Let's learn about Motors!

Motors are important machines that convert one form of energy into *mechanical energy*. One simple – but useful! – type of motor is an **electric motor**, which uses the interaction of flowing *electricity* in a *magnetic field* to generate a *force* that causes the motor's shaft to move.

What is electricity? Electricity is the presence and flow of *electric charge*. Transmission of electrical energy can happen naturally (such as lightning), or be made by people (such as in a generator). It can be used to power machines and electrical devices. When electrical charges are not moving, electricity is called *static electricity*. When the charges are moving, they are an *electric current*.

What is magnetism? Magnetism is a force that can attract (pull closer) or repel (push away) certain objects. The most common types of magnets are called *permanent magnets* – like the type that stick to the metal door of your refrigerator. It turns out that electric current flowing in a wire is another type of magnet – an *electromagnetic*. All magnets have an unseen area around them called a *magnetic field*. Magnetic objects inside this unseen field are affected by the magnet.

How do electricity and magnets interact? When electric charges are sitting still, they don't interact with a magnetic field. However, when electric charges begin to move in a magnetic field, they feel a force. The direction of the force depends on which way the charge is moving, and which way the magnetic field is pointing. The force the moving charge feels is called the Lorentz force, and it is what drives an electric motor!

Hardy Scientists, let's build some motors!

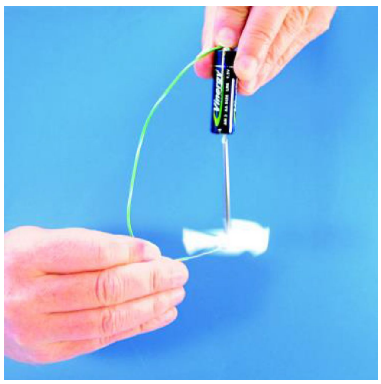
Did you know that you can make a motor using a single battery, a wire, and a magnet? This kit will help you in building one of the simplest electric motors, a "homopolar" motor (also referred to as a "monopolar" motor). Let's see how!!!

A few notes first (Adults: please read carefully):

1. The kit contains a nail that can be sharp – be careful.
2. Do not puncture the battery.
3. The wire may become hot from the flow of electric current. Only run your motor for brief periods.
4. 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.

How to build a basic motor:

1) Place the magnet on the head of the nail. This will cause the nail itself to become magnetized.
2) Hold the battery vertically with the positive (+) end up.
3) 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.
4) 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.
5) Touch the other end of the wire to the edge of the magnet.
6) The nail should begin to rotate. Make note of the direction of rotation.



Some possible modifications:

1. Flip the magnet over, so the opposite pole is in contact with the nail. What change occurs?
2. Try flipping over the battery, so the nail is contacting the negative (-) end. How does this affect your motor?
3. 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?

How to build a spiral motor:

1) 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.
2) Place the magnet on the positive (+) end of the battery and place the battery on a table standing on the magnet.
3) 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!***
4) 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.

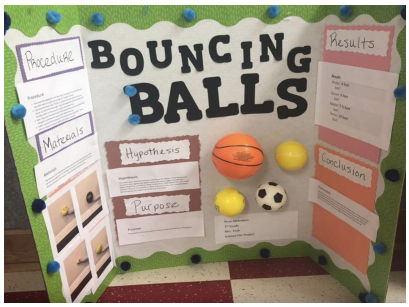
How to build a butterfly motor:

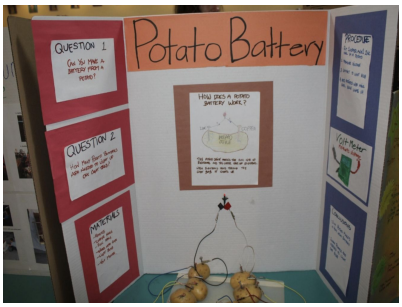
1) Fold the wire in half to find the exact center point. Strip the center of the wire to create a pivot point. Also strip about 1 cm at the end of each "arm" (Alternatively, you could strip the entire wire.)
2) Place the magnet on the positive (+) end of the battery and place the battery on a table standing on the magnet. *A second magnet, double-stacked may be helpful until you get your motor adjusted just right.*
3) 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 (+).
4) 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!***
5) 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.
6) 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. What methods can you develop to control the speed of the motors to make them more stable? How do wide versus narrow "wings" affect the motor?

Suggestions for how to turn this exercise into a project using the scientific method and present it at the Hardy Science Fair on Feb 27th!

While the exercise of creating different electric motors can be a fun learning experience, you can also use the kit to apply the scientific method to develop a project. The steps for applying the scientific method are as following:

1. Ask a ***question***
2. Make some predictions (***develop a hypothesis***) about what you think might happen
3. Carry out some tests (***experiments***) to answer the question
4. Make ***observations*** of what you see in your experiment
5. Use what you learned from your experiments to answer your question (***conclusions***)





Websites to help you make a great poster:

https://www.weareteachers.com/free-scientific-method-posters/

https://kidsactivitiesblog.com/130376/step-by-step-guide-for-making-a-great-science-fair-poster/

Hardy scientist adults can also help answer poster questions…..reach out to *Alham Saadat (alhams999@gmail.com) or Doris Pfaffinger (do.77.ris@gmail.com)* to get connected!