Energetic Water

Grade Level:
Upper Elementary, Middle School

Subject Areas:
Physical Science, History

Duration:
Preparation time: 50 minutes

Activity time: Depends on extent of student projects

Setting: Classroom

Skills:
Gathering information (observing); Applying (designing, problem solving); Evaluating

Charting the Course
Physical properties of water are introduced in the activities "Molecules in Motion," "Hangin' Together," and "Adventures in Density." Students can explore how the movement of water is used in three-dimensional art projects in "wAteR in moTion."

Vocabulary
work, energy, kinetic energy, potential energy

What works without moving a muscle or breaking into a sweat?

Summary
Students invent devices or create activities that demonstrate how moving water can accomplish work.

Objectives

Students will:

- identify the forms of energy in water.
- demonstrate how water can be used to do work.

Materials

- *Two 1-pound (450-g) coffee cans with plastic lids* (Using hammer and nails, pound several equally spaced holes around the side of the bottom of one can. Do the same with the second; however, when you drive the nails into the second can, force the nail sharply to the left. Cover the holes on the bottom of both cans with masking tape. Poke a pair of holes near the top of each can through which to thread a string, making a handle.)
- *Student Invention Kits,* trays containing the following items:
  - *blocks of wood*
  - *coarse sandpaper*
  - *glue*
  - *masking tape*
  - *paper cups of different sizes*
  - *pieces of Styrofoam*
  - *pipe cleaners*
  - *plastic spoons*
  - *plastic straws (flexible and non-flexible)*
  - *scissors*
  - *several corks of varying size*
  - *several dowels of varying length*
  - *several pieces of cardboard*
  - *string or monofilament line*
  - *tongue depressors*

NOTE: Because of the experimental nature of the student activity, this listing includes suggested materials. Other items that are readily available in the classroom can be included at the teacher's discretion.

Making Connections

Many students have witnessed the energy in water when they looked at a waterfall, river, or dam. However, they may not relate the movement of water to turning lights on and off or moving heavy objects. Designing equipment or simple machines that use water to move things helps students appreciate the energy in water and how water can work for us.

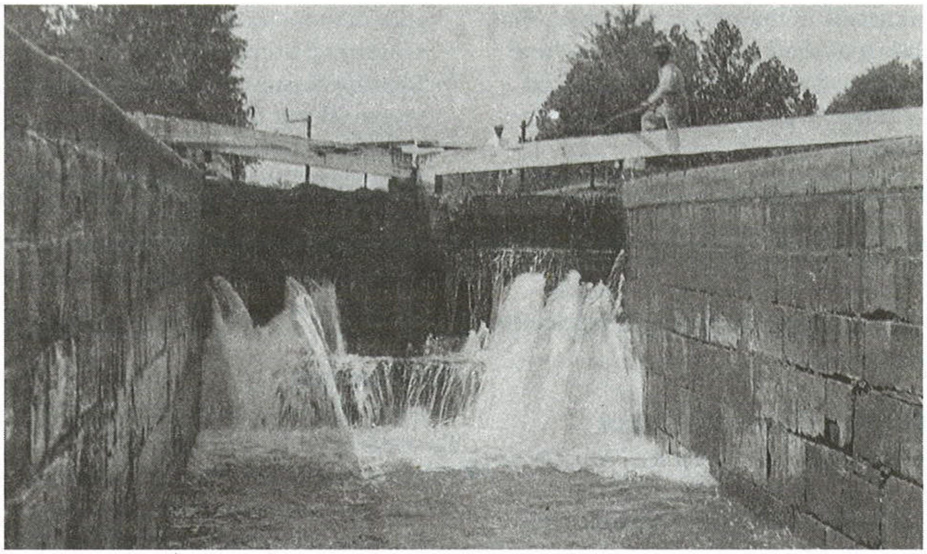
Background

For thousands of years, inventive people have tapped the natural energy in water to do useful work. Water has been used to help play a musical instrument (the water organ invented by Ctesibius, a Greek engineer); grind grain into flour (water-driven grist mills); spin silk; pump bellows; operate sawmills; tell time (the clepsydra or water clock); operate flush toilets, dishwashers, water meters, and centrifugal pumps in automobile cooling systems; lift heavy ships over land separating bodies of water (through locks in the Panama Canal, C & O Canal, etc.); operate automobiles, locomotives, and ships (steam engines); generate electricity; vary the buoyancy of submarines; and do a host of other jobs.

Following this activity is a time line (*Water Through Time*) showing a sampling of the historic human adaptations of water power.

Moving water can be used to do work because its potential energy changes to kinetic energy. When water is elevated (such as on the brink of a waterfall or in a reservoir behind a dam) it has gravitational potential energy. This potential energy changes to kinetic energy when the water falls or is allowed to flow. For example, when holes in the bottom of a container allow water to escape, the water's potential energy becomes kinetic energy.

The energy generated by moving water can be transferred to other objects, causing them to move and thus accomplishing work. Work involves applying force (a push or a pull) to an object to create movement. Sometimes humans use water alone to help execute work (e.g., carrying logs or moving boats downstream). Water has also been used to complement the actions of many simple machines that lift, push, turn, and pull objects. These include levers, pulleys, wheels and axles, and screws. Using the energy in water involves locating or creating places where potential energy is changed to kinetic energy (such as a waterfall or dam). Water can also be channeled and diverted to where it is used to produce work (such as over a turbine or into a lock).



Lock on C & O Canal, Seneca, Maryland, circa 1900. COURTESY: NATIONAL PARK SERVICE, E. B. THOMPSON

Procedure

▼ *Warm Up*

Show students the coffee can (with the straight-punched holes) and fill it with water. Ask students if they think there is any energy in the can. Discuss what forces might be present that could produce energy. Indicate gravitational pull and explain that it causes the water to have potential energy. Have students define potential energy and relate it to the water in the can.

Hold the can by its handle above a sink or tray. (This could be messy, so it may be done outdoors.) Remove the tape from the can with the straight holes so students can observe what happens. Water will drain from the can in straight streams, but the can should remain motionless.

Ask students what happened to the potential energy of the water. Explain that it was converted to kinetic energy when water was allowed to flow. Define work (application of force to create movement) and ask if students think any work was accomplished. The force of gravity caused the water to move, but did the can do any work? Since it did not move, no work was done.

Repeat the procedure with the other can. The streams of water draining the can will be directed sideways by the bent holes, and the can will spin in the opposite direction. Explain how you can make the flowing water do work by altering or directing its flow as it drains from the can (a simple classroom example of engineering).

▼ *The Activity*

1. **Share the *Water Through Time* time line with students. Discuss how water has been used throughout history to do work.**

2. **Tell students they are going to create their own designs to use water to do work. Their task is to build a machine, develop a technique, or demonstrate an action that illustrates how the energy generated by water (changing from potential to kinetic) lifts, moves, pulls, twists, smashes, or in some way changes the present placement or condition of an object.**

The following are suggested challenges. Use water to:

- lift a pencil 3 inches (7.5 cm) off a flat surface.
- move a pencil 10 inches (25 cm) across a surface.
- wind a piece of thread around a pencil.
- drop a pencil from a height of 5 inches (12.5 cm) .
- throw a soft object 2 feet (60 cm).
- grind a cracker into small pieces.
- break open a hollow object.
- rotate a series of gears.

3. **Divide the class into small groups or "engineering teams." Give each team a *Student Invention Kit* containing common materials from the classroom and describe the challenges.** They may use the

materials in their trays (or others that they may find in the classroom) and the knowledge they have acquired by observing the ***Warm Up*** demonstration.

4. **Allow groups several hours to complete projects; more challenging endeavors may take a few weeks.** Encourage students to visit with engineers and architects to help with their design.

▼ *Wrap Up and Action*

Have "engineering teams" tell the class how they approached the challenge or task, and explain and/or demonstrate their team's solution. They should identify what form of energy was used and what work was accomplished. Encourage them to relate the action to work done in real life (in the past or the present). Other teams can evaluate the design and provide suggestions for improvement. Designs can be presented in a school display case.

Assessment

Have students:

- invent or build a simple device that demonstrates the ability of water to do work (step 4).
- identify forms of energy present in water (***Wrap Up***).
- relate inventions to examples of how water has actually been used to conduct work (***Wrap Up***).
- evaluate water inventions and provide suggestions for improvement (***Wrap Up***).

Extensions

Further alterations can be made to the cans used in the ***Warm Up***. Explain that energy is transferred to the suspended can, causing it to spin in the opposite direction of the force applied by the jets of water, and that the can spins at a rate equal to the force of the water leaving the can.

Discuss how the flow of water draining from the cans can be increased or decreased by changing the rate of flow (e.g., by having fewer or smaller holes, by changing the angle at which water drains from the can, or by creating a vacuum or partial vacuum by covering the open end of the can with a plastic lid). Note that as the water level drops and the weight of the column of water decreases, the pressure of water escaping from the can decreases and so does the rate of spinning. Thus, a constant flow of water into the can would be required to keep the can spinning at a constant rate.

Old mill at Cades Cove, Great Smoky Mountains.
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Have students collect images (photographs, paintings, drawings) depicting the movement of water in nature (raindrops striking the ground, a river valley, a glacier or ice field, etc.) Students can use the pictures they have gathered to make a hallway exhibit or a portfolio for the classroom.

Using the time line presented at the end of this activity (supplemented with other events if desired), instruct students to make a montage of pictures showing the natural power of water intermixed with images of ways people have tapped the power of water through the ages.

Visit a local power plant and have a representative explain the role of water in the generation of electricity. Advanced students can try to build a mini-turbine able to generate an electrical current.

Resources

🍎 Ardley, Neil. 1983. *Working With Water*. New York, N.Y.: Watts.

🍎 Catherall, Ed. 1981. *Water Power*. Morristown, N.J.: Silver Burdett.

Cuevas, Mapi M., and William G. Lamb. 1994. *Physical Science*. Austin, Tex.: Holt, Rinehart & Winston.

🍎 Macaulay, David. *The Way Things Work*. 1988. Boston, Mass.: Houghton Mifflin Company.

Tennessee Valley Authority Environmental Education Program Development Group. 1992. *The Energy Sourcebook—Junior High Unit*. Norris, Tenn.: TVA.

🍎 Zubrowski, Bernie. 1982. *Messing Around With Water Pumps and Siphons*. New York, N.Y.: Little Paper.

Water Through Time

3000 B.C. – 2500 B.C.	Egyptians use water power to carry stones from distant quarries to build pyramids at Giza
A.D. 100	Greeks invent first waterwheel
A.D. 100	Greek scientist Hero invents simple steam engine called the aeolipile. Its potential is not tapped for over a thousand years
159	First water clock, or clepsydra, invented in Rome
1019	First water-driven mechanical clock built in Peking (Beijing), China
1328	Sawmill is invented. Early versions are powered by water
1510	Leonardo da Vinci designs a horizontal water wheel, the precursor of the water-driven turbine
1543	Blasco da Garay designs first steam-driven ship
1582	First waterworks founded in London. Waterwheels are installed on London Bridge
1589	First flush toilet, or water closet, designed by Sir John Harrington
1700	Mills driven by water power in common use throughout Europe
1705	Thomas Newcomen invents first practical steam engine. Water turbine invented by Pierre-Simon Girard
1764	James Watt invents condenser, first step leading to development of efficient steam engine
1769	First steam-operated "road carriage" invented by N. J. Cugnot
1775	James Watt perfects development of steam engine
1782	James Watt invents rotary steam engine
1783	Jouffroy d'Abbas sails paddlewheel steamboat on the Saône River
1785	James Watt and Mathew Bolton install steam engine in cotton spinning factory
1803	Robert Fulton invents steam-powered boat
1814	First practical steam locomotive invented by George Stephenson. *London Times* printed by steam-operated press
1815	First steam-driven warship (the *Fulton*) built
1818	First steamship (the *Savannah*) crosses the Atlantic
1830	Steam-driven cars common on the streets of London
1850	The Francis turbine, now in use in many powerplants, invented by James Francis
1859	Steamroller invented
1884	Sir Charles Parson develops first practical steam turbine engine
present	Water used as coolant in nuclear power plants