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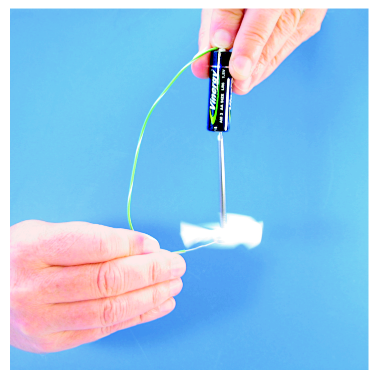
HomoMotor Kit

KIT-700/710

This kit will help you in building one of the simplest electric motors, a “homopolar” motor (also referred to as a “monopolar” motor). A homopolar (“one pole”) motor does not involve a polarity change as is utilized in more complex motors. The first of these types of motors are credited to Michael Faraday. In 1821, he built and demonstrated motors that used these principles to the Royal Institution in London. Faraday's motor used a movable wire that rotated about a magnet that was sitting in a pool of mercury.

Our motors will use a single battery, a wire and a powerful neodymium magnet. Review all instructions before trying this with your class. Also, don't miss the Important notes and suggestions section below.

Building the basic motor:



Place the magnet on the head of the nail. This will cause the nail itself to become magnetized.

Hold the battery vertically with the positive (+) end up.

Use the negative (-) end of the battery to pick up the now magnetized nail by the pointed end. The nail should be magnetically suspended from the battery.

Connect one stripped end of your wire to the positive (+) end of the battery. Secure it with a piece of tape, or just hold it firmly with a finger. Caution: The wire may become hot. If holding the wire, only run your motor for brief periods.

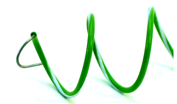
Touch the other end of the wire to edge of the magnet.

Optional: You can tape a pinwheel, or other lightweight decoration, to the magnet to make the rotation more easily observed. See page 5 for a pinwheel template.

The nail should begin to rotate. Make note of the direction of rotation. Flip the magnet over, so the opposite pole is in contact with the nail. What change occurs? Try flipping over the battery, so the nail is contacting the negative (-) end. How does this effect your motor? Will the motor work if, rather than touching the end of the wire to the edge of the magnet, you touch the wire to the side of the shaft of the nail? Why, or why not?

Building the spiral motor:

Wrap the wire tightly around the battery making a coil of wire. To make a pivot point, bend one of the stripped ends to make the tip of the wire point through the center of the coil.



Place the magnet on the positive (+) end of the battery and place the battery on a table standing on the magnet.

Slip your coil of wire over the battery so that the wire point that you made earlier touches the center of the negative (-) end. *Helpful tip: Use the nail and a gentle rap with a hammer to put a small dimple in the center of the battery's negative contact. This will help keep the pivot centered.* ***Do not puncture the battery!***

You now need to adjust the coil. The bottom of the coil needs to just touch the edge of the magnet. The coil should also be able to spin freely around the magnet. It may take several adjustments to make a coil that spins without binding, and still makes contact at both the top and bottom.

Building the butterfly motor:

The butterfly motor is different because it has two wire “arms” sticking out in opposite directions. Very decorative motors can be made by bending the wire into wings, a heart, or many other shapes. It can be challenging to get this type of motor balanced correctly. Also, the motor can be made to run longer by finding ways of controlling the speed of the spinning wire.

Fold the wire in half to find the exact center point. Strip the center of the wire to create a pivot point. Also strip about 1 cm at the end of each “arm” (Alternatively, you could strip the entire wire.)

Place the magnet on the positive (+) end of the battery and place the battery on a table standing on the magnet. *A second magnet, double-stacked may be helpful until you get your motor adjusted just right.*

Bend the “arms” of the wire, leaving a sharp fold at the pivot point. These arms will need to reach from the pivot point at the negative (-) end of the battery, to the magnet at the positive (+).

Slip your bow of wire over the battery so that the pivot point touches the center of the negative (-) end. *Helpful tip: Use the nail and a gentle rap with a hammer to put a small dimple in the center of the battery's negative contact. This will help keep the pivot centered.* ***Do not puncture the battery!***

As with the earlier motor, you now need to adjust the wire. The bottom stripped ends of the two arms needs to just touch the edge of the magnet. Both stripped ends need to make contact with the magnet, yet spin freely.

What Makes Them Work?

One fascinating fact about electromagnetism is that when charges are sitting still they don't interact with a magnetic field that is constant. However, electricity starts affecting magnetism and vice versa as soon as one starts changing.

When charges begin to move they feel a force from the magnetic field. The direction of the force depends on which way the charge is moving and which way the magnetic field is going. Still more interesting is that the force the charge feels is not in the direction of the magnetic field or of its motion, rather it is perpendicular to both. This force is called the Lorentz force. (For further study your student could research the Lorentz force and Hendrik Lornentz who discovered it.)

In the basic motor, the direction of a given current will change depending on which end of the battery has the magnet, sometimes the negative (-) current will be flowing down the nail, through the magnet and to the outside edge of the magnet. Sometimes it will flow from the outside edge through to the middle and back up the nail. Either way the direction of the current flow will be along the radius of the magnet. The magnetic field points from one flat side of the magnet to the other.

The only direction that is perpendicular to both the magnetic field and the direction of the current is the direction that would cause the nail (or coil, or "wings") to spin.

One little extra piece your students may have noticed on their own. When a strong magnet is attached to certain metals it makes the metal object magnetic as well. In case of the basic motor the neodymium magnet is attached to the head of a nail and then the nail itself becomes magnetic.

All homopolar motors work on these basic principles. Most small electric motors are "Brushed DC" motors. The brushes complete the circuit of an electromagnet which is attracted to a permanent magnet, thus causing the armature to turn. When the two magnets get close enough, the polarity of the electromagnet is changed so that it pushes away from the permanent magnet and continues moving. These homopolar motors designs all take advantage of the perpendicular Lorentz force, eliminating the need for a commutator, brushes and other components used in the more complex motors.

Important Notes and Suggestions

With all of these motors, don't be surprised if they spin so rapidly that they quickly shake themselves apart. It may take many adjustments to get them to spin freely for long periods. Also, keep in mind that **the wire will get hot**, especially if run longer.

What methods can your student develop to control the speed of the motors to make them more stable?

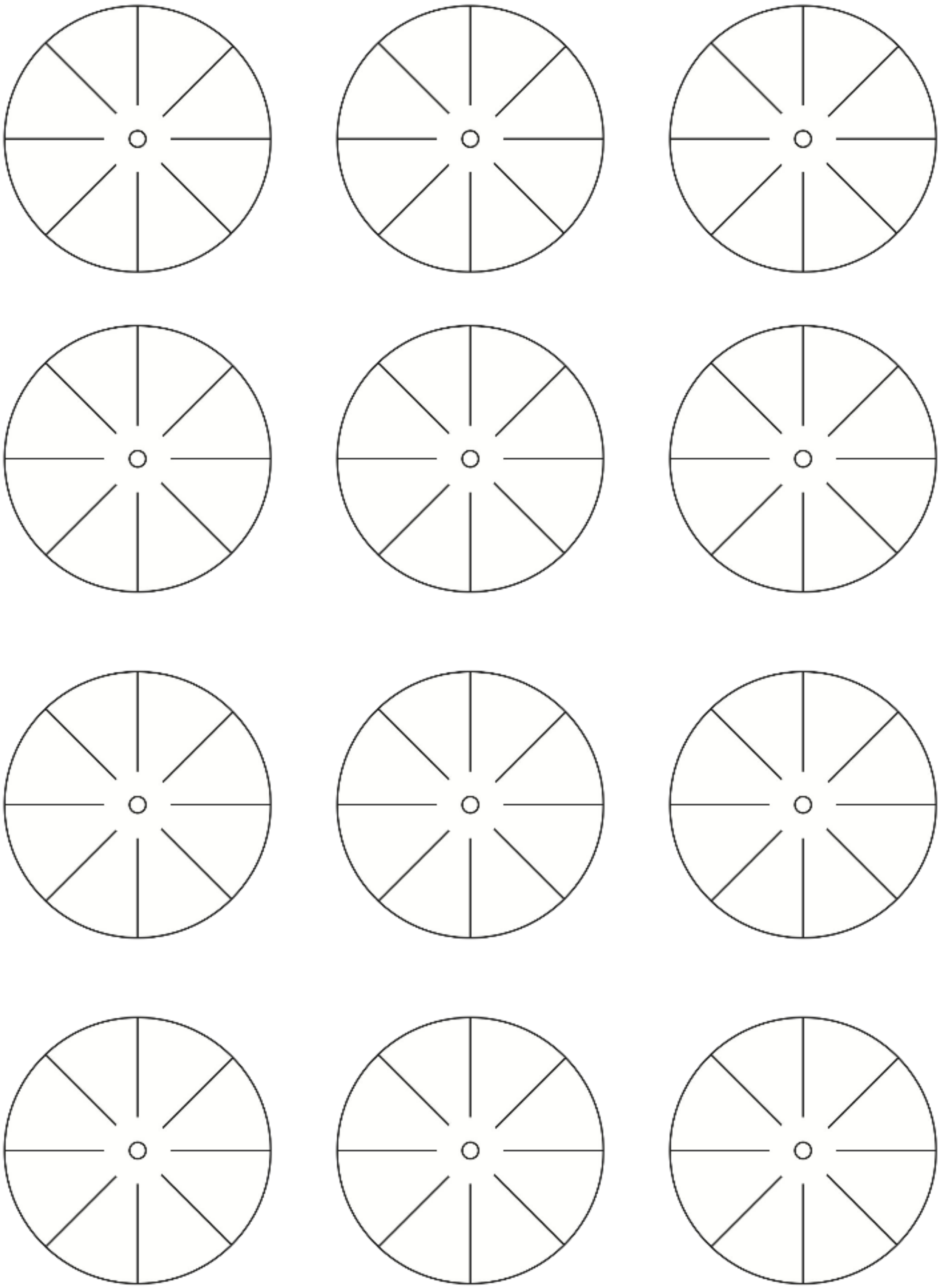
The wires included in this kit are copper-core. How might aluminum or other wires effect performance? For the butterfly motor, how do wide versus narrow “wings” effect the motor?

Have your students research how more practical motors are made. Have them find the definitions for the motor components, such as armature, commutator, or brushes. Could the exposed contacts on your homopolar motors be described as brushes? Why or why not?

Can your student have one of these motors perform some practical work?

Special thanks to Dr. Rebecca Thompson of the American Physical Society for her assistance with this kit. (www.aps.org)

Pinwheel Template



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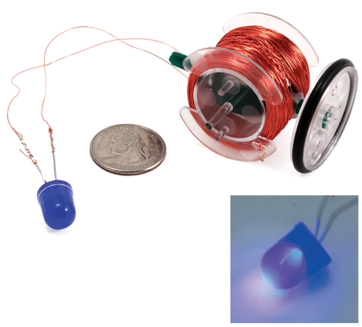
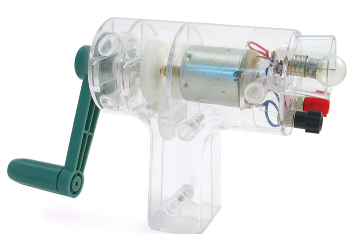


The Transparent Alternator Kit (OHM-150)

Our ingenious Transparent Alternator Kit has been designed to take the mystery out of how electricity is produced. This little device can be assembled easily in 20 minutes without tools. That's when the discoveries begin! What can you power with your alternator? How is electricity generated from a magnet and some copper wire? A wonderful hands-on introduction to electricity. With modifications, you can produce enough electricity to charge a cell phone! Once built, this alternator can be unwound, disassembled, and rebuilt over and over again.

World's Simplest Motor (SS-11)

This easily assembled motor is able to run for more than five hours on a simple D-Cell (flashlight battery). Recommended for ages eight and up.



Hand-Cranked Generator (GEN-100)

This hand-held crank generator produces up to 12 volts of DC electricity. It can be connected to an external circuit or used independently as a flashlight with the included bulb. Housed in tough transparent plastic, all of the components can be easily observed. In addition, other devices can be easily connected to the black and red screw terminals on the front of the generator without the need for any special adapter that could be quickly lost. When compared with similar products costing more than twice as much, we overwhelmingly preferred this one for its simplicity and usability.