



# Everything You Wanted To Know About Electric Motors... But Were Afraid To Ask



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## Lesson Focus

Electric Motors: their principles and everyday uses. Note: This lesson plan is designed for classroom use only, with supervision by a teacher familiar with electrical and electronics concepts.

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## Lesson Synopsis:

Students learn the basic principles of electric motors and explore everyday uses. They build a working model of an electric motor for classroom use, using inexpensive kit.

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## Age Levels

10-14.

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## Objectives

- ✦ Learn basic principles of electric motors.
- ✦ Apply theory to everyday uses of electric motors.
- ✦ Build a working model of an electric motor for classroom use.

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## Anticipated Learner Outcomes

As a result of this activity, students aged 10-14 should develop an understanding of:

- ✦ Principles of electric motors
- ✦ Principles of magnetism
- ✦ Principles of electric currents

Students should also apply theory to everyday uses of electric motors, and expand their knowledge of motor design and operation.

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## Electric Motors: Introduction

The following are basic educational principles of electric motors:

- ✦ Magnets both attract and repel each other. Like poles repel, opposite poles attract.
- ✦ An electric current produces a magnetic field. The strength and direction of the magnetic field varies according to the strength and direction of the electric current.
- ✦ Simply winding a wire that carries an electric current around an iron bar creates a magnet that can be switched on and off. Also, the strength and direction of the magnetic poles can easily be controlled by changing the strength and direction of the electric current.

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## Electric Motors: Introduction (continued)

### Overview of Basic Motor Principles

#### ◆ Principles of Magnetism

Magnetism is a force of nature that attracts and repels. Unlike gravity, which only attracts and which affects all objects, only some types of materials can be magnetized so that they exert magnetic force, and only some materials are affected by that force—mostly metals like iron and nickel. When an object becomes magnetized and exerts magnetic force, it is called a magnet. A magnet has a magnetic pole at each end, one called the north pole and one called the south pole. Like poles repel, and opposite poles attract. That is, a north pole attracts another magnet's south pole but repels a north pole, and south attracts north but repels south. The Earth is actually a giant magnet, which is why it has north and a south magnetic poles, and why the south pole of a small magnet (such as the tip of the needle on a magnetic compass) will always point north. The magnetic force around a magnet forms a magnetic field. The field is made up of lines of force that run from the north pole to the south pole. When opposite poles are brought together, their lines of force join, but when like poles are brought together the lines of force push each other away.

#### ◆ Electromagnets

Scientists long wondered if the attractive and repulsive forces of electricity and magnetism were related. In 1820 Danish physicist Hans Christian Ørsted discovered that a wire with an electric current flowing through it produced a magnetic field. In fact, wrapping a wire around an iron core and running a current through it produces a strong magnetic effect; this is called an electromagnet. British scientist Michael Faraday then discovered that a wire moving through a magnetic field developed a current running through it. This is called induction.

#### ◆ Applying Magnetic and Electric Principles Into Motor Design

These discoveries led to the invention of electric generators and electric motors. An electric generator turns motion (which could be caused by a steam engine, by wind power, or whatever) into electricity. An electric motor turns electricity back into motion. These two machines are the basis of modern electric power.

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## Lesson Activities

### Outline

- I. Introductions
- II. Overview of basic motor principles
  - A. Principles of magnetism
  - B. Electromagnets
  - C. Applying magnetic and electric principles into motor design.
- III. Cooking up a motor
- IV. Now you try it
- V. Classroom instruction ideas
- VI. Questions and answers
- VII. Teacher feedback

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## Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Inexpensive toy electric motor kit, available from Science First, 800-799-8301 or [www.sciencefirst.com](http://www.sciencefirst.com). See attached product description.
- ✦ Resources not included in kit: sandpaper, cellophane tape, scissors or wire cutting pliers, batteries, small screwdriver



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## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

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## Internet Connections

- ✦ IEEE Teacher In-Service Program ([www.ieee.org/organizations/eab/precollege/tispt](http://www.ieee.org/organizations/eab/precollege/tispt))
- ✦ IEEE Virtual Museum ([www.ieee-virtual-museum.org](http://www.ieee-virtual-museum.org))
- ✦ International Technology Education Association Standards for Technological Literacy ([www.iteawww.org/TAA/PDFs/ListingofSTLContentStandards.pdf](http://www.iteawww.org/TAA/PDFs/ListingofSTLContentStandards.pdf))
- ✦ McREL Compendium of Standards and Benchmarks ([www.mcrel.org/standards-benchmarks](http://www.mcrel.org/standards-benchmarks))  
A compilation of content standards for K-12 curriculum in both searchable and browsable formats.
- ✦ National Science Education Standards ([www.nsta.org/standards](http://www.nsta.org/standards))
- ✦ Science First (Supplier of Toy Motor Kit) ([www.sciencefirst.com](http://www.sciencefirst.com))

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## Recommended Reading

- ✦ The Usborne Book of Batteries & Magnets (ISBN: 074602083X)
- ✦ DK Eyewitness Series: Electricity (ISBN: 0751361321)
- ✦ Janice VanCleave's Physics for Every Kid : 101 Easy Experiments in Motion, Heat, Light, Machines, and Sound, by Janice VanCleave. John Wiley & Sons (ISBN: 0471525057)

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## Optional Writing Activity

- ✦ Identify examples of motors in use at your home or school. Write an essay (or paragraph depending on age) about how the motor impacts the machine it is used in. For example, an electric fan without a motor would have to be moved in some other way to produce wind.

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## References

Ralph D. Painter, Douglas Gorham, and other volunteers from Florida's West Coast USA Section of IEEE  
URL: <http://ewh.ieee.org/r3/floridawc>

# Electric Motors



## For Teachers: Alignment to Curriculum Frameworks

Note: All Lesson Plans in this series are aligned to the National Science Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, to the International Technology Education Association's Standards for Technological Literacy

### ◆National Science Education Standards Grades 5-8 (ages 10 - 14)

#### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop an understanding of

- ✦ Motions and forces
- ✦ Transfer of energy

#### **CONTENT STANDARD F: Science in Personal and Social Perspectives**

As a result of activities, all students should develop understanding of

- ✦ Risks and benefits
- ✦ Science and technology in society

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ History of science

### ◆National Science Education Standards Grades 9-12 (ages 14 - 18)

#### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop understanding of

- ✦ Motions and forces
- ✦ Interactions of energy and matter

#### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology

#### **CONTENT STANDARD G: History and Nature of Science**

As a result of activities, all students should develop understanding of

- ✦ Historical perspectives

### ◆Standards for Technological Literacy - All Ages

#### **Technology and Society**

- ✦ Standard 7: Students will develop an understanding of the influence of technology on history.

#### **Design**

- ✦ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

#### **The Designed World**

- ✦ Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.

# Electric Motors

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## For Teachers: Teacher Resources



### Helpful Hints For Assembling The Motor Kit

- ✦ Winding the field coil is made much easier by taping the field poles to the mounting bracket using cellophane tape before winding the field coil.
- ✦ Winding the armature is also made easier by taping the two armature pieces together with cellophane tape. After taping the armature pole pieces together, the shaft is inserted between the pole pieces. The position of the armature pole pieces on the shaft is then adjusted by simply placing the armature on the bearing posts and then sliding the armature pole pieces along the shaft until the pole pieces line up with the field poles.
- ✦ The small plastic tubing that is used as a spacer between the armature coil and the commutator can be cut to fit in the following manner. After the armature coil is wound, temporarily slide the commutator onto the shaft. Place the armature on the bearing posts, lining the armature poles up with the field poles. Slide the commutator along the shaft so that the commutator lines up with the post that supports the brushes. Cut a piece of tubing to fit the space between the armature windings and the commutator. Slide the commutator off the shaft, place the tubing on the shaft snugly against the armature coil. Replace the commutator on the shaft, this time threading the lead wires from the armature coil into the commutator.
- ✦ When the motor kits are purchased in bulk packages, the parts must be sorted to make up individual motor kits. Much class time can be saved by pre-sorting the parts into individual plastic sandwich bags.

### Materials Not Included In The Kit

- ✦ Sandpaper. Any type of fine sandpaper or emery cloth will do.
- ✦ Cellophane tape. Not strictly required, but helpful for holding the field and armature pole pieces together while winding the coils.
- ✦ Scissors or wire cutting pliers.
- ✦ Batteries. The battery clips provided are for AA size batteries. While a carefully assembled motor will operate on a single AA battery that is new, using two AA batteries in series to form a three-volt battery results in more reliable operation. In fact, it is good to have a six-volt lantern battery on hand to "jump-start" finicky motors
- ✦ Small screwdriver.

### Suggestions For Teaching With The Motor Kits

The motor kits can be used in a wide variety of ways limited only by the combined imaginations of the teacher and the students. The suggestions that follow are intended only to stimulate your thinking. No one knows better than the teacher just how a particular group of students will respond to a given learning opportunity. The use of the motor kit can be as simple as having an assembled motor on the teacher's desk to pique the curiosity of students or it can involve follow-up activities such as research papers or team efforts to improve the motor design. A list of experiments appears in of the instruction sheet that comes with the motor kit.

### Electric Motors

## **For Teachers:**

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### **Teacher Resources (continued)**

The motor kits can be used as a classroom or laboratory exercise in electromagnetism for high school students. One approach is to have students observe their instructor assemble one motor kit. Each student is then given an instruction sheet and a motor kit to assemble at home. A satisfactory grade is awarded to each student who demonstrates a working motor to the instructor within a period of one week. Students are allowed to receive help from parents, siblings or friends. The hands-on nature of the project ensures that some learning will take place regardless of the amount of help the student receives. The project is generally well received by parents. The activity can be expanded by asking each student to write in his own words a description of how the motor works.

With practice, the motor kit can be assembled in about 40 minutes or less. Students, however, are novices and will require much more time. If the teacher chooses to have the students build the motor during a class period, then the project can be done in parts. For instance, day one can include a brief explanation of the exercise and the assembly of the field winding. Day two can be devoted to the winding of the armature. Day three can then be the final assembly and test running of the completed motor.

Researching the history of the invention of the electric motor is a good follow-up assignment for especially able students. An internet search turned up mentions of Oersted, Faraday, Henry, Page, and Tesla. All of these men from Denmark, England, America, and Hungary had a part in the invention and development of the electric motor. However, one major final step in the development of the electric motor was entirely accidental. During an industrial exposition in Vienna in 1873, an idle dynamo generator was accidentally connected to an second dynamo generator that was already in operation. The idle generator started and ran as a motor. The effect was recognized by Zenobe Theophile Gramme, the designer of the dynamos in question.

Hans Christian Andersen and Hans Christian Oersted shared more than first and middle names. Both men lived in Denmark in the first half of the nineteenth century and both men became famous. Hans Christian Andersen earned fame as a writer of fairy tails such as *The Ugly Duckling* and *The Match Girl*. Hans Christian Oersted, on the other hand, became a distinguished scientist. While performing a laboratory demonstration for a group of students, Oersted noticed that a nearby compass was affected by the flow of electric current in the wires leading to his apparatus. Oersted published a paper describing this interaction between electric current and magnetism in July of 1820. Andersen was only fourteen when he first met Oersted. Gradually, Andersen and Oersted became close friends. Andersen was eventually to write of Oersted, " his house became very early a home for me; his children, when they were small, I have played with, seen them grow up and keep their love for me. In his home I have found my eldest and unchanged friends." Without revealing these facts to your students beforehand, challenge your students to research and report on both men to see if any student can discover the connection between these two famous men.

## For Teachers:

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### Teacher Resources (continued)

#### Applications Of This Type Of Electric Motor

The toy motor kit is an example of a “universal” motor so called because it can be operated on either direct current (DC) or alternating current (AC). This type of motor is also referred to as a series motor because the armature winding is connected in series with the field winding. The series motor does not have very good speed regulation since the speed of the motor varies appreciably as the load is increased from no load to full load. However, the series motor produces higher torque as the speed drops and can be designed to operate at very high speeds. These properties allow the motor designer to put a large amount of power into a relatively small package. Typical applications for the series motor are listed below.

- ✦ Kitchen mixers
- ✦ Food processors
- ✦ Hand held power tools such as drills, circular and reciprocating saws, routers and sanders.
- ✦ Automobile starter motors
- ✦ Electric hair dryers
- ✦ Rotary electric shavers
- ✦ Traction motors for diesel electric locomotives, electric trains, and subway trains
- ✦ Golf cart and electric car motors
- ✦ Electric wheelchair motors
- ✦ Robot motors
- ✦ Vacuum cleaners

Other types of electric motors exist, principally AC induction motors. However, practically all electric motors depend on the forces of attraction and repulsion between electromagnets that is demonstrated by the series motor.

# Electric Motors

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## For Teachers: Kit Description/Ordering Instructions



### Science First Toy Motor Kit

Questions and Orders:

Call 800-799-8301 or visit [www.sciencefirst.com](http://www.sciencefirst.com).

- Build a real working motor for less than the price of a slice of pizza
- Also available in handy class-packs
- Our best-selling product for over 40 years
- For scout groups, science fairs and more
- Revised instructions with computer-generated assembly diagrams

All you need to build a working DC motor and learn its parts from the inside out! Assembly involves winding your own armature and field coil; building the commutator with two snap-together pieces; installing brushes into the holes in the base; and slipping one battery into battery clips. This isn't a watered-down geegaw with a few measly parts that you'll handle once and then discard. This clever kit has been used for over 40 years to teach crucial concepts to children aged 10 and up. Our customers include Del Brown at Burley Junior High, Burley, ID, who has known used this kit since our early days. Kit includes: coil of copper wire; plastic base with holes for parts; field poles; armature core; brushes; all fasteners; and detailed, illustrated assembly instructions with 8 experiments. You need 1 AA battery.

An Accent exclusive! We can't take credit - this idea came from a professor at Case Western Reserve. Our teacher-friendly Toy Motor bulk packs contain enough parts for 30 or 48 students (plus spares). We keep costs low by including only half the instructions, allowing 2 students to share.

### Pricing:

(Note: Check current pricing at Science First's website: [www.sciencefirst.com](http://www.sciencefirst.com))

Code	Name Size	Material Price
10-135	Toy Motor Kit	Each: \$4.25
10-136	Toy Motor Kit	12 pack: \$47.50
10-137	Toy Motor Kit	Bulk Pack 36: \$79.95
10-138	Toy Motor Kit	Bulk Pack 48: \$124.95

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# Electric Motors



## Student Handout:

### Introduction To Electric Motors

#### Basic Educational Principles of Electric Motors

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These discoveries led to the invention of electric generators and electric motors. An electric generator turns motion (which could be caused by a steam engine, by wind power, or whatever) into electricity. An electric motor turns electricity back into motion. These two machines are the basis of modern electric power.

# Electric Motors

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## Student Handout:

### History of Electric Motors



Most people would say that they don't see an electric motor every day, like they do a light bulb or a telephone. That is because electric motors aren't like that. They are simpler things that are found within many appliances. A motor's purpose is to turn electrical energy into mechanical energy. It takes electricity and turns it into energy that can be used by us.

An electric Motor uses magnetism and electric currents to work. There are two different kinds of motors, Alternate Current (AC) and Direct Current.(DC) Motors. These kinds of motors use the same parts as a basic electric motor, only using two different kinds of current. For more information on Alternate and Direct current, refer to the Generating page.

Motors began with electromagnets. IN 1831, Michael Faraday succeeded in building the first electric motor. Joseph Henry was working with motors at that time. Henry and Faraday are both credited with building the first experimental electric motors. In 1837, Charles Grafton Page worked on improving the electric motor and created a model of his own. In 1887, Nikola Tesla (see Other Inventors) introduced the Alternate Current (AC) motor. All other motors up to that time had been using direct current. Now, alternate current motors are easier to use than direct current ones.

Today, motors are used everywhere. They are used in cars and many household appliances. Even though many people don't recognize what all it does, the electric motor has become a very useful invention.

(Source: ThinkQuest Library: [www.thinkquest.org/library](http://www.thinkquest.org/library))

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