Electric Motors and Generators

Motors run a tremendous number of devices, from toy trains to refrigerators, from air conditions to cars. What is inside a motor? How do they work? How are motors related to electric generators? Those are the questions that we will investigate in today's lab.

Activity 1: Building the simplest electric motor

Steps to building the motor

-The first step to building an electric motor is to make an electromagnet. (Recall that a coil of wire with electric current running through it is an electromagnet.) In order to make an electromagnet, first find the cup with copper supports and coil like the one shown here.

Attach one battery lead to the bottom of each copper support. This should be done in such a way that current will run through the coil but the coil is free to spin. **The battery will go dead if you leave it connected very long.** (If you are confused about where to attach the battery leads, think back on what you know about current flow. Where can you attach the battery leads so that current can run through the coil but so that the coil is also free to rotate?)

-The second and last step to building an electric motor is to get the coil (electromagnet) to spin. To do this, take one or two permanent magnets and move them around the coil to a find a location where they interact strongly with the electromagnet (coil). If necessary, you can try blowing gently on the coil to help it get started. If the coil will not spin continuously, try putting the magnet somewhere else, turning the magnet over or bending the support wires or wires on the coil so that the coil spins more smoothly. Once your motor is spinning well, show your instructor and then disconnect the battery. **The battery will go dead if you leave it connected very long.**

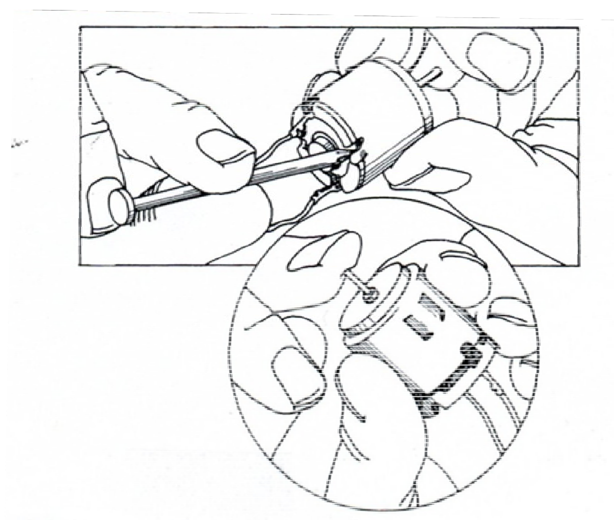
1. Take out a sheet of paper that you will use for your lab write-up. Put your name on the top. Have your teacher initial #1 to confirm that your motor works.
2. The coil is an electromagnet. What evidence do you have for this?
3. What force makes the coil spin? The magnetic force? The electrostatic force? Something else? Explain your reasoning.

Exercise 2: Parts of a small electric motor

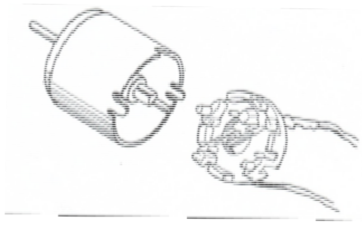
-Hook the small electric motor (with the red and blue wires attached) to the battery and make sure that you can make the motor run. You may need to tap the motor on the table to get it going.

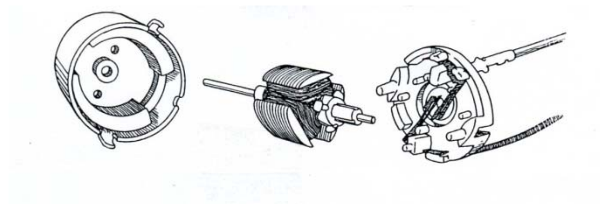
4. Can you make the motor turn in the opposite direction? If so, how? You can put a small piece of a straw or tape on the end of the motor to make it easier to see the motor turning.
5. What type of energy is input to the motor? What type of energy is output from the motor?

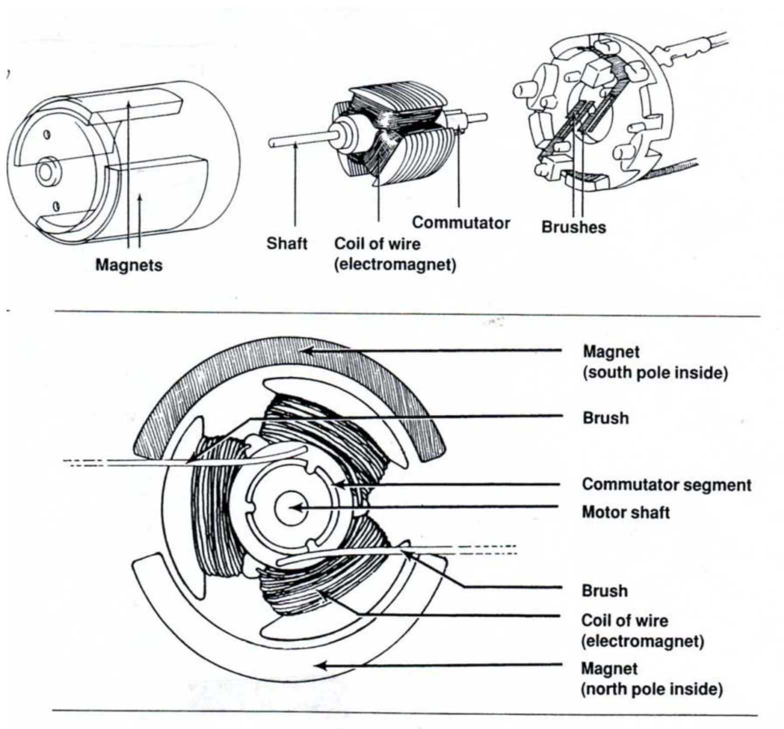
-Now you are going to take the motor apart. Begin by bending the metal tabs away from the plastic at the end of the motor as shown below. You can use a nail to do this if that helps. Once you bend the tabs out of the way, push on the axel of the motor to open it up.



The motor cap should come off as shown. Next, separate the motor into three pieces by taking out the spinning coils.







6. Look at all of the parts that make up the motor. Think about the simple (spinning coil) motor you just built and compare it to this motor. Think about what the parts of each motor do. In the lists below, draw a line connecting parts from each motor that serve the same purpose.

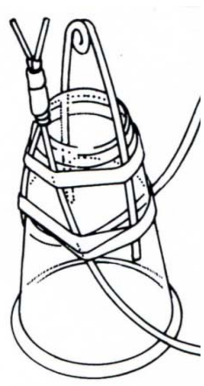
Simple Spinning Coil Motor	**Commercial Motor**
Coil	Red and Blue magnet inside the case
Straight wires sticking out from the coil	Brushes
Permanent magnet	Coils of blue wire
Copper support wires	Commutator
Clips attached to battery wires	Shaft

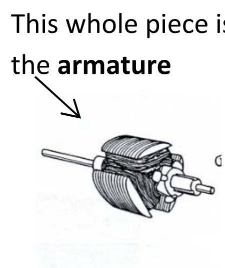
7.   All of the parts of the motor help in some way to make the motor run. What does the commutator do? What do the brushes do? For each part, write a complete sentence that uses the name of the part and states what role the part plays. If you can't figure out what the part does, ask your teacher.

8. Suppose that a friend asks you to explain the physics behind an electric motor. In a few complete and clear sentences answer your friend. (Keep it simple.)

Activity 3: Making an armature spin

-Find the cup stand that looks like this.





Attach one of the battery leads to bottom end of one of the black wires and the other battery lead to the bottom end of the other black wire.   No wires are attached to the loop support. Place the armature of the motor you took apart on this stand.   Bend the wires so that the armature fits and will not fall off.

9. You are going to want to get current to run through the coils on the armature. To do this, which end of the armature needs to rest in the V? The end with the commutator or the end without the commutation? Explain why that is the end of the armature that must be in the V?

-Connect the battery and position the armature so that current flows through the coils of wire and the rest of the circuit. Hold a magnet near the armature. Keep trying until you can make the armature spin. This might require changing the position of the magnet or adjusting the position of the armature in the V. Remember, you need to get current running through the coils on the armature to make an electromagnet and making an electromagnet is necessary for making the motor spin.

10. Experiment with two magnets to find the location that makes the motor spin the fastest. Does it matter how close the magnets are to the armature? What can you do to make the motor slow down?

11. Experiment to find ways to make the motor change direction. How many ways can you find? What are they?

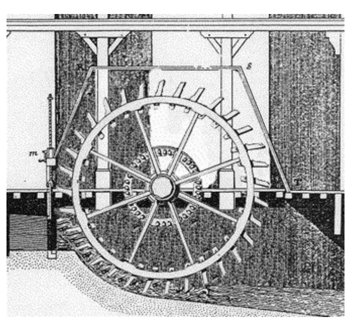
12. Put the motor back together. Have your teacher initial your lab sheet to confirm that you were successful in rebuilding the motor **and that it still works.**

Activity 4: Electric Generators are Just Electric Motors Run Backward

In the activities above you put electric energy into a motor and got rotational motion (kinetic energy) out of the motor. We are now going to try the opposite. We are going to **make the motor turn** (put rotational kinetic energy in) and see if we can get electricity out. To do this, find the box with a rubber band on it. The rubber band should be at the very edge on the longer side of the box. Find the "new" motor that is attached to a light bulb forming a closed loop. Quickly spin the shaft of the motor by running the shaft along the rubber band on the box. YOU SHOULD BE ABLE TO MAKE THE BULB LIGHT. **The electric motor is now operating as an electric generator.**

13. Have your teacher initial your lab sheet to confirm that you got the bulb to light.

Electric generators that are fundamentally just like our little electric motor/generator are the basic component in all large electricity generating facilities. The key difference between wind generated electricity, hydroelectric, nuclear, natural gas or coal fired power plants is simply what energy source is used to make the shaft of the generator rotate. In wind farms, wind directly turns blades attached to the shaft of the generator. In hydroelectric plants, the shaft is rotated when falling water passes through a device called a **turbine** (see the figure below) which is basically a sophisticated water wheel. Nuclear, coal and natural gas fired power plants use those fuels to heat water. The steam produced flows through the turbine which turns the generator shaft. Electricity generated using solar energy is produced using entirely different physics.



A very basic turbine (water wheel) using falling water to turn the shaft of an electric generator.

14. What type of energy is input to an electric generator? What type of energy is output from an electric generator?
15. In what ways, if any, is an electric motor different from an electric generator in regard to their basic design and key components?

16. The subtitle of this section is “Electric Generators are Just Electric Motors Run Backward”. Given your answers to #14 and #15 above would you agree? Explain.

17. Suppose that you had the set-up shown below and a permanent magnet. Describe what you need to do to generate electricity.