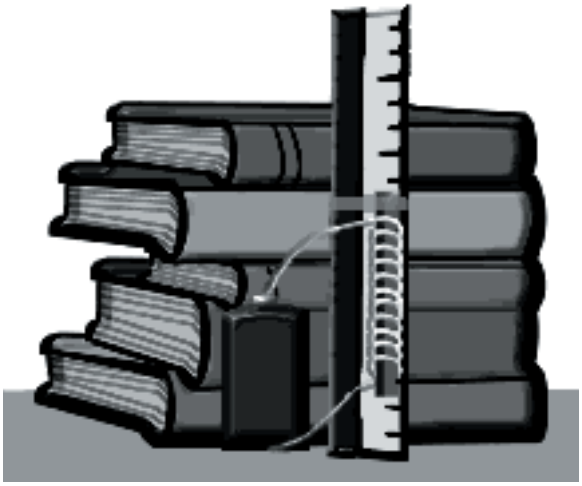
MAGNETS AND WORK

PLANNING YOUR EXPEDITION

Assign homework (see "For Your Planbook") before implementing the activity.

You will need a device from which the students can hang their electromagnets. You can approach this is in one of two ways: either provide clamps or some predetermined method of suspending the electromagnet or allow students to devise their own way of completing the task. (See picture below.)

As a companion to "Use Electricity to Make a Magnet" and "Build a Stronger Electromagnet" will help you and the students you teach conceptualize magnetic fields. It will encourage students to measure the force of the magnetic fields of the electromagnets they create. You may choose to use the electromagnets that they already constructed (Expeditions 7 and 8) or you may want to have the students build electromagnets as you discuss variables to be tested in this activity.



Students will be making the link between a magnetic field and energy as they convert energy to work. This is another way of thinking about the force that magnetic fields generate. Students will manipulate the strength of the magnetic field by changing the core material, adding or subtracting iron rods, or using another material altogether. Students will also be defining and distinguishing between energy and work. These concepts are difficult for students to grasp unless there is an experience that accompanies the information. Students will answer the following questions: How far does the magnet's influence extend? Can the magnetic field be used to do work? If so, how much work can the field produced by the electromagnet do, and what can we do to influence it?

Students will measure the mass of the items they are attempting to pick up with the electromagnet. This will give students practice in using balance scales and the metric system. This is a good place to review the concepts of mass, density, and volume since students will be using scales (see CD-ROM).

Choose either

1. After gathering their materials, students will set up the device you have designed for them to suspend their magnet (one that allows students to raise and lower it to complete various tests).

Or, 1. After gathering materials, students construct a device from which they can suspend their electromagnet (one that allows students to raise and lower it to complete various tests).

2. Students choose the item(s) they wish to work with and measure their mass before going any further with the Expedition.
3. Students are now ready to begin their investigation. They lower the magnet until their object is attracted to the magnet. Then, students measure the distance the object has been lifted.
4. Students use results to calculate how much work was done on the object by plugging their data into the formula w = f x d.
5. Encourage students to change the magnet to make it do more work and less work. They accomplish this by changing the core material or the amount of material (they can use two or more iron rods). Students again calculate the work that the magnetic field does and record all changes and answers in their Alpha Logs.
6. Students share their results and compare their methods and calculations with other groups and record the results of the conversations in Logs.

BACKGROUND INFORMATION

This activity introduces students to the concepts of energy, force, and work. For those students to whom you have already presented these ideas, demonstrating these concepts in a concrete way will enhance their understanding. It may help differentiate among the terms since they are words that students use every day; specifying the use of these words for science class may be difficult for some. Beginning with definitions and then applying the words deepens students' understanding of concepts that the words represent.

The definitions can be found in a standard physical sciences text. It is suggested, however, that students use one of the definitions that they looked up for homework. By doing so, you will be requiring the students to demonstrate their knowledge of the most appropriate definition for their particular task.

work: transfer of energy as an object is moved.

force: a push or pull exerted on an object.

energy: that which may be converted into work.

Mass is the measure of the amount of matter in an object. Weight is the measure of the amount of force gravity exerts on an object's mass. To calculate work being done, use the formula work (w) = force (f) x distance (d). Work is expressed in Newton-meters (Nm) or Joules (J); 1 Nm = 1 J. To find the force, multiply the mass by the conversion factor, 9.8 N/kg.

For example, the students' electromagnet generates a magnetic field that lifts a 5g object 10cm. Remember, students must convert mass to kilograms and distance to meters to use the formula. Students can refer to the CD-ROM for conversions.

5g = 1kg/1000g = 0.005kg

10cm = 1m/100cm = 0.1cm

w = f x d

w = (0.005kg x 9.8N/kg) x 0.10m

w = 0.049N x 0.10m

EXCURSIONS

Have students read "The Truth About Pyecraft" by H.G. Wells (see Appendix C). In a whole class discussion or short discussion paper, students will determine that Pyecraft was confused between mass and volume. By identifying that he was floating on the ceiling at the end of the story students will realize that he was still the same size although he had no weight. Pyecraft could have avoided this by defining of his terms before he asked for a magic solution to his weight problem.

SC.A.1.3.1-2,6, SC.D.2.3.1, SC.H.3.3.1-5

Have students brainstorm a list of songs, films, or television shows that have the words work, force, or energy in them. This will reinforce that these words are used in many and varied ways, and when doing science, one must be certain of the definition being used. When scientists communicate, use of words is vital to understanding of their work. Some examples: "Magnum Force," "I've Been Working On The Railroad," and "Force Ten From Navarone."

If you are still reading The Secret Life of Dilly McBean, discuss with students whether or not Dilly's hands are doing more work because they are magnetized. How do they know this? Can they prove it? Have students draw a picture of their favorite scene from the novel that in some way reflects their knowledge of magnets and magnetic fields.

SC.C.2.3.1-7, SC.H.3.3.1-4

Have students research the many ways that magnets are used to do work. Some examples to guide their thinking could be magnets as trash separators, magnets used in junkyards to separate metals and pick up compacted cars, or magnets as door latches. Students could prepare a poster presentation for the class to share their ideas and add to the general body of knowledge on magnetism. Each student, pair or students, or group of students sets up their posters and students are then encouraged to walk around the room and see what others have researched and how they have presented their findings. Posters should demonstrate that research was done in answer to the question "Where in real life do magnets perform work?" Posters should be visually attractive and include the information in both print and pictures. In this case, since you are creating a poster session for your classes, only posters will be allowed and all posters should be left up for other classes to view.

SC.C.2.3.1-7, SC.H.1.3.1-3, 6, 3.3.1-7

Magnets were used on the doors that separated water-tight compartments on the Titanic. This is an interesting connection between how magnets have been used and current science research. The sinking of the Titanic has been an event that has fueled much speculation among the general public as well as the science community. Recently, a scientific expedition attempted to find out why the Titanic sank so quickly. Students

could read articles about current efforts to find out more about the Titanic disaster. The Discovery Channel has a 2-hour video available on this subject.

SC.C.2.3.1-3. 3.3.1-4

FOR YOUR PLANBOOK: Magnets and Work

Suggested Time: 1 hour

Gear: Electromagnet or electromagnet materials from "Can You Build a Stronger Electromagnet?" or "Using Electricity to Make a Magnet," paper clips or other material that a magnet attracts, balance scale, masking tape, rulers

National Science Content Standards: A, B, E

Sunshine State Standards Benchmarks: SC.A.1.3.2, SC.C.2.3.1, SC.C.2.3.2, SC.C.2.3.4, SC.H.1.3.1, SC.H.1.3.2, SC.H.1.3.4, SC.H.1.3.5, SC.H.1.3.7, SC.H.3.3.4, SC.H.3.3.6

Homework: Have students define the words work, energy, and force using a dictionary (not a science book glossary). Since there are many definitions for these words, it may seem somewhat tedious, but instruct students to write down all definitions, counting them if there are more than three. Students will answer the following question: Which definition (that you wrote down) for each word do you think we will use in science class? Tell students to bring to class all definitions with the ones they choose underlined.

Homework Assessment: Your students will recognize that, although we use these words everyday, when the words are applied to specific tasks, or in certain situations, only one definition might suffice. Students will initially believe that these are "easy" words to define because they have heard these words all their lives. Because they have preconceived ideas of what the words mean, it may be difficult for students to apply the words properly and use them in the context of physical science. To successfully complete this assignment, students will have from 10-20 definitions of the word work; 5-10 definitions of force and the same for energy. They will have underlined the definition that matches those in the "Background Information" portion of this activity.

Assessment: Assign the following: Imagine that you are trying to explain this activity to a younger friend who is very interested in magnets. How will you explain what you have done? What will you say the purpose was for doing this activity? Why was it important to change the core of your magnet? Indicate the age of the person for whom you are writing. This assignment asks that students put into words what they have taken from this activity. The depth of their answer will depend upon how much *they* have learned rather than what *you* have taught, so all reasonable answers should be acceptable.

Have students draw a diagram of the device used to suspend the magnet, labeling all parts including the magnet, the items being picked up, and the measurement instrument. This will reinforce the concept of distance and force plus the fact that work is done by picking up paper clips or some other object(s).

Student Alpha Logs should indicate that students predicted outcomes before they proceeded with the investigation demonstrating that they have a good idea of the meaning of the words work, force, and energy. Logs should include a diagram of the device that students used (or developed) to complete their investigation indicating that they know how important it is for someone else to replicate their work. Questions should be answered in a way that shows you that students can use the work = force x distance formula; that they know which variables to "plug into" the formula.

Read aloud "Why Does the Knuckleball Behave That Way?" (from The New York Times Book of Science Literacy, Harper Perennial, 1992, ISBN 0-06-097455-9). Students will, in discussion in small groups, make the connection between sports and force, work, and energy.

MAGNETS AND WORK

Itinerary

Mass is the measure of the amount of matter in an object. Weight is the measure of the amount of force gravity exerts on an object's mass. To calculate work being done, use the formula work (w) = force (f) x distance (d). Work is expressed in Newton-meters (Nm) or Joules (J); 1 Nm = 1 J. To find the force, multiply the mass by the conversion factor, 9.8 N/kg.

Be sure that a definition for each of the words "work", "force", and "distance" are entered in your Alpha Log. As you work, enter all measurements and calculations in your Alpha Log, any questions that you have while doing this investigation and answers questions posed in the activity itself.

1. The materials manager will assemble everything needed to complete this activity: either the electromagnet you made in an earlier activity or the materials needed to make one; a device with which you can raise and lower your electromagnet or the materials to make one (see diagram); paper clips and other objects that are attracted to the magnet; a centimeter ruler; iron rods; insulated wire; and a balance scale.
2. Suspend your electromagnet from the magnet stand. Placing the paper clips (or other objects) on the bottom, slowly lower the magnet until they are attracted to the magnet. Measure the distance that the object traveled and enter this into the formula (w = f x d).
3. Using the balance scale, measure the mass of the objects in grams, convert to kilograms, and enter this data in your Alpha Log. Mass in kilograms times 9.8 N equals force. You are now able to calculate the amount of work done. How far does the magnet's influence

extend? Can the magnetic field be used to do work? If so, how much work can the field produced by the electromagnet do? What can we do to influence the magnetic field of the electromagnet? Complete all calculations and answers in your Log.

4. Now, using the answer from Step 3, modify your magnet so that it has a stronger magnetic field. Enter all data and calculations in your Alpha Log and answer the following question: How did you modify your magnet? If you make the statement: "Guess what? Magnetic fields can do work" and someone says to you, "Prove it!", what will you provide as evidence to back up your original statement? Enter this conversation in the Log.

5. Share what you have done with another group and record the results of this conversation in your Log.