MECHANICAL

Mechanical and Other Forms of Energy

Have you ever coasted from the top of a hill to the bottom on a bicycle or in-line skates without applying your brakes? Hopefully, even if you have not tried this yourself, you know that your speed at the top of the hill will be low, but will become increasingly faster as you roll down the hill. At the bottom of the hill, your speed will be extremely high, but with no more incline, you eventually slow down (before crashing into a tree or by-stander!). This example illustrates the effects of mechanical energy, or more specifically, the conservation of mechanical energy.

Just what is mechanical energy and what does it mean to *conserve* it? Mechanical energy is the sum of two other forms of energy: kinetic energy (energy of motion) and potential energy (energy of position). Mechanical energy has the unique property of staying constant (conserved) at all times. In other words, the energy of motion and the energy of position at any moment in time always add up to the same value. This concept is easier to understand if we return to our hill example. At the top of the hill, you have almost no kinetic energy since you are moving very slowly. But the force of gravity is encouraging you to roll down the hill and there is still plenty of hill yet to roll down, so you are full of potential energy. At the bottom of the hill, the situation is reversed. Your potential energy is nearly zero since the force of gravity cannot pull you down the hill any further; however, you are going very fast, so your kinetic energy value is large. There has been no change in mechanical energy from the top of the hill to the bottom, since increases in kinetic energy are offset by decreases in potential energy.

The concept of conservation of energy can be extended to different forms of energy as well. Energy is always converted from one form to another–it is never created or destroyed. This phenomenon has many interesting implications in the fields of physics, chemistry and engineering.

Under Pressure

Recommended grade levels: K-3

Goal: Students will demonstrate how the velocity of water coming out of a dam varies with the level of the water above where the water escapes.

Process skills:
Applying concepts
Collecting data
Making graphs
Observing

Frameworks: Force and Motion

Materials: (per student pair)
three large Styrofoam cups (at least 16 oz.)
one sharp pencil
one yardstick
masking tape
water

Teacher background information:
Water coming out of a hole near the bottom of a dam has a much higher speed than water coming out of a hole near the top. The equation describing this principle is named Torricelli's Law, after the 17th century Italian scientist who first discovered it. Oddly enough, the pressure is independent of how much water is in the dam, or how big an area it covers. This effect is very important in deciding how and where to build hydroelectric dams.

Procedure:
Student pairs will:
1. Poke one hole in three different cups at different heights using the sharp pencil. (Teacher may need to do this for younger students.)
2. Place a cup on the edge of a wall, platform, or ledge. This edge is the starting line.
3. Fill the cup with water while one student places a finger over the hole.
4. Stand behind the starting line and remove their finger from the hole on the cup.
5. Mark the water landing point with a piece of masking tape.
6. Record the distance from the starting line to the landing point.
7. Repeat steps 2-7 with different cups until students have tested all three heights. Graph results to compare trajectory points produced by different cups. (Younger students may construct a class graph while older students may construct individual graphs).

Discussion:

1. How did the placement of the hole in the cup affect the distance the water traveled?
2. Which hole made the water project the farthest?
3. Where would engineers want water to come out of a dam to produce the greatest possible amount of energy?

Extension:

1. Demonstrate what happens when there are three holes at varying heights in the same cup. (A gallon milk jug can be used.)

Teacher resources:

Cole, Joanna. *The Magic School Bus at the Waterworks*
Gr. K-5. Ms. Frizzle takes her class on a fieldtrip to the waterworks where they experience the water purification system from the inside.
ISBN: 0-590-40360-5

Rauzon, Mark J. and Bix, Cynthia Overbeck. *Water, Water, Everywhere*
Gr. K-3. This book conveys the marvel of our "water planet", the importance of water in the life cycle, and the urgency of protecting our limited resource.
ISBN: 0-87156-598-6

Sullivan Hill, Lee. *Dams Give Us Power*
Gr. 3-6. This book introduces readers to dams, their purposes, and how they may be built. Illustrated with photographs including all important dams in the Midwest and a mill with water wheel.
ISBN: 1-575-5-0230-4

Paddle Wheel Boat

Recommended grade levels: K-6

Goal: Students will gain knowledge of how energy can be stored and released by building a model (rubber band-powered paddle boat).

Process skills:
Controlling variables
Making models
Observing

Frameworks: Force and Motion

Materials: (per student)

one cork
one 1/2 gallon cardboard milk carton
one 2 liter plastic pop bottle
two pencils
rubber bands
scissors
knife*
stapler or tape
pool, pond, large tray of water, or section of rain gutter

* *Before starting this activity, the teacher should use the knife to cut four evenly-spaced slits in the cork.*

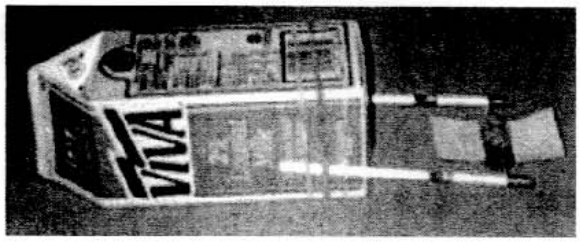
Teacher background information:
The paddle wheel boat is a good example of how energy can flow through a system. When a student winds the rubber band up, potential energy is stored in the form of a stretched rubber band. When the boat is released on the water, the rubber band gives up its energy to the cork paddle wheel, causing it to spin. The paddles' contact pushes the water backwards, moving the boat forward.

Note: *For tips on how to obtain large numbers of milk cartons, see the teacher background information for "Water Powered Boats." Packages of corks frequently can be found in hardware or craft stores.*

Procedure:

Students will:

1. Staple or tape the top of the carton shut.
2. Wrap three or four rubber bands around the bottom half of the carton, then slide two pencils under the rubber bands on two opposite sides of the milk carton. They should be placed so that half the length of the pencils extend beyond the carton.
3. Cut two paddles from the plastic bottle. The exact size of the paddle will depend on the size of the cork used. In general, a square with sides the same length as the cork will work well.
4. Slide each of the paddles into two opposite slits in the cork and slide one rubber band into the two remaining slits. (What they should have then is a rubber band loop at both the top and bottom of the cork, with the rest of the rubber band gripped by the cork.)
5. Mount the cork paddle wheel by slipping one loop of the rubber band over each pencil. Their boat is now complete.
6. To make the boat move, wind the paddle up and place the boat in the water. The direction the paddle is wound will determine whether the boat goes forward or backwards. Students should try both directions.



Discussion:

1. What makes the boat move?
2. Can the design of the boat be improved? How?

Extensions:

1. Have students make boats with other sizes of milk cartons.
2. Have students design a car or toy powered by a rubber band.

Teacher resource:

Edom, Helen and Usborne, Kate Woodward. *The Usborne Book of Science Activities-Volume 1* Gr. 1-6. This book contains a section on experimenting with water, including an activity on water power. It also provides descriptions of water wheels, water-powered boats, water cycle, and hydro-electric dams.
ISBN: 0-7460-0698-5

Water-Powered Boats

Recommended Grade Levels: K-6

Goal: Students will gain knowledge of propulsion in a reaction-driven vessel by experimenting with a model water-powered boat.

Process skills:
Controlling variables
Making models
Observing

Frameworks: Force and Motion

Materials: (per student or student group)
one 1/2 gallon cardboard milk or juice carton
scissors
one straw
one large paper or Styrofoam cup
one large plastic tray of water, plastic swimming pool , or section of rain gutter

Teacher background information:
The water-powered boat is a reaction-drive vessel, so called because it moves forward in reaction to the water flowing out the back. This is the same principle used by rockets. The rocket engines push high velocity gas in one direction, and the rocket travels in the other direction. After the students finish this activity, you might wish to display a picture or diagram of a rocket (a Saturn V or a space shuttle are good examples) to illustrate the similarities. Alternatively, this activity could be done as part of a unit on astronomy, space, or space travel. More down-to-earth examples of a reaction-drive vessel are jet skis and jet airplanes. A water-propelled rocket, available at toy stores, is a good demonstration model.

If a large swimming pool or pond is available nearby, the students can do time-and-distance measurements on their boats. Some boats may have problems with water leakage. The students can be encouraged to experiment with ways to fix this. Chewing gum, duct tape, or plastic or polymer clay can be used.

Note: *Younger students may have difficulty making holes in the bases of the milk cartons. A hole punch may help, or the teacher can make holes for them. Another option is to do this activity with an older class, or as part of a Family Science Night.*

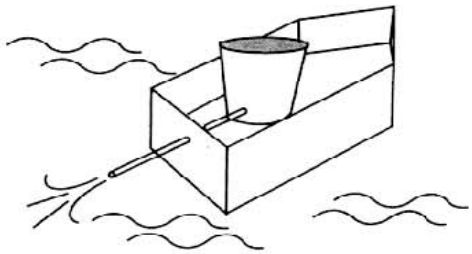
Finding a large supply of one-half gallon milk cartons can be a challenge. If a nearby town has a dairy, it is possible to buy new, clean cartons from them. Failing that, a local

grocery store could put you in touch with their dairy product distributor. The school's milk supplier is another potential source. You could also ask each student to bring a clean, used carton from home. For a chemical-powered reaction-drive see Extension 3.

Procedure:

Students will:

1. Make the hull of the boat by cutting the milk or juice carton in half lengthwise. They should leave the pointed front (or bow) intact.
2. In the rear (or stern) of the boat, make a hole near the bottom just big enough for a drinking straw.
3. Poke another hole, for a drinking straw, near the bottom of the cup.
4. Set the cup into the boat.
5. Insert a plastic drinking straw so that one end sticks into the cup and the other end protrudes from the boat's stern. Be sure the end of the straw is coming out of the boat's stern.



6. Place their boat in a few inches of water.
7. Fill the cup with water and hold a finger over the end of the straw.
8. Remove their fingers and the boat will move across the surface of the water.

Discussion:

1. Why does the boat move?
2. What happens when the cup runs out of water?
3. How was the force that moved the boat created?

Extensions:

Have students:

1. Make a twin-hulled boat (called a catamaran) by fastening two cartons together, with each hull holding one or two cups for power.
2. Experiment with straws that have a larger diameter on different sizes of cups and cartons.
3. Experiment with a foam-powered boat. Alka-Seltzer and water, or vinegar and baking soda can be used to produce the foam. They will need to experiment to find the correct proportions. The top of the cup must be sealed off with plastic wrap and a rubber band.

Teacher resource:

Gibson, Gary. *Making Things Float and Sink*
Gr. K-6. This book is part of the *Science for Fun* series. It includes simple projects and color illustrations. Readers are guided in analyzing text and then are offered more activity ideas.
ISBN: 1-56294-617-X

Spinning Fountain

Recommended grade levels: K-6

Goal: Students will investigate kinetic energy by observing and experimenting with a model spinning fountain.

Process skills:
Applying concepts
Making models
Observing

Frameworks: Force and Motion

Materials: (per student group)
two 2-liter plastic drink bottles
one 2-hole stopper to fit the neck of the bottle
two bendable plastic straws
string

Teacher background information:
This activity uses the same principle as "Water-Powered Boats" (p. 63) and makes a good companion activity. Like the boat, the fountain moves in one direction because the water moves in the other. Some water sprinklers work in a similar manner.

Note: *Consider conducting this activity outside and suspending the bottle from a branch or gym equipment.*

Procedure:
Student groups will:
1. Cut out the bottom of a plastic 2-liter bottle.
2. Cut the straws 1/4 in. from the edge of the bendable part on both ends.
3. Insert the straws into the stopper, creating two spouts. **(See Figure 1.)**
4. Insert the stopper tightly into the mouth of the bottle. The straws should be bent according to **Figure 1**.
5. Fill the spare bottle with water.
6. Suspend the bottle with the string. As it is being filled with water, they should block the ends of the straws with their fingers so no water pours out of the suspended bottle. **(See Figure 2.)**
7. Release their fingers from the straws when the bottle is full. The bottle will spin.

Discussion:
1. What source of energy caused the bottle to turn?

Extensions:

1. Define a turbine and discuss the different regions of the United States that rely on water power to turn turbines.
2. Visit a hydroelectric power plant if there is one in your area.

Teacher resource:

White, Larry. *Water*

Gr. 3-6. This series provides simple projects that rely on easily obtained materials such as string, paper cups, coins, cardboard, bottles, balloons, coat hangers, and paper clips. All experiments are indexed.

ISBN: 1-56294-472-X

Figure 2.

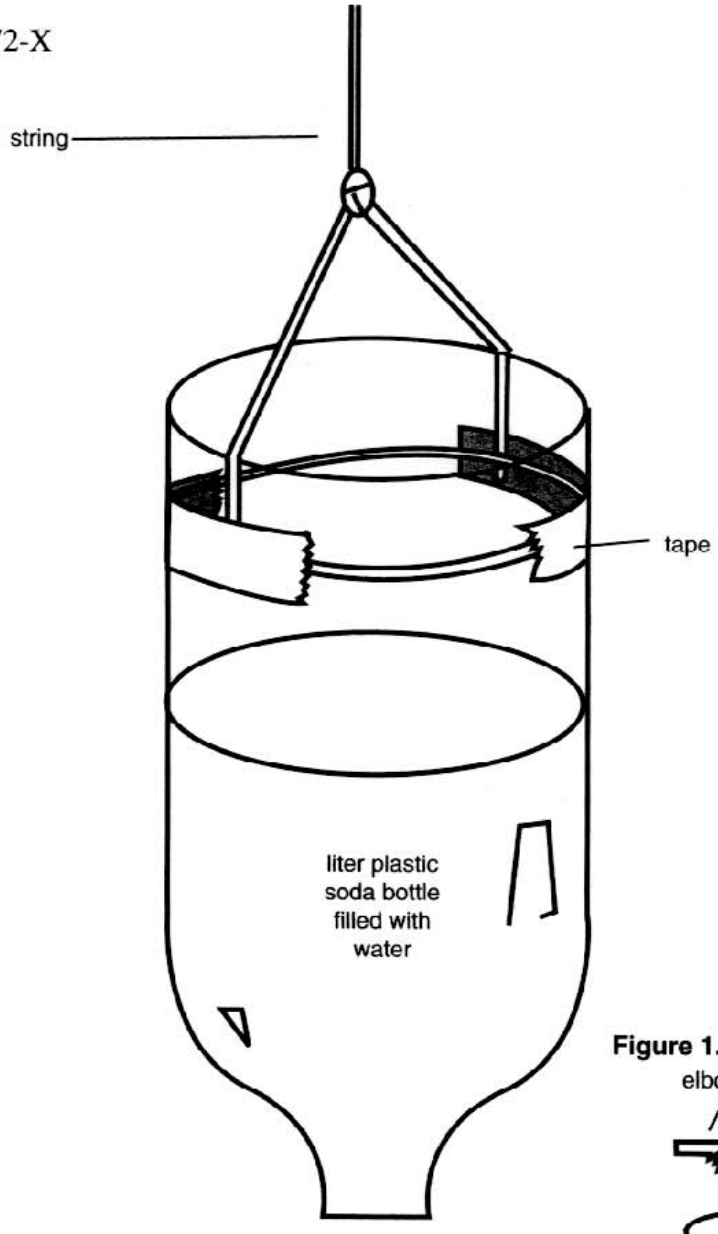
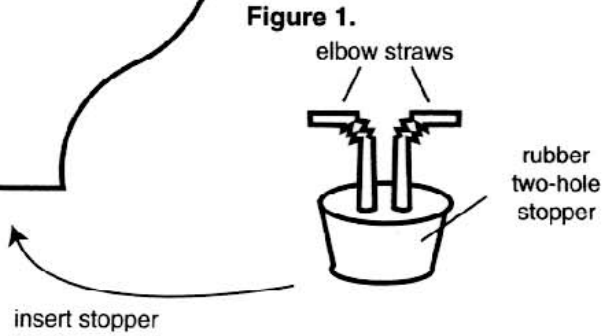


Figure 1.



Water Makes the Wheel Go Round

Recommended grade levels: 2-6

Goal: Students will be able to explain that water power is energy produced from falling or running water.

Process skills:

Collecting data
Controlling variables
Making graphs
Measuring
Observing

Frameworks: Force and Motion

Materials: (per student group)

two chairs
one plastic pail
four 4 oz. paper cups
one metric ruler
one 1/2 gallon paper milk carton
one large pan to catch water
scissors
red marker
stapler
tape
one 1/2 inch wooden dowel, 100 cm. long
one large Styrofoam cup (16 oz. or larger)

Teacher Information:

In this activity, students build and attempt to optimize a water wheel. This can be done as a stand-alone activity, or it can be followed by "Water Makes the Weight Go Up," (p. 69) in which the wheel is used to make a water-powered winch.

Procedure:

Student groups will:

1. Cut two cardboard strips, which measure 30 cm x 6 cm, from the milk carton.
2. Place the two strips of cardboard perpendicular to each other at their midpoint and staple at the intersection. (This forms a plus sign.) The staples should be placed near the edges, not in the center.
3. Punch a hole in the center of that intersection just large enough to force the dowel through. The cardboard wheel should be positioned towards the middle of the dowel as shown in **Figure 1.** Then tape the dowel to the wheel so that they turn together.
4. Use the red marker to color the outside of one of the cups.
5. Attach a paper cup to the end of each cardboard strip using a stapler.
6. Place the dowel so that each end rests on the seat of a chair. Tape a strip of cardboard over each end of the dowel on the chair to hold the dowel loosely in place.
7. Punch a small hole in the bottom of a large Styrofoam cup. Fill it with water, blocking the hole with a finger so none of the water spills.

8. Hold the large cup over the water wheel so that the falling water makes it turn. Allow the water to fall for one minute and count the number of spins that the waterwheel makes in this time. Record the number of spins on a data sheet. **(See Figure 2.)**
9. Experiment with different ways to improve the water wheel. Suggested changes: Restaple the cups in different positions or cut the cups into different forms. Each time a change is made, describe it on the data sheet, and record how many turns the wheel made in one minute.

Figure 1.

Figure 2.

Discussion:

1. What makes the water wheel turn?
2. How many times per minute did your water wheel turn in your first trial?
3. What was the difference in the number of turns between your fastest and slowest designs?

Extensions:

1. Have students graph results.
2. Have students increase the size of the hole in the Styrofoam cup, then predict, perform experiment, and discuss results.

Teacher resources:

Ardley, Neil. *Bridges*
Gr. 3-5. This is a book that introduces children to engineering and construction practices. Each book has a historical overview of the topic, information on how to plan and execute construction of the structures, and science experiments relating to various stages of the project.
ISBN: 0-944483-75-5

Sullivan Hill, Lee. *Dams Give Us Power*
Gr. 3-6. This book introduces young readers to dams, their purposes, and how they may be built. It includes photographs including all important dams in the Midwest and a mill with a water wheel.
ISBN: 1-575-5-0230-4

Water Makes the Weight Go Up

Recommended grade levels: K-6

Goal: Students will be able to explain that water power can be used to perform useful work.

Process skills:

Collecting data
Controlling variables
Making graphs
Measuring
Observing

Frameworks: Force and Motion

Materials: (per student pair)

water wheel from "Water Makes the Wheel Go Round" (include mount and water pan)
tape
scissors
one large Styrofoam cup (16 oz. or larger)
string
small, heavy weights
paper clip, plastic egg, or small bag (See teacher background information)

Teacher background information:

In this activity, students use their best water wheel design from the "Water Makes the Wheel Go Round" activity (p. 67–abbreviated as "Wheel" from now on) to make a simple machine–the water-powered winch.

The weights used in this activity are dependent upon the imagination and supplies of the teacher. Although lead fishing weights are ideal, students should not handle objects containing lead. Newer fishing weights are often plastic-covered and are safe to use. Steel washers and hex nuts also work well, as do matchbox cars, small stones, or weights from a balance scale.

There are many ways to attach weights to the string, depending on which weights have been chosen: a paper clip can be bent into a double-ended hook, with the string tied to the hook at one end. A hollow plastic Easter egg (the kind that splits into two pieces) can be used by loading the inside with weights and clipping the egg onto the string; or a small plastic bag can be tied onto the string and loaded with weights.

One possible approach for this activity would be to provide the class with a box of supplies and allow the students to decide which weights to use and how to attach them to the string.

The key observation of this activity is that the more weight you add, the slower the wheel turns. When there are no weights on the string, all of the energy from the falling water goes into spinning the water wheel. After the first weight is added, some of the energy from the falling water goes into lifting the weight. When more weight is added, more energy is used to lift it.

Procedure:

Student pairs will:

1. Select their best water wheel design from "Wheel." Slide the wheel onto the dowel and place the dowel on two chairs or tables, as described in "Wheel."
2. Cut a length of string long enough to reach from the dowel to the ground and securely tape one end of the string to the dowel.
3. Hold the large cup over the water wheel so that the falling water makes it turn. Observe how much time it took for the string to be wound up on the dowel and record this time.
4. Unwind the string from the dowel and add a small weight to the end of it. Repeat Step 3. Do this several times, each time observing how much time it takes for the string to wind up on the dowel. As they add more weight to the string, it may be necessary to use more than one cup of water to wind the string completely up.

Discussion:

1. Where does the energy come from to lift the weights?
2. How does adding weights change the behavior of the wheel?
3. Why do you think this happens?

Extension:

1. Have students graph the results.

Teacher resource:

Edom, Helen and Usborne, Kate Woodward. *The Usborne Book of Science Activities-Volume 1* Gr. 1-6. This book contains a section on experimenting with water, including an activity on water power. It also provides descriptions of water wheels, water-powered boats, water cycle, and hydro-electric dams.
ISBN: 0-7460-0698-5

An Uplifting Experience

Recommended grade levels: 4-6

Goal: Students will observe wind by building a model.

Process skills:
Applying concepts
Observing
Reasoning

Frameworks: Force and Motion

Materials: (for whole class demonstration)
one candle (or lamp)
match
soap bubbles and bubble wand
aluminum foil
one pie tin
safety goggles (*recommended*)

Teacher background information:
When a candle is lit, the chemical energy stored in the wax molecules is released. The chemical energy is changed to heat which warms the air around the flame. The warmer air is less dense than the surrounding air and starts to rise as it's heated. This creates a convective current.

Note: *The use of the candle makes this activity best suited for a teacher demonstration. However, a high-wattage lamp (plant light, heat lamp, solar lamp), may be substituted for the candle, allowing the students to perform it for themselves.*

Procedure:
The teacher will:
1. Make a holder for the candle with the aluminum foil.
2. Place the candle in the foil holder in the pie tin to provide a safe working area.
3. Blow some soap bubbles toward the unlit candle. Have students observe what direction the bubbles move.
4. Light the candle.
5. Gently blow some soap bubbles towards the flame.
6. Watch the directions of the bubbles as they near the flame.

Discussion:
1. What happened to the soap bubbles as they got nearer to the flame?
2. Why did the bubbles rise?
3. Where did the heat come from?

Wind Watching

Recommended grade levels: K-3

Goal: Students will comprehend wind as a source of energy to do work.

Process skills:
Communication
Observing
Predicting

Frameworks: Force and Motion

Materials: (for whole class demonstration)

one clean aquarium (*substitution: a cardboard box with a piece of glass or Plexiglas)*
one heat lamp (*substitution: candle*)
small bowl of ice
oak tag
waxed paper
matches

Teacher background information:
In Earth's equatorial region, the sun's light is strong and warms the air. Warm air is less dense than cool air, so the warm equatorial air rises and cool air flows down from the poles to replace it. Wind and solar energy are shown to be linked.

In this experiment the heat lamp and ice create a model Earth to show this process.

Procedure:
1. Collect student ideas about what wind is and does.
2. Students will place the small bowl of ice in one end of the aquarium.
3. Teacher will mount the heat lamp above the aquarium at the opposite end.
4. To make a small amount of clean smoke, the teacher will roll waxed paper into a tube, light it, and let it burn for a few moments before blowing it out.
5. Teacher will place the smoking end of the waxed paper above the bowl of ice.
6. Teacher will place an oak tag lid over the aquarium with two holes–one over the heat lamp and one over the waxed paper location.
7. Students will verbalize their observations.

Discussion:
1. Describe how the air feels in both ends of the aquarium.
2. What happens to the warm air?

Extensions:

1. Have students make wind socks with paper lunch bags and tissue paper streamers. Go outside to observe the effects of wind on the wind sock.
2. Discuss why the wind blows at a greater or lesser velocity.
3. Discuss how tornadoes are created.

Teacher resources:

Watts, Bernadette. *The Wind and the Sun: An Aesop Fable*
Gr. K-3. The wind and the sun set a test to determine which of the two is stronger: the winner will be the one who can remove the coat from a traveler's back.
ISBN: 1-55858-162-6

Weather Vanes

Recommended grade level: K-3

Goal: Students will be able to identify the direction from which the wind is blowing.

Process skills:
Collecting data
Making graphs
Observing

Frameworks: Force and Motion

Materials: (per student or student group)
one magnetic compass
one pencil with eraser
one straight pin
one plastic straw
one feather
sidewalk chalk
tape

Teacher background information:
When relying on wind to produce energy, one uncontrollable factor is the direction from which the wind is blowing. Windmills, hot air balloons, and sailboats, for example, all are dependent on the direction of the wind.

Procedure:
1. Students will draw a compass rose on the sidewalk in the correct position using the magnetic compass. **(See Figure 1)** Talk with students about the cardinal directions.
2. Teacher will explain that students will build a device, called a weather vane, to indicate the direction of the wind.
3. Students will tape the feather to one end of the straw so that the feather points along the long part of the straw.
4. Students will push the straight pin through the center of the drinking straw, attaching it to the top of a pencil eraser. **(See Figure 2)** This is a weather vane.
5. Students will take the weather vane outside and will use the compass rose to test the direction from which the wind is blowing.

Figure 1.

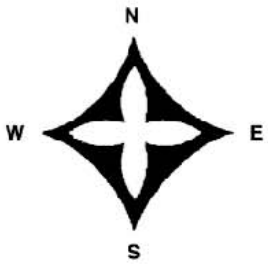
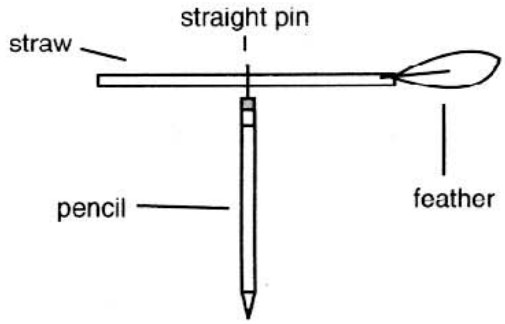


Figure 2.



Discussion:

1. How did you know from which direction the wind was blowing?
2. Does a weather vane tell us anything about the speed of the wind?
3. If the breeze is very slight, can you tell from which direction the wind is blowing?
4. How would the direction of the wind affect windmills, wind turbines, or other wind-powered objects? What happens if the wind shifts?
5. Can the direction of the wind be predicted far in advance?

Extensions:

1. Have students test wind direction several times during the day or week and graph the results.
2. If the direction of the wind can not be predicted or controlled, how must we be prepared to respond to changes in the direction of the wind? (eg. Windmills and wind turbines rotate to capture the wind, and sailboats have booms/masts that pivot.)

Teacher resource:

Dorros, Arthur. *Feel the Wind*

Gr. 1-2. This book explains what causes wind and how it affects our environment. Instructions for making a weathervane are included.

ISBN: 0-06-445095-3

Building an Anemometer

Recommended grade levels: 4-6

Goal: The students will record the variation in wind speed over time.

Process skills:
Collecting data
Hypothesizing
Making graphing
Measuring

Frameworks: Force and Motion

Materials: (per student group)
one disposable plastic plate
stapler
one stick- approximately 1" x 2", 24 inches long
one nail
four paper cups with handles
stopwatch

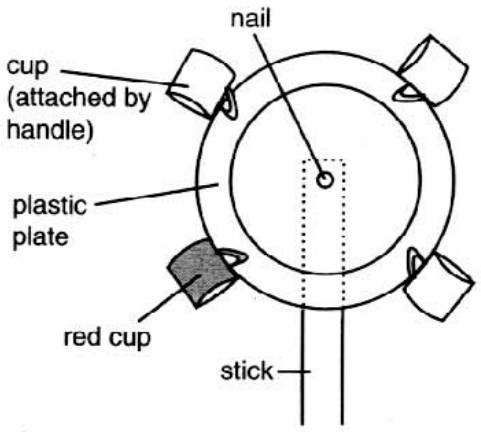
Teacher background information:
Today there is a growing interest in using the energy of the wind to generate electricity. For wind to be a dependable source of energy it must be steady and strong over long periods of time.

Before a wind generator is built, studies are made of how reliable the local winds are. In this activity, students will be able to conduct a similar study of the winds in their community.

Procedure:
Students will:
1. Color one of the cups red, then staple the cups to the plastic plate by the handles. All the cups should face the same way. **(See Figure 1)**
2. Make a hole in the center of the plate large enough that the plate can spin on the nail. Insert the nail through the hole and pound the nail into the top of the stick.
3. Place the stick in the ground outside.
4. Use the red cup to count how many times the plate turns in the wind. Count the turns in one minute. Multiply by 60 to get the approximate speed per hour. Have students repeat this activity several times in a day, or each day for a week.

Discussion:
1. Did the wind speed stay the same each day?
2. How could wind speed be used to generate energy?
3. Would this be a good site for a wind-powered electrical generator?

Figure 1.



Extensions:

1. Discuss how wind affects our life (e.g. as an energy source, the weather, or clothes on a laundry line).

Language Arts

1. Read a poem about wind to the class or have students write or find poems.
2. Have students write about where they would build a wind generator. Is Nebraska a good area? Tell why.
3. Have students describe the wind in writing.

Math

1. Have students graph the data.
2. Have the students make up story problems involving wind speed. Have them exchange problems and solve.

Teacher Resource:

Gardener, Robert & Webster, David, *Science Projects about Weather*
Gr. 4-6. A collection of 22 activities, organized into 7 chapters, that help students understand weather phenomena and forecasting. Each experiment is preceded by an introduction and a clear statement of purpose. Most experiments are done with materials that are readily available.
ISBN: 0-89490-533-3

Wind-Powered Vehicles

Recommended grade levels: 4-6

Goal: Students will experiment with model wind powered vehicles to determine efficiency of energy use.

Process skills:

Classifying
Collecting data
Controlling variables
Estimating
Making graphs
Making models
Observing
Predicting

Frameworks: Forces and Motion

Materials: (per student pair)

ten straws
four round beads (diameter of the hole must be larger than that of a straw)
one sheet of 8.5" x 11" paper
straight pins
paper clips, multi-link cubes or other non-standard units of measurement (for grades K-2)
yard or meterstick, tape measure or ruler (for students grades 3-6)

Teacher background information:

The sail was an early invention that allowed humans to harness the power of the wind. The wind did work on the sail, causing it and the ship to move. Until the creation of coal-fired engines, ships with sails were the fastest way humans could travel. Today sailboats are mostly pleasure craft, but people's use of wind for work continues. Wind-powered water pumps are a familiar sight in Nebraska, and the feasibility of wind-generated electricity is being researched.

Procedure:

1. Explain that students will create vehicles propelled by wind.
2. Students will construct vehicles, in any manner they choose, by using all the materials provided. Straws and paper may be cut as desired, but all pieces must be used. An unlimited number of straight pins may be used. **(See Figure 1.)**
3. On a large floor space, mark a starting point. A large table makes a useful alternative.
4. Allow students a chance to practice strategies to move their wind-powered vehicles. (Possible strategies: body position, number of people blowing on a vehicle or a "big puff" vs. a "steady stream of air,".)
5. Students will predict and teacher/students will record predictions of how far each vehicle will travel in three breaths.
6. From the starting point, allow students to use three breaths to move their vehicle as far as they can. Once they have started blowing, they may not touch the vehicle for any reason. **(See Figure 2.)**

7. Students will measure and record distances with standard or non standard measuring devices, as appropriate for their grade level. The teacher may want to record individual results for younger students.
8. Students will graph team results using a form appropriate to the grade level of the students (e.g.; bar graph at grade 3, line graph at grade 4, comparative line graphs at grade 5, or box and whisker plot at grade 6).

Figure 1.

Figure 2.

Discussion:

1. What work did the wind energy do?
2. Why did some vehicles go farther than others?
3. If you were going to create a second vehicle, what changes would your team make?
4. What kind of change of energy occurred?

Extensions:

Have students:

1. Alter their first vehicle or create a second vehicle. They may want to make a record of what their first vehicle looked like. One method is to photocopy the base of the wind mobile.
2. Explore a variety of techniques to propel the vehicles (e.g. blowing through a straw, using a paper fan or an electric fan).
3. Experiment with their vehicles on a variety of surfaces (e.g. carpet, tile, and cement).
4. Explore different measurement techniques and graphing forms. Present their data, analysis, and conclusions to classmates.

Teacher resource:

Jennings, Terry. *Flying and Gliding*
Gr. 2-4. This book explores the properties of air, and the role air plays in flying and gliding.
ISBN: 0-817239596

Building a Wind Turbine

Recommended grade levels: 4-6

Goal: Student will investigate how wind energy can be harnessed to do work.

Process skills:
Applying concepts
Making models
Observing
Predicting

Frameworks: Force and Motion

Materials: (per student or student pair)

one ruler
one 12-inch square of lightweight cardboard
one 14-inch piece of coat hanger wire
two squeeze bottle tops (*see teacher background information*)
one thumb tack
one plastic straw
three corks
string
tape

Teacher background information:
Wind is air in motion and has kinetic energy. This energy can be used by wind turbines to do useful work. Many farms in Nebraska use the wind to operate water pumps. Research is also being done on how to use the wind to generate electricity.

Note: *The squeeze bottle tops needed are not the dishwashing soap-type with a pillar running through the center of the assembly. Instead, you need the hollow-cone type found on some brands of glue.* **(See Figure 1)**

Procedure:
Students will:

1. Draw lines between the opposite corners of the cardboard (two diagonals). **(See Figure 2.)**
2. Cut a little more than 1/2 way along each line, towards the middle, then bend one section from each of the four corners forward so that the points are all at the center of the square. The direction of each "wing" formed must be in the same direction as the others.
3. Place a thumb tack through the center of the paper pinwheel and attach it to a cork.
4. Insert one end of the wire into the other end of the cork, then slide one of the cone-shaped bottle tops on the wire up to the cork so that the larger end of the top touches the cork.

5. Slide the straw up to the cone bottle top and then slide the second bottle top on the wire up to the straw so that the small end of the cone bottletop touches the straw. **(See Figure 3.)**
6. Tie the string to the second cork as illustrated in **Figure 3.**
7. Place the second cork on the free end of the wire.
8. Tie the third cork to the end of the string.
9. Predict what will happen in the wind and then test their predictions by taking the wind turbine outside into a strong breeze and holding turbine by the straw.

Figure 1.

Figure 2. (Before folding corners)

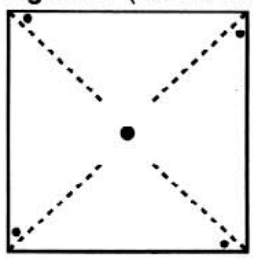
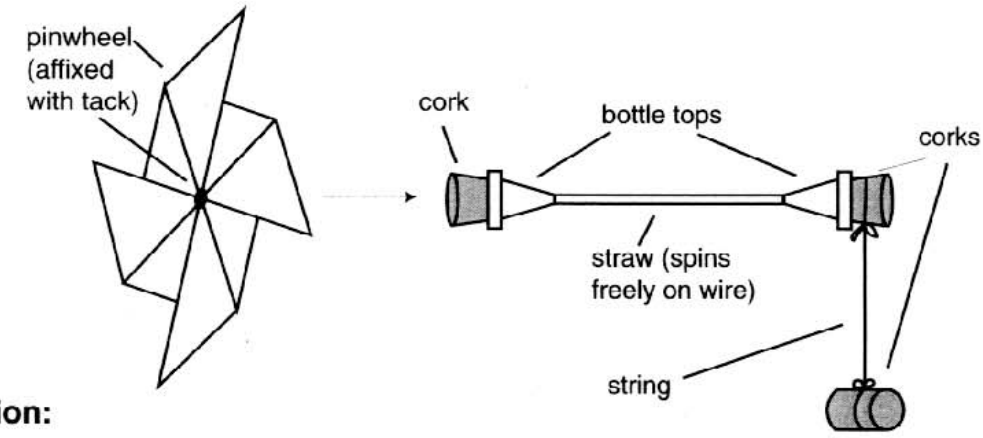


Figure 3.



Discussion:

1. Were your predictions correct?
2. What caused the turbine to turn?
3. When would a turbine be able to generate the most energy?

Extensions:

Have students:

1. Draw or construct an imaginary invention that uses wind power.
2. Demonstrate or explain how the device would work.

Teacher resource:

Rickard, Graham. *Wind Energy*

Gr. 4-6. This book discusses how today's modern wind turbines have developed from the windmills of the past and how techonology relating to wind power continues to develop.

ISBN: 0-08-680711-1

Grain Auger

Recommended grade levels: 4-6

Goal: Students will construct a simple screw-type machine, called a grain auger.

Process skills:
Measuring
Observing

Frameworks: Forces and Motion

Materials: (per student or student group)
- one plastic pop bottle
- one wooden dowel (3/8" diameter, 18" long)
- scissors
- pen
- cardstock
- tape
- one large bowl
- one small bowl
- puffed wheat or rice cereal

Teacher background information:
Using simple machines allows a person to accomplish a job they might not otherwise be able to do. There are five classes of simple machines: levers, inclined planed, gears, pulleys, and screws.

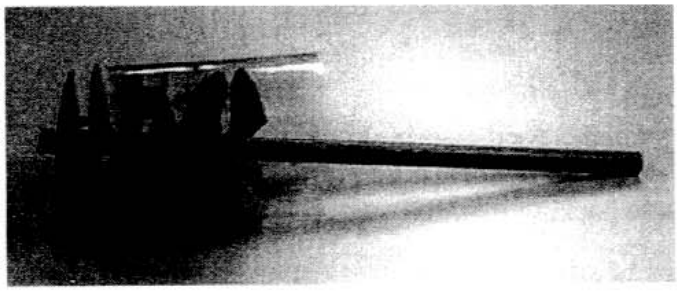
The grain auger is an example of a simple machine known as the screw. This device makes it possible to move a large amount of material with a minimum of force. In the past, it was used to lift water out of channels to irrigate fields. In Nebraska, it may be found as the part of the combine that moves the separated grain into the following truck. Note that the grain must travel a greater distance riding the auger–there is always a trade-off when using simple machines.

Note: *It is important to the success of this activity that the circles that form the auger screw be perfectly round, and that the hole be placed in the exact center. It may help if a template is created beforehand by the teacher and distributed to the students.*

Procedure:
Students will:
1. Cut off both ends off of the bottle, to form a plastic tube. This will be the outer case of the auger.
2. Use the tube as a pattern and draw six circles on the cardstock.
3. Use the dowel as a pattern and draw a small circle in the center of each large circle.

4. Cut out each large circle. Cut a radius in each large circle and then cut out the small circles.
5. Tape one cut edge of one radius to the opposite edge of the next. Continue until all circles are taped together to form a spiral. **(See Figure 1)**
6. Slide the spiral onto the dowel and tape one end of the spiral to the bottom of the dowel. Expand the rest of the spiral open so that it forms a screw, then tape the other end of the spiral to the dowel about 1/3 of the way from the end of the dowel. Finally, slide the screw assembly into the plastic shell. The auger is now assembled.
7. Pour puffed cereal into large bowl, then place a few books on the table next to the large bowl. Put the small empty bowl on top of the books.
8. Place the bottom of the auger in the bowl of cereal, then turn the dowel so that the cereal moves up the tube and into the small bowl.

Figure 1.



Discussion:

1. Where would a machine like this be useful?
2. Why would using an auger be preferable to just lifting the cereal out of the bowl?
3. Why do students think humans build machines?

Teacher resources:

Ardley, Neil. *The Science Book of Machines*
Gr. 2-6. This book contains simple experiments with photographs to illustrate mechanical principles.
ISBN: 0-15-200613-3

Gordon, Maria. *Simple Science: Push and Pull*
Gr. K-4. This book is a colorful, easy-to-read description of mechanical energy.
ISBN: 1-56847-456-X

Lafferty, Peter. *Force & Motion*
Gr. 3-6. By the creators of the distinguished *Eyewitness* series, *Force & Motion* has high standards of writing and illustration. Three-dimensional photos accompany text.
ISBN: 1-879431-85-8

Packing Materials: Sink or Swim?

Recommended grade levels: K-4

Goal: Students will explore potential energy by hypothesizing about the buoyancy of materials, observing and comparing the behavior of the materials, and drawing conclusions about the degradability of packing materials.

Process skills:
Hypothesizing
Observing

Frameworks: Matter

Materials: (per student group)
one bowl of water (*optional:* food coloring)
foamed plastic packing pieces of at least four different shapes, sizes, colors, etc.
one piece of degradable packing material

Teacher background information:
Packing materials are often made from petrochemical by-products; therefore, packing materials such as the familiar plastic "peanut" contain potential energy. Degradable packing materials conserve energy and landfill space.

Note: *This is a discovery activity; do not give advance information about what will happen or about the conclusion of the lesson.*

Save some packing materials from yearly orders. Major educational resource companies use only biodegradable packing pieces. These companies usually send an information sheet explaining why they have chosen different materials.

Procedure:
In groups of four, students will:
1. Observe and record properties of the packing pieces. Note color, shape, size, texture, etc.
2. Let the water in the bowls simulate any body of water (an ocean, sea, or lake).
3. Make and record predictions about individual packing pieces. Which one will sink? Which one will float? Which one will turn upside down in the water? Which will fade or change color?
4. Put packing pieces, one at a time, into the bowls of water. Record observations.
5. Compare observations with predictions.
6. Discuss packing materials. What is each made from and what are some possible advantages and disadvantages of each?

Discussion:

1. If a large truckload of the degradable packing material were dumped in a landfill or ocean, what would happen to the packing materials after a month or a year?
2. If a large truckload of foamed plastic pieces were dumped into a landfill or ocean, what would be the condition of the packing pieces after a month? a year? five years? fifty years?
3. If great masses of nondegradable material–including all-plastic products–are dumped in landfills or oceans, what will be the consequences after many years?
4. Can you think of any disadvantages to using only water degradable packing material?
5. Could water degradable material replace foamed plastic? Would you buy a soda or hot coffee in a water soluble container rather than a foamed plastic cup? (No–liquids would dissolve a water soluble cup.)

Extensions:

Have students:

1. Write a persuasive paragraph explaining the benefits of degradable packing material.
2. Make a compost can with buried foamed plastic and corn starch pieces. Record their observations.

Teacher resource:

World Wide Web site: http://ec26.enrg.lsu.edu/educat/sink_or_swim.htm
Information Services Division (ISD)
ISD is a coastal Energy and environmental information and resources clearinghouse. This site has energy links addressing kinds of energy, energy issues, science resources and teacher resources on energy.