Activity 5

Building an Electric Motor

GOALS
In this activity you will:
• Construct, operate, and explain a DC motor.
• Appreciate accidental discovery in physics.
• Measure and express the efficiency of an energy transfer.

What Do You Think?
You plug a mixer into the wall and turn a switch and the mixer spins and spins—a motor is operating.

• How do you think the electricity makes the motor turn?
Write your answer to this question in your Active Physics log. Be prepared to discuss your ideas with your small group and other members of your class.

For You To Do
1. Study the diagram on the following page closely. Carefully assemble the materials, as shown in the diagram, to build a basic electric motor. Follow any additional directions provided by your teacher.
2. When your motor is operating successfully, find as many ways as you can to make the motor change its direction of rotation.
   a) Describe each way you tried and identify the ways that were successful.

3. Hold another magnet with your fingers and bring it near the coil from above, facing the original magnet, as the motor is operating.
   a) Describe what happens. Does the orientation of the second magnet make a difference?

4. Replace the single magnet with a pair of attracting magnets on top of the battery.
   a) What is the effect?

5. Think of other ways to change the speed of the motor. With the approval of your teacher, try out your methods.
   a) Describe ways to change the speed of the motor.

6. Use a hand generator as the energy source instead of the battery. You can disconnect the battery without removing it from the structure by placing an insulating material, such as a piece of cardboard, between the safety pin and the battery to open the circuit at either end of the battery. Then clip the wires from the generator to the safety pins to deliver current from the generator to the motor.
   a) Discuss what you find out.

7. Your motor turns! Chemical energy in the battery was converted to electrical energy in the circuit. The electrical energy was then converted to mechanical energy in the motor.
   a) List at least three appliances or devices where the motor spins.
8. The spin of the motor occurs because the current-carrying wire has a force applied to it. You know if something moves, a force must be applied. As you observed, when the battery connection was broken, the motor stopped turning. You know from a previous activity that a current-carrying wire creates a magnetic field. Pause for a bit to remind yourself of the behavior of magnets. Take a bar magnet and place its north pole near a compass. The compass is a tiny bar magnet that can easily turn.

   a) Draw a sketch to show the orientation of the compass.

9. Shift the compass to the south pole of the bar magnet.

   a) Draw a sketch to show the orientation of the compass.

10. The north pole of the bar magnet repelled the north pole of the compass. The south pole of the bar magnet attracted the north pole of the compass. This attraction and repulsion is the result of a force on the compass. You can now investigate the force between the poles of a magnet and the magnetic field of a current-carrying wire.
The magnetic field lines are drawn for a horseshoe magnet. The direction of the magnetic field lines is identical to a direction that a compass would point. The compass would point away from the north pole and toward the south pole. The magnetic field of the current-carrying wire is circular, as you investigated in an earlier activity. Compare the direction of this magnetic field to the direction of the magnetic field of the horseshoe magnet.

11. Think of the magnetic field lines above as small compasses.
   a) Write down whether the compasses above the wire attract one another or repel one another.
   b) Write down whether the compasses below the wire attract one another or repel one another.

12. This attraction/repulsion causes the wire to jump. There is a force on the wire. This force on the current-carrying wire is the basis for the electric motor that you built in this activity. The use of the loop of the wire allows the wire to rotate instead of jumping in the way a single wire would.

13. It is the moving electrons in the wire that create the current. In some TV sets, there is an electron beam that shoots the electrons from the back of the TV to the front. There are horseshoe magnets of a sort in the television. The moving electrons experience a force. The electrons’ path is affected by the magnetic field. By varying the strength of the magnetic field, the electron beam can hit all parts of the screen and you receive a TV image.
FOR YOU TO READ

The history of science is filled with discoveries that have led to leaps of progress in knowledge and applications. This is certainly true of physics and, in particular, electricity and magnetism. These discoveries “favor” the prepared mind. Oersted’s discovery in 1820 of the magnetic field surrounding a current-carrying wire already has been mentioned. Similarly, Michael Faraday discovered electromagnetic induction in 1831. Faraday was seeking a way to induce electricity using currents and magnets; he noticed that a brief induced current happened in one circuit when a nearby circuit was switched on and off. (How would that cause induction? Can you explain it?) Both Oersted and Faraday are credited for taking advantage of the events that happened before their eyes, and pursuing them.

About one-half century after Faraday’s discovery of electromagnetic induction, which immediately led to development of the generator, another event occurred. In 1873, a Belgian engineer, Zénobe Gramme, was setting up DC generators to be demonstrated at an exposition (a forerunner of a “world’s fair”) in Vienna, Austria. Steam engines were to be used to power the generators, and the electrical output of the generators would be demonstrated. While one DC generator was operating, Gramme connected it to another generator that was not operating. The shaft of the inactive generator began rotation—it was acting as an electric motor! Although Michael Faraday had shown as early as 1821 that rotary motion could be produced using currents and magnets, a “motor effect,” nothing useful resulted from it. Gramme’s discovery, however, immediately showed that electric motors could be useful. In fact, the electric motor was demonstrated at the very Vienna exposition where Gramme’s discovery was made. A fake waterfall was set up to drive a DC generator using a paddle wheel arrangement, and the electrical output of the generator was fed to a “motor” (a generator running “backwards”). The motor was shown to be capable of doing useful work.
Reflecting on the Activity and the Challenge

Decision time about the Chapter Challenge is approaching for your group. In this activity you built a very basic, working electric motor. This is an important part of the Chapter Challenge. However, knowing how to build an electric motor is only part of the challenge. Your toy must be fascinating to children. You must also be able to explain how it works.

Physics To Go

1. Some electric motors use electromagnets instead of permanent magnets to create the magnetic field in which the coil rotates. In such motors, of course, part of the electrical energy fed to the motor is used to create and maintain the magnetic field. Similarly, electromagnets instead of permanent magnets are used in some generators; part of the electrical energy produced by the generator is used to energize the magnetic field in which the generator coil is caused to turn. What advantages and disadvantages would result from using electromagnets instead of permanent magnets in either a motor or generator?

2. Design three possible toys that use a motor or a generator or both. One of these may be what you will use for your project.

3. The motor/generator you submit for the Chapter Challenge must be built from inexpensive, common materials. Make a list of possible materials you could use to construct an electric motor.

4. In the grading criteria for the Chapter Challenge, marks are assigned for clearly explaining how and why your motor/generator works in terms of basic principles of physics. Explain how an electric motor or generator operates.