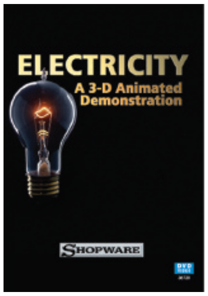

SHOPWARE

Instructor's Guide

Electricity: A 3-D Animated Demonstration

ELECTRIC MOTORS

Introduction

This instructor's guide provides information to help you get the most out of *Electric Motors,* part of the eight-part series *Electricity: A 3-D Animated Demonstration.* The series makes the principles of electricity easier to understand and discuss. The series includes *Electrostatics; Electric Current; Ohm's Law; Circuits; Power and Efficiency; Electricity and Magnetism; Electric Motors;* and *Electric Generators*.

Electric Generators explores the physics elements at play in the function of electric motors.

Learning Objectives

After watching the video program, students will be able to:

- Describe and illustrate basic physics principles of electric motors
- Illustrate how magnets and electric current function in an electric motor
- Explain and demonstrate the left-hand rule as related to motor force
- Apply physics equations associated with motor force (motor effect)
- Construct an electric motor

Educational Standards

National Science Standards

This program correlates with the National Science Education Standards from the National Academies of Science, and Project 2061, from the American Association for the Advancement of Science.

Science as Inquiry
Content Standard A: As a result of activities in grades 9-12, all students should develop:
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science
Content Standard B: As a result of their activities in grades 9-12, all students should develop an understanding of:
- Structure of atoms
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

History and Nature of Science
Content Standard G: As a result of activities in grades 9-12, all students should develop understanding of
- Nature of scientific knowledge
- Historical perspectives

English Language Arts Standards
The activities in this instructor's guide were created in compliance with the following National Standards for the English Language Arts from the National Council of Teachers of English.

- Standard 7: Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

- Standard 8: Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Mathematics Standards

This program correlates with the Principles and Standards for School Mathematics by the National Council of Teachers of Mathematics.

Problem Solving
Instructional programs from pre-kindergarten through grade 12 should enable all students to:
- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems

Reasoning and Proof
Instructional programs from pre-kindergarten through grade 12 should enable all students to:
- Select and use various types of reasoning and methods of proof

Principles and Standards for School Mathematics by the National Council of Teachers of Mathematics. Published 4/12/2000. Reprinted with permission.

Technology Standards

The activities in this Teacher's Guide were created in compliance with the following National Education Technology Standards from the National Education Technology Standards Project.

Standard 2: Communication and Collaboration
Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.

Standard 3: Research and Information Fluency
Students apply digital tools to gather, evaluate, and use information.

Standard 4: Critical Thinking, Problem-Solving & Decision-Making
Students use critical thinking skills to plan and conduct research, manage projects, solve problems and make informed decisions using appropriate digital tools and resources.

The National Education Technology Standards reprinted with permission from the International Society for Technology Education. Copyright 2007.

Program Summary

This program explores the basic principles behind the operation of electric motors. An explanation is given about how one or more fixed magnets, either permanent or electromagnetic, can cause linear movement or rotation of a current-carrying wire. A hand rule is developed to predict motor force. Motor torque is explained as a prelude to the practical design of a direct current motor.

Main Topics

Topic 1: Motors and Magnets
The program introduction notes how electricity and magnetism allowed for the development of the electric motor, which, as the film describes, requires two basic components to function.

Topic 2: Current and Magnet Interaction
This segment describes the interaction of forces between a magnet and an electric current; it is this interaction that is an electric motor's foundation.

Topic 3: Left-Hand Rule
In this section, students examine a variation of the left-hand rule that, in the context of electric motors, determines the direction of motor force.

Topic 4: Motor Force
Students explore the relationship between a magnetic field and motor force, as well as recognize two physics equations critical for defining the motor effect.

Topic 5: Motor Torque
This segment introduces and illustrates the rotational force in an electric motor.

Topic 6: DC Motors
In this final segment, students explore what a direct current electric motor requires to function and what is at play in its operation.

Fast Facts

- Electric motors usually convert more than 80% of electric energy into mechanical energy.
- The Danish Physicist Hans Christian Oersted first discovered that an electric force exerts a force on a magnet.
- Isaac Newton's third law of motion states that every action causes an equal and opposite reaction: when a magnet is fixed and a wire is free to move, the law predicts that the wire will be deflected by an equal and positive force, moving away from the magnet in an opposite direction to the earlier deflection of the magnet.
- Electric motors require two essential components: a moveable current-carrying coil and one or more fixed magnets.
- Each one of a pair of magnets has its own magnetic field between its two poles.
- A tesla measures the strength of a magnetic field; current is measured in amperes; force is measured in Newtons.
- A torque is a rotating force. It is produced by the magnetic force that emerges when an electric current passes through a magnetic field. The torque twists the coil in the magnetic field.
- A single split-ring commutator is what supplies the electric current in a DC motor.
- Most motors translate electric power into rotary motion.
- Two important equations define the motor effect: one defines a magnetic field's strength and the other determines the length of a coil in a magnetic field.

Vocabulary Terms

ampere: The metric unit of current, one coulomb per second; also called "amp."

axis: The center around which something rotates.

commutator: The rotating switch attached to the brushes of a DC generator. The commutator maintains DC when the rotation of the armature switches the polarity of the conductor.

DC motor: An electric rotating machine energized by direct current and used to convert electric energy to mechanical energy.

deflect: To turn aside or to cause to turn aside.

electromagnet: A magnet that is propelled by electricity.

exert: To put forth or into use, as power; to put into vigorous action.

left-hand rule: If fingers of the left hand are placed around a wire so that the thumb points in the direction of electron flow, the fingers will be pointing in the direction of the magnetic field being produced by the conductor.

magnetic field: The region around a magnet where the magnetic force acts.

magnetic force: The force exerted between magnetic poles, producing magnetization.

magnetism: Attraction properties possessed by magnets; phenomena by which materials exert attractive or repulsive forces on other materials.

motor effect: Tendency of a wire carrying an electric current in a magnetic field to move; term used when a current carrying wire in the presence of a magnetic field experiences a force.

newton: The unit used to measure force.

pole: Either of the two regions or parts of an electric battery, magnet, or the like, that exhibits electrical or magnetic polarity.

proportionality constant: The constant value of the ratio of two proportional quantities x and y; usually written y = kx, where k is the factor of proportionality.

slip-ring: A conductive device attached to the end of a generator rotor that conducts current to the brushes.

split-ring: A conductive device that spins rapidly with the armature of a DC motor or generator while in contact with the fixed brushes.

tesla: A unit of magnetic induction.

torque: A rotary force; the force that causes rotation; the measure of a force's tendency to produce torsion and rotation about an axis.

Pre-Program Discussion Questions

1. What is an electric motor?
2. What is a DC motor?
3. How do motors function?
4. How do you think a magnet and an electric current figure into an electric motor?
5. How do you think one might measure the force of a motor (or motor force)?

Post-Program Discussion Questions

1. What is the foundation of an electric motor? Explain.
2. What is motor force?
3. Explain the significance of the left-hand rule within the context of motor force.
4. What do the two important motor effect equations — outlined in the film — measure or define?
5. What is a commutator and what role does it play in a DC motor?

Individual Student Projects

Deconstructing a Motor
Students can take apart an appliance or toy to locate, name, and examine the components of a motor. In the process, they apply and illustrate the physics principles at play in the motor's operation.

Newton's Third Law: Trying It Out

Expand on Newton's third law of motion, as mentioned in the film. Provide students with several simple experiments/activities that demonstrate how the law's premise materializes.

How Many Types of Electric Motors Are There?
Students research, explore, and compare and contrast different types of AC and DC electric motors. They create diagrams of motors to show how each one functions. Where possible, they apply physics concepts to describe their varied operations. Also, if appropriate, students may bring in models of these motors to demonstrate differences.

Group Activities

Building Motors…and Understanding How They Run
Select from several motor-making experiments that allow students to not only construct an electric motor, but also determine how they run. The following Web sites offer several such experiments (also reference the "Additional Resources" section):

- Build an Electric Motor: www.scifun.org/homeexpts/BuildAMotor.htm
- Build an Electric Motor: www.boyslife.org/hobbies-projects/projects/2909/build-an-electric-motor
- Building an Electric Motor: www.sciencebuddies.org/science-fair-projects/project_ideas/Elec_p009.shtml
- Electric Motor: www.eas.asu.edu/~holbert/wise/dcmotor.htm

Making Calculations: Motor Effect Equations
Provide students with examples of the motor effect equations highlighted in the film: measurement of magnetic field and measurement of the length of a coil placed in a magnetic field. Offer students practical problems to which they can apply these equations.

Applications: The Left-Hand Rule
Have students apply the left-hand rule through various electric motor-centered activities and/or experiments, for example:

- Cool Magnet Man: Motors: www.coolmagnetman.com/magmotor.htm
- Motor Effect — Rolling Bar: www.gcse.com/energy/rolling_bar.htm
- Moving Wires and Motors (scroll down to Fleming's left-hand rule): www.crocodile-clips.com/absorb/AP4/sample/DJFPh054.html

Internet Activities

All About Oersted and/or Newton

Students further explore the work and life of Hans Christian Oersted and/or Isaac Newton to create an annotated timeline or a biography of the experiments of either or both Oersted and Newton, as well as other discoveries and related work. Sites to jumpstart research include:

- About.com: History of Electromagnetism — Innovations Using Magnetic Fields: http://inventors.about.com/od/estartinventions/a/Electromagnets.htm
- Hans Christian Oersted: http://chem.ch.huji.ac.il/history/oersted.htm
- Isaac Newton's Laws of Motion: http://id.mind.net/~zona/mstm/physics/mechanics/forces/newton/newton.html
- Isaac Newton's Life: www.newton.cam.ac.uk/newtlife.html
- The Newton Project: www.newtonproject.sussex.ac.uk
- NNDB: Hans Christian Oersted: www.nndb.com/people/341/000104029/

Surveying Electric Motor Web Sites

Students locate and compare and contrast a variety of Web sites centered on electric motors. After logging on and using the sites' interactive tools, students rate them for things such as ease of use, quality of information provided, how easy content is to grasp, etc. Students create a site review for use by appropriate teachers and students. (Note: Some of these sites are included in this guide's "Additional Resources" section.)

Electric Motors: How They Work

Students log on to and read "How Electric Motors Work" (http://electronics.howstuffworks.com/motor.htm). Using this article as a model, students write a student-focused online article to describe how electric motors work, incorporating — in simple terms — physics principles. Students may pitch this article to the "How Stuff Works" editorial staff or to a similar online scientific site or journal for high school and college students. Students may also opt to describe how other electric motors work.

Assessment Questions

1: What does the left-hand rule indicate with regard to electric motors?

2: Draw a diagram that presents a simple DC electric motor's primary components (label these).

3: Build on the diagram in question 2 to explain how a DC motor works.

4: Which of the following reverses the current in a coil?
a) Magnet
b) Split-ring commutator
c) Brush

5: A unit that measures a magnetic field's strength is a _______________.

6: An electric motor
a) transfers charge into current.
b) transfers electrical energy into mechanical energy.
c) transfers a coil to a torque.

7: What causes a reduction of the motor force?

8: Outline the three "proportionalities" that reflect the variations of a motor force.

9: Two commutators in a DC motor
a) allow for the continuation of the current flow in the same direction.
b) allow for the motor to continue running.
c) allow for the reversal of a current's direction.

10: What is the most critical role of a torque?

Assessment Questions Answer Key

1: What does the left-hand rule indicate with regard to electric motors?

A: This hand rule is used to detect, in the case of an electric motor, the direction of the magnetic force that acts to move the conductor: this force is the motor force.

Feedback: Based on the electron flow model of an electric current, from negative to positive, a third variation of the left-hand rule indicates the direction of the magnetic force that acts to move the conductor. As the film describes … with fingers extended, place the left hand so that the thumb aligns in the direction of the current flow. Imagine the magnet's field, with its line emerging from the north pole of the magnet. Rotate the hand until the fingers point in that magnetic field's direction. If you push normally with your hand, the palm points in the direction of the force exerted on the conducting wire. This is motor force, the basis of the electric motor.

2: Draw a diagram that presents a simple DC electric motor's primary components (label these).

A: Student drawings should resemble the illustration found at "How Stuff Works" (http://electronics.howstuffworks.com/motor1.htm).

Feedback: A simple electric motor has the following components: coil, permanent magnets, brushes, split-ring commutators, axis, and armature.

3: Build on the diagram in question 2 to explain how a DC motor works.

Feedback: Student responses should reflect the following:

- DC motors have a magnet or magnets in fixed housing (permanent magnets).
- Motor housing fixes the magnets in place and determines an axis for a rotating coil.
- The coil rotates on the shaft held in place by sets of bearings in the motor housing.
- The coil will rotate at right angles to the magnets, and the plane of the coil will turn through the plane of the magnets.
- The number of turns in the coil increases the length of the wire in the field, which then increases the motor force.
- Direct current is carried to the coil, and away from it, by connecting through a pair of sliding carbon or metal brushes.
- The brushes slide against slip-ring commutators that are insulated from the shaft.
- With the split-ring commutators, the coil begins its rotation and approaches a point at right angles to the magnets. The current-delivering brush and the current-receiving brush pass across a small dead gap in the commutator, then begin delivering and receiving current to and from the opposite sides of the coil. The current reverses direction.
- The motor force now pulls downwards and upwards at first towards the center of the coil but as forces become unbalanced, they twist the coil further in its original rotational direction.
- These forces continue to pull the coil back towards the plane of the magnets, and then beyond the heading for a perpendicular position in the opposite direction where the split on the opposite side of the split-ring commutator switches the current once again.
- The coil continues to rotate; this process repeats itself hundreds, maybe thousands of times per second.

4: Which of the following reverses the current in a coil?
- **a) Magnet**
- **b) Split-ring commutator**
- **c) Brush**

A: Split-ring commutator
Feedback: The secret to a DC motor is a split-ring commutator. In the motor, the coil begins its rotation and approaches a point at right angles to the magnets. At that point, the current-delivering brush and the current-receiving brush pass across a small dead gap in the commutator, then begin delivering and receiving current to and from the opposite sides of the coil. The current reverses direction. The motor force pulls downwards and upwards at first towards the center of the coil, but as the forces become unbalanced, they twist the coil further in its original rotational direction.

5: A unit that measures a magnetic field's strength is a________________.
A: tesla
Feedback: A tesla is the value by which magnetic field (also called magnetic induction) strength is measured. The intensity of a magnetic field can be measured by placing a current-carrying conductor in the field. The magnetic field exerts a force on the conductor, a force dependent on the amount of the current and on the conductor's length. (One tesla is defined as the field intensity generating one newton of force per ampere of current per meter of conductor.)

6: An electric motor
- **a) transfers charge into current.**
- **b) transfers electrical energy into mechanical energy.**
- **c) transfers a coil to a torque.**

A: b
Feedback: Most motors translate electric power into rotary motion to perform an incredible variety of tasks. Electric motors usually convert more than 80% of the electric energy into mechanical energy.

7: What causes a reduction of the motor force?
A: Magnetic forces that are not at right angles to the electric current.
Feedback: Motor force is the force that is exerted on a conducting wire (use the left-hand rule in question 1 to understand how to identify this force's direction).

8: Outline the three "proportionalities" that reflect the variations of a motor force.
A: Motor force varies directly as the strength of magnetic field perpendicular to the conductor; it varies directly as the strength of the current; it varies directly as the length of the conductor inside the magnetic field.
Feedback: These three proportionalities can be combined to produce a single proportionality; a proportionality constant converts this relationship to an equation that helps to define motor effect.

9: Two commutators in a DC motor

a) allow for the continuation of the current flow in the same direction.
b) allow for the motor to continue running.
c) allow for the reversal of a current's direction.

A: a

Feedback: Assume the use of two commutators in a DC motor, one to deliver current into one side of the loop, a second commutator to carry electricity away, completing the circuit and allowing current to flow through the coil. Beginning with the coil in the magnets' plane, the motor force on each side of the wire provides the torque that pulls the coil on its shaft until the coil reaches a plane at right angles to the magnets' plane. But, the commutators don't allow the motor to start: they allow the current to run in the same direction and the motor force remains locked in balance. It is the split-ring commutator that propels motor force by allowing for the reversal of the current's direction.

10: What is the most critical role of a torque?

A: Torque twists the coil in the magnetic field until it reaches a balance point.

Feedback: If a coil is fixed along one axis, but is free to rotate, the force on each side of the coil twists the coil around its axis until the coil reaches a position where the two current-carrying sides of the coil are in a plane perpendicular to the plane of the magnets. The motor force on each side of the loop pulls outwards, away from the other force. The coil stops moving, balanced between two equal and opposite forces.

Additional Resources

BOOKS

Electricity and Magnetism, by Kyle Kirkland, Ph.D. Facts on File, 2007. ISBN: 978-0-8160-6112-9

Awesome Experiments in Electricity & Magnetism, by Michael A. DiSpezio. Sterling, 1999.
ISBN: 0806998199

Basic Electricity, by Nooger and Neville Van Valkenburgh. Prompt; 1st edition, 1995. ISBN: 0790610418

Basic Electricity: Reprint of the Bureau of Naval Personnel Training Manual, by Staff of the Bureau of Naval Personnel. Barnes & Noble Books, 2004. ISBN: 9780760752388

Electric Motor Handbook, by H. Wayne Beaty. McGraw-Hill Professional, 1998. ISBN: 0070359717.

Electric Universe: The Shocking True Story of Electricity, by David Bodanis. Crown, 2005.
ISBN: 1400045509

Handbook of Small Electric Motors, edited by W.H Yeadon and A.W. Yeadon. McGraw-Hill, 2001. ISBN: 978-0-07-072332-0.

Physics Demonstrations: A Sourcebook for Teachers of Physics, by Julien Clinton Sprott. University of Wisconsin Press; 1st edition, 2006. ISBN: 0299215806

Schaum's Outline of Basic Electricity, 2nd edition, by Milton Gussow. McGraw-Hill, 2006.
ISBN: 0071474986

WEB SITES

Charles Stuart University: NSW-HSC online — Motors and generators
http://hsc.csu.edu.au/physics/core/motors/2578/phy931.html

comPADRE: Digital Resources for Physics & Astronomy Education
www.compadre.org

The Electric Motor
http://resources.schoolscience.co.uk/CDA/14-16/physics/index.html

Exploratorium: Motor Effect
www.exploratorium.edu/snacks/motor_effect.html

Exploratorium: Stripped Down Motor
www.exploratorium.edu/snacks/stripped_down_motor.html

How Stuff Works: How Electric Motors Work
http://electronics.howstuffworks.com/motor.htm

HowThingsWork.Virginia.edu — Electric Motors
http://howthingswork.virginia.edu/electric_motors.html

HyperPhysics — Electric Motors
http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

IEEE — Everything You Wanted to Know about Electric Motors
www.ieee.org/web/education/preuniversity/tispt/lmotors.html

Institute of Physics: Teaching Resources — Episode 415: Electric motors
www.iop.org/activity/education/Teaching_Resources/Teaching%20Advanced%20Physics/Fields/Electromagnetism/page_4818.html

Magnet Man: Experiments with Motors
www.coolmagnetman.com/magdcmot.htm

MIT OpenCourseWare — Electricity and Magnetism
http://ocw.mit.edu/OcwWeb/Physics/8-02Electricity-and-MagnetismSpring2002/CourseHome/index.htm

Molecular Expressions: Electricity & Magnetism — Generators and Motors
http://micro.magnet.fsu.edu/electromag/electricity/generators/index.html

Motors & Drives
http://tristate.apogee.net/mnd/home.asp

National Science Teachers Association
www.nsta.org

NDT Resource Center — The Electric Motor and Magnetism
www.ndt-ed.org/EducationResources/HighSchool/Magnetism/electricmotor.htm

PBS: Tesla
How Do We Convert Electrical Energy into Mechanical Energy?
www.pbs.org/tesla/tt/tt05.html

Science Joy Wagon: The Physics Zone — Direct Current Electrical Motor
www.sciencejoywagon.com/physicszone/otherpub/wfendt/electricmotor.htm

Teacher Tube — A Simple Electric Motor and How It Works
www.teachertube.com/view_video.php?viewkey=dac4f3a6fb4458ca07c9

Try Engineering — All About Electric Motors
www.tryengineering.org/lessons/motor.pdf

Additional Resources from www.films.com • 1-800-257-5126

The Science of Electricity Poster
- **17" x 32" Poster**
- **Correlates to National Science Education Standards**
- **Item # 36854**

Recommended for grades 7-12. © 2006

Newton's 3rd Law Poster
- **17" x 22" Poster**
- **Item # 39208**

This is poster 8 of the 8-part poster series *Physics of Fun*. Recommended for grades 6-12. © 2008

Hybrid Auto Repair Series: Common Hybrid Components

- **DVD/ VHS #35527**
- **Preview clip online**
- **Close captioned**
- **Correlates to educational standards**
- **Includes viewable/printable instructor's guides.**

Hybrid vehicles are complex machines—help your students get to know them inside and out. This video guides viewers through the system components common to hybrid automobiles, including the battery pack, the electric motor, the internal combustion engine, the transmission, and the generator. (16 minutes) ©2007

Electricity and Electronics

- **DVD/ VHS #34798**
- **Preview clip online**
- **Close captioned**
- **Correlates to educational standards**
- **Includes viewable/printable instructor's guides.**

This ten-part series provides a comprehensive video guide to the study of electronics, ranging from the fundamental laws and principles of electricity at the atomic level to troubleshooting and repair of electronic components. Lively computer animation and hands-on demonstrations make these videos an ideal resource for the classroom. The series includes the following titles: *Electrical Principles • Electrical Circuits: Ohm's Law • Electrical Components Part I: Resistors, Batteries, and Switches • Electrical Components Part II: Capacitors, Fuses, Flashers, and Coils • Electrical Components Part III: Transformers, Relays, and Motors • Electronic Components Part I: Semiconductors, Transistors, and Diodes • Electronic Components Part II: Operation-Transistors and Diodes • Electronic Components Part III: Thyristors, Piezo Crystals, Solar Cells, and Fiber Optics • Electrical Troubleshooting • Electronic Circuit Repair.* A Shopware Production. (18-24 minutes each) © 2006

Electric Power on the Move

- **DVD #34288**
- **Preview clip online**
- **Correlates to national sceince educational standards**
- **Includes viewable/printable instructor's guide**

This *Science Screen Report* examines the production, transportation, and consumption of electricity. Using the Hoover Dam as an example of efficient hydroelectric power generation, the program illustrates how transformers raise or lower voltage to manageable levels and how electricity is specifically channeled to illuminate buildings, power devices, and propel vehicles. Vital electrical concepts are discussed, including the difference between alternating and direct current, the advantages of neon over filament bulbs, and the definitions and significance of ohms, volts, and amperes. Produced in association with the Accreditation Board for Engineering and Technology and the Junior Engineering Technical Society. (18 minutes) © 2004

Electricity and Magnetism

- **CD-ROM #10267 (Windows/Macintosh)**
- **Preview clip online**
- **Correlates to the National Science Education Standards developed by the National Academies of Science and Project 2061 Benchmarks for Science Literacy from the American Association for the Advancement of Science.**
- **Includes activity sheets**

Since the early experiments with electricity over two hundred years ago, scientists have made many discoveries that help explain its nature. These discoveries have linked many areas of science including static electricity, electric current, magnetism, and materials. In all areas of our life at home and at school we rely on electricity, which has become a crucial part of modern society. Electricity and Magnetism examines the principles involved and gives students an insight into this fascinating topic, covering such subjects as: Static electricity; Attraction/repulsion; Current electricity and electrical circuits; Measuring electricity—current, voltage, meters; Electrical calculations; Magnetism—materials, fields, rules, Earth's field; Field around a current-carrying wire; Link between electricity and magnetism—induction. © 1999

Energy I Video Library

- **DVD #30960**
- **Close captioned**
- **Correlates to educational standards**
- **Includes user guides**

Contains 22 video clips on forms of energy, nuclear energy, electricity, and magnetism:

- Fuel Cells
- Solar Energy
- Potential and Kinetic Energy
- Nuclear Energy Forms
- Nuclear Medicine
- Nuclear Submarines
- Electrical Energy
- The Body Electric
- Electricity Production
- Electromagnetism
- Lodestone
- Energy Production
- Chemical Energy
- Introduction to Nuclear Energy
- Natural Nuclear Reactions
- The Atomic Bomb
- Introduction to Electricity
- Harnessing Electricity
- High Wire Act
- Introduction to Magnetism
- Animal Navigation
- Earth as a Magnet

The *Energy I Video Library* is part of the complete Discovery Channel/Films for the Humanities & Sciences Science Video Library. © 2003