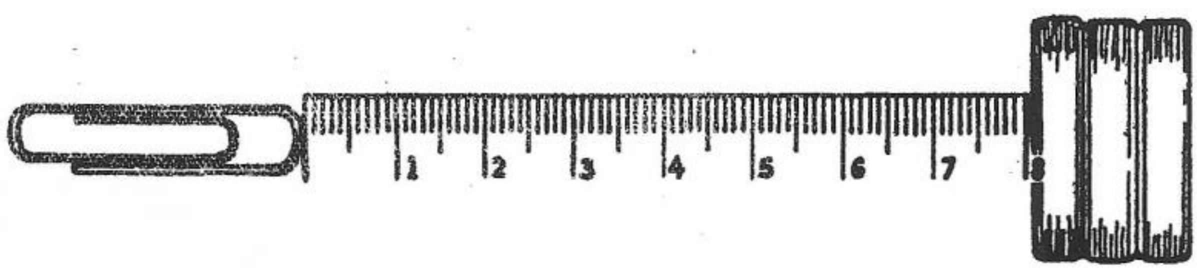
What's Going On?

Graphite is an electrical conductor. Electrons move in the planes of the graphite. A graphite line on paper models a wire in a circuit. A graphite line also has more resistance than a metal wire. Therefore, the graphite itself lowers the voltage that passes between the two alligator clips to a level that will successfully light the LED (around 3-5 volts) and not burn it out.

Check out a great video on this activity:
http://www.youtube.com/watch?v=BwKQ9Idq9FM&safety_mode=true&persist_safety_mode=1&safe=active

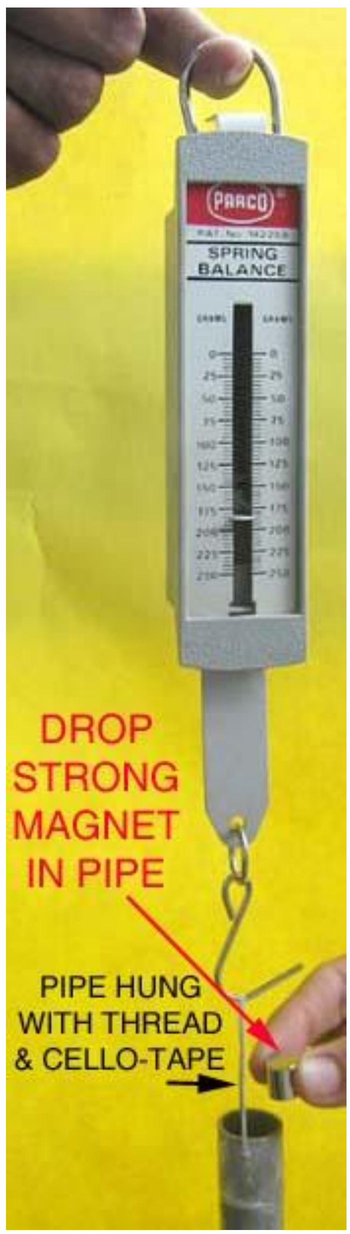
Magnetizing Paper Clips

Use the scale on the bottom of the page to correctly measure how close the magnet(s) can get to the paper clip before the paperclip is moved. Place a paperclip and the magnet(s) directly on their pictures on the bottom of the page. Slide the magnet until the magnetic field draws the clip toward the magnet. Record the distance between the magnet and the paperclip at the point of movement.

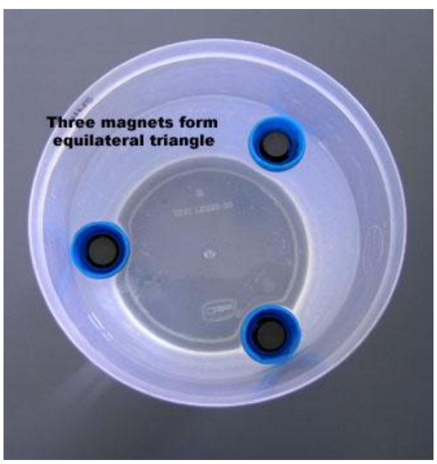


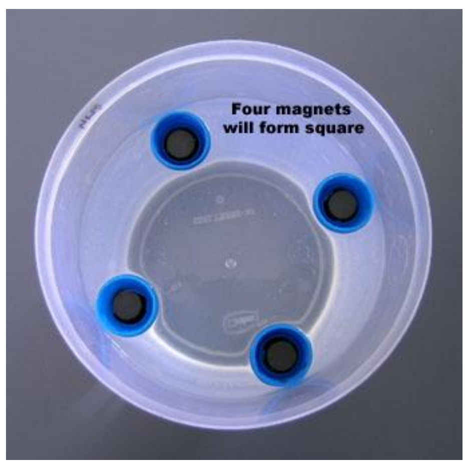
Forceful Fall

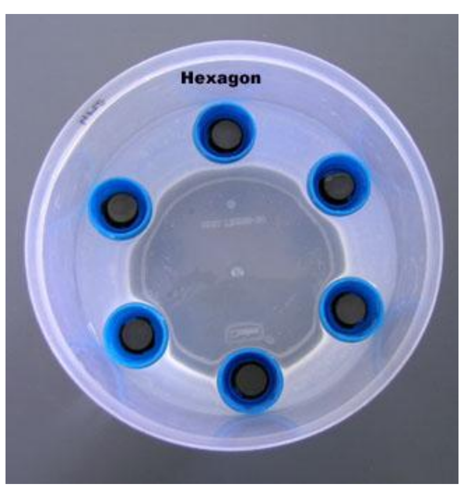
Take a long copper tube and hang it by a spring scale. Note the reading of the scale. Now take a strong cylindrical magnet (less than the diameter of the tube) and drop it in the tube. The scale will register an increase in mass. The magnet creates eddy currents in the tube which slow down the fall of the magnet. This results in a downward force exerted by the magnet.



Geometry with Magnets

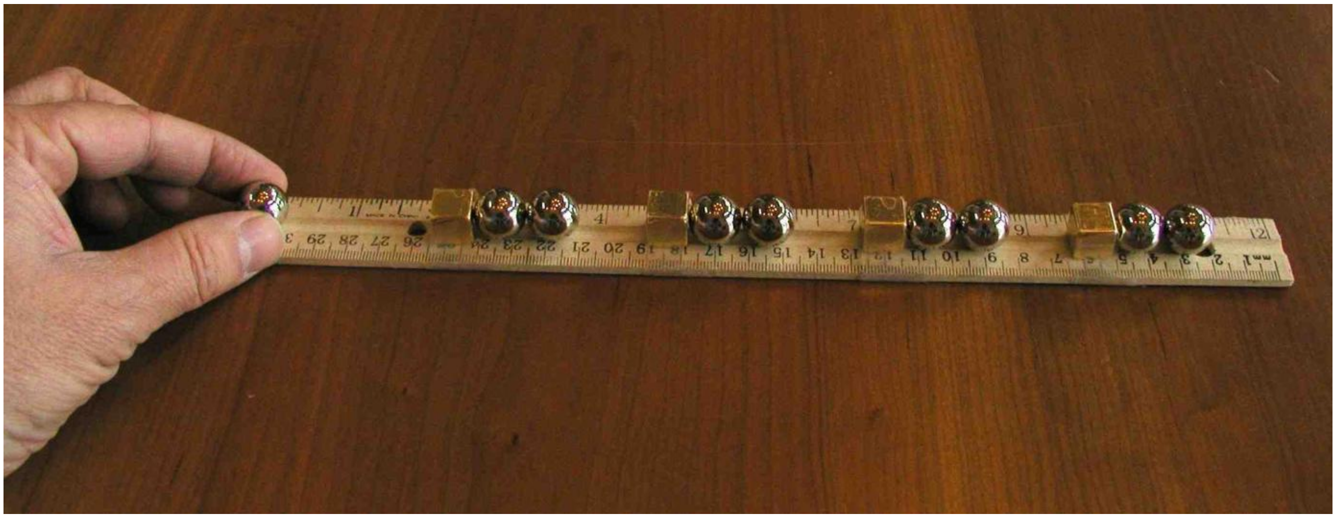






Magnetic Rail Device

Here's another way to look at this device that may be a little easier to collect some data with your students:



In this model, the magnets are not glued to the ruler but are taped down. This may be beneficial if you would like to use your magnets for other activities.

Explanation:
When you release the first ball, it is attracted to the first magnet. It hits the magnet with a respectable amount of force, and a kinetic energy we will call "1 unit".

The kinetic energy of the ball is transferred to the magnet, and then to the ball that is touching it on the right, and then to the ball that is touching that one. This transfer of kinetic energy is familiar to billiards players -- when the cue ball hits another ball, the cue ball stops and the other ball speeds off.

The third ball is now moving with a kinetic energy of 1 unit. But it is moving towards the second magnet. It picks up speed as the second magnet pulls it closer. When it hits the second magnet, it is moving nearly twice as fast as the first ball.

The third ball hits the magnet, and the fifth ball starts to move with a kinetic energy of 2 units. It speeds up as it nears the third magnet, and hits with 3 units of kinetic energy. This causes the seventh ball to speed off towards the last magnet. As it gets drawn to the last magnet, it speeds up to 4 units of kinetic energy. The kinetic energy is now transferred to the last ball, which speeds off at 4 units, to hit the target.

* Many thanks to scitoys.com and arvindguptatoys.com/toys.html for several of these ideas and images!