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Steamship *Portland*

Where's the Energy?

Focus
Energy conversions

Grade Level
5-6 (Physical Science)

Focus Question
What energy conversions are involved in the operation of a steam engine?

Learning Objectives
Students will be able to explain the basic operation of a steam engine.

Students will be able to identify and describe the energy conversions involved in the operation of a steam engine.

Materials
- ❒ Small plastic bottles with a tops, one for each student group
- ❒ Rubber bands, one for each student group
- ❒ Sticks (or pencils), approximately 6 inches long, one for each student group
- ❒ Small cardboard juice or milk carton, one for each student group
- ❒ Tape and scissors
- ❒ Empty cardboard paper towel rolls, one for each student group
- ❒ Sink or washtub filled with water

Audio/Visual Materials
- ❒ (optional) VHS copies of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin!" episode of "The Mighty Mississippi" (see Extensions)

Teaching Time
One 45-minute class period, plus time for student research

Seating Arrangement
Groups of 2-3 students

Maximum Number of Students
30

Key Words
Steamboat
Mechanical energy
Kinetic energy
Potential energy
Chemical energy
Electromagnetic energy
Nuclear energy
Electrical energy
Thermal energy
Energy conversion

Background Information
On Thanksgiving Saturday, November 26, 1898, the passenger steamship *Portland* left Boston Harbor with 192 passengers and crew bound for Portland, Maine. During the night, New England was hit by a monster storm with northeasterly winds gusting to 90 mph, dense snow, and temperatures well below freezing. At 5:45 a.m. on the morning of November 27, four short blasts on a ship's steam whistle told the keeper of the Race Point Life-Saving Station on the tip of Cape Cod that a vessel was in trouble. Seventeen hours later, life jackets, debris, and human bodies washed

ashore near the the Race Point station, confirming that the *Portland* and everyone aboard had been lost in one of New England's worst maritime disasters.

For 90 years, the location of the *Portland* wreck was unknown, despite intense and continuing public interest. Then in April 1989, members of the Historical Maritime Group of New England found wreckage more than 300 feet deep that they were certain had been the *Portland*. Because of the depth, however, the discoverers were unable to obtain photographs or other evidence that could confirm their find. Thirteen years later, on August 29, 2002, the U.S. Commerce Department's National Oceanic and Atmospheric Administration (NOAA) confirmed that the wreck of the *Portland* had been found within NOAA's Stellwagen Bank National Marine Sanctuary. Using side-scan sonar and a remotely operated vehicle (ROV), scientists obtained high-quality video and side-scan images in a joint research mission of the Stellwagen Bank National Marine Sanctuary and the National Undersea Research Center at the University of Connecticut.

Built in 1889, the *Portland* was a state-of-the art vessel. Eighty-two years earlier, Robert Fulton had demonstrated the potential of steamboat technology when the *Clermont*, the first steamboat built in the United States, successfully completed its trial run from New York to Albany. Unlike sailing vessels, steamboats could travel great distances on reliable schedules, and for this reason quickly became the preferred means of transportation along major waterways of the United States. Steamboats had a major influence on nineteenth century life in the United States and contributed to the development of tourism, transportation of perishable foods and supplies, settlement of frontier areas, and growth of the U.S. mail service.

Because they were propelled by large paddlewheels, steamboats could maneuver in waters that were too shallow for sailing ships. By the 1870's, many people routinely boarded steamboats to travel between port cities. But the paddle-wheelers had a serious flaw: they were built long and narrow (the *Portland* was 281 feet long and 62 feet wide), and this shape combined with a shallow draft (the *Portland's* keel was only 11 feet below the water line) made these ships extremely unstable in high seas. When the *Portland* steamed out of Boston Harbor into a strong northeasterly wind, the captain could not turn back: to have done so would have placed the ship broadside to wind and waves that would surely have capsized her. The only choice was to continue to head northeast into the waves, and hope to ride out the storm. Four hours after her departure, a vessel believed to have been the *Portland* was seen near Thatcher Island, about 30 miles northeast of Boston. But the *Portland* was apparently unable to make much more progress against the storm: she sank about 18 miles southeast of Thatcher Island, perhaps because of the intense, constant pounding that may have lasted for 24 hours or more. The loss of the *Portland* underscored the inherent instability of sidewheel paddleboats. Sidewheelers were gradually replaced by propeller-driven boats, which have a lower center of gravity.

In this lesson, students will study some of the science behind steamboats, and build a simple paddlewheel boat.

Learning Procedure

1. Download a copy of "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource" from http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/. You may also want to download a copy of "The Portland Gale" from http://www.hazegray.org for more information on the *Portland* and the monster storm of 1898. Visit http://oceanexplorer.noaa.gov for up-to-date information on the 2003 Steamship *Portland* Expedition.

2. Briefly review the story of the *Portland* and the gale of 1898. Discuss the role of steamboats in development of the United States during the 1800's.

3. Have students construct the model paddle-wheel boat described on page 15 of "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource" (please note that this activity was adapted from "Water, Paddles, and Boats" by Pam Robson).

4. Lead a discussion of the energy sources and transformations that take place when the model paddlewheeler is operating. Students should recognize that the initial source of energy is the person who winds the rubber band. The rubber band stores this mechanical energy as potential energy. When the rubber band unwinds, the potential energy is changed to kinetic energy that causes the paddlewheel to turn, pushing against the water and causing an opposite reaction by the boat (the boat moves forward). Ask students to take this sequence farther back: they should recognize that mechanical energy from the person winding the rubber band comes from muscles that are using chemical energy that came from food that ultimately can be traced back to photosynthesis that used electromagnetic energy from the sun).

5. Tell students that their assignment is to prepare a written report on the basic principles of a steam engine, including an analysis of the energy sources and conversions involved when a steam engine is operating. An alternative to a written assignment is to give students a series of questions to research as a basis for group discussion.

   Lead a discussion of students' research results. Most of the following points should emerge during this discussion:

   - The basic elements of a steam engine are a source of steam (usually a boiler fired by wood, coal, or other combustible fuel), a device that is moved by the steam (such as a piston inside a cylinder or a turbine), and a means for converting the motion of the device into useful work. Steam engines of the 1800's had many more features that made them more efficient.
   - The source of energy for steam engines can be fossil fuels (which were originally produced by photosynthesis, since these fuels are the remains of once-living plants and animals), wood (also a product of photosynthesis), nuclear reactions, or sunlight (one type of solar generator uses a parabolic mirror to focus the sunlight onto a pipe containing water that is heated to produce steam).
   - Energy conversions typically involved in the operation of a steam engine are conversion of chemical energy (in fuels) to thermal energy, conversion of thermal energy to mechanical energy (by increasing the motion of water molecules), and sometimes conversion of mechanical energy into electrical energy (in the case of an electric generator).
   - Early steam engines used steam to move a piston inside a cylinder. This produced a back-and-forth motion, which was okay for pumps, but not as useful for propelling boats or turning machinery. Many devices were built to convert back-and-forth motion to rotary motion. The *Portland* used what is known as a "walking beam engine" to make this conversion. A large diamond-shaped beam was mounted on an A-frame structure. One end of the beam was connected to a rod attached to the piston of the steam engine. The other end of the beam was attached to a second rod that drove a crankshaft, which in turn caused the paddlewheels to rotate, propelling the ship through the water.
   - The piston-cylinder type of steam engine was replaced by engines that used steam to turn turbines. This is the type of steam engine found in many electrical generating plants today.
   - James Watt is often credited with developing the first steam engine, but Hero of Alexandria (who lived more than 2,000 years ago) documented many of the principles upon which the steam engine is based. The first operating steam engine was built in 1712 by English engineer Thomas Newcomen (visit http:

//technology.niagarac.on.ca/people/mcsele/newcomen.htm for a description of the Newcomen engine). Newcomen's engine was simpler than the systems described above: steam from the boiler was let into the space between the inside of the cylinder and the piston. The other end of the piston was attached to the pump by means of a rod. Water was sprayed onto the cylinder to cool the steam. As the steam cooled, its volume decreased, and caused a vacuum to form inside the cylinder. The piston was sucked down into the cylinder by the weight of the air on top of it, then was pulled back by the weight of the pump attached to the rod. Steam was let into the chamber again, and the cycle repeated.

- Robert Fulton is often credited with building the first operating steamboat, but Johnathan Hulls of London patented a steam-driven tugboat in 1736. John Fitch of Connecticut built a steam-driven paddle boat in 1786, but rowboats could outrace it. Fulton's credit probably should be for developing the first reliable steamboat.

The BRIDGE Connection

http://www.vims.edu/bridge/archive1200.html/

The "Me" Connection

Tell students to imagine that they are living 100 years in the future. Have them write a short essay comparing and contrasting the history of steamboats with the history of the airplane.

Connections to Other Subjects

English/Language Arts, Social Studies, Earth Science

Evaluation

Written reports prepared in Step 5 provide an opportunity for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest Steamship *Portland* discoveries.

Watch the History Channel production of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin! " episode of "The Mighty Mississippi," (both available from http://store.aetv.com/html/) and check out study guides for these programs at http://www.historytv.com/classroom/admin/study_guide/archives/thc_guide.1378.html.

Resources

Bachelder, P. D. and M. P. Smith. 2003. Four Short Blasts. The Gale of 1898 and the Loss of the Steamer *Portland*. The Provincial Press. Portland, ME.

http://www.hazegray.org/ – Website with information on naval ships, photos, etc., and a page about the *Portland* Gale of 1898

http://score.rims.k12.ca.us/activity/bubbles/ – Marine archaeology activity guide based on investigations of the wreck of a Spanish galleon; from the Schools of California Online Resources for Education website

http://www.historytv.com/classroom/admin/study_guide/archives/thc_guide.1378.html – Study guide for history channel program on steamboats on the Mississippi

http://www.howstuffworks.com/steam1.htm – Animated explanation of how a steam engine works

http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/ – US Department of the Interior Minerals Management Service publication, "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource"

http://www.usatoday.com/weather/movies/ps/perfectstorm.htm – USA Today website with information about extreme storms

http://pao.cnmoc.navy.mil/educate.neptune/quest/wavetide/waves.htm – Naval Meteorology and Oceanography Command website with information on waves and tides

http://school.discovery.com/lessonplans/programs/tidalwave/index.html – Discovery Channel School lesson plans on tsunamis (tidal waves)

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Motions and forces
- Transfer of energy

Content Standard D: Earth and Space Science

- Structure of the Earth system

Content Standard E: Science and Technology

- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives

- Natural hazards
- Science and technology in society

For More Information

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Acknowledgements

This lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration.