Thunder Bay 2010:
Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships

Death Ship

(adapted from the 2003 Steamship *Portland* Expedition)

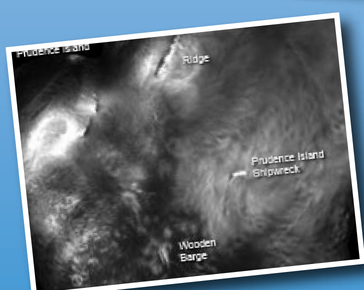

Image captions/credits on Page 2.

lesson plan

Focus

Energy conversions and simple machines

Grade Level

7-8 (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.
- Students will be able to identify at last three simple machines in a steam engine and explain their function.

Materials

For the miniature steam engine:

- Unused, gallon-size metal paint can with lid
- Unused, quart-size metal paint can with lid
- Soft copper tubing, 1/4" inside diameter, 6 m long
- Soft copper pipe, 1/2" insider diameter, 15 cm
- Hard plastic tubing, 1/8" – 1/4" diameter, 35 cm
- Metallic tape
- 2 wine corks
- Circular metal electrical junction box
- Electrical cable clamp to fit holes in junction box
- 2 hose clamps, 1/2" – 1-1/4"
- Metal mesh screen, 12 cm x 24 cm
- Charcoal
- Wooden skewer, about 20 cm long
- Wooden dowel, 3/8" diameter, 1.5 cm
- Flathead screwdriver
- Electric drill with 1/2" diameter metal bit
- Tin snips
- Pliers
- Hammer
- Scissors

For students' invented machines:
- ❑ Mechanical pencil sharpeners, one for each student group
- ❑ Meter sticks, one for each student group
- ❑ Duct tape
- ❑ Coathangers, one for each student group
- ❑ Chairs, one for each student group

Audio-Visual Materials
- ❑ None

Teaching Time
Two or three 45-minute class periods, plus time for student research

Seating Arrangement
Groups of 2-3 students

Maximum Number of Students
32

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

Background Information
NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

August 9, 1865 – Early this evening in one of the Great Lakes' worst maritime disasters, the steamship *Pewabic* collided bow-to-bow with her sister ship *Meteor* and quickly sank, taking 125 passengers and crew to watery graves 180 feet below the surface of Lake Huron.

Nicknamed the "Greyhound of the Lakes," because she could achieve a top speed of 12 knots, *Pewabic* was one of the most elegant ships of her day. Passengers enjoyed stained glass windows, skylights, satin draperies, marble tabletops, rosewood furniture, and silver tableware. In addition to passengers, *Pewabic* also carried package freight. When

Images from Page 1 top to bottom:
Existing (yellow) and proposed (green) boundaries of the Thunder Bay National Marine Sanctuary. Locations of some known shipwrecks are indicated. Source: Thunder Bay National Marine Sanctuary

A crew in a support boat releases the line from the Naval Undersea Warfare Center (NUWC) REMUS 600 unmanned underwater vehicle equipped with the Integrated Precision Underwater Mapping (iPUMA) subsystem in Narragansett Bay during the Autonomous Vehicle Fest in May 2008.
http://www.militaryaerospace.com/index/display/article-display/337291/articles/military-aerospace-electronics/volume-19/issue-8/features/special-report/swimming-robots.html

This image was captured by iPUMA, a wide-swath forward-looking sonar used to identify possible targets. Here we see the two wrecks off Prudence Island, as well as features on the surrounding seafloor. To get a sense of scale, consider that the wooden barge is 120 feet long.
http://oceanexplorer.noaa.gov/explorations/08auvfest/logs/summary/media/ipuma_s2_3_sonar.html

Once a shipwreck has been located on a sonar image, archaeologists don SCUBA gear to "ground truth" the discovery. Dives deeper than about 40 m require the use of special breathing mixtures containing helium, oxygen, and nitrogen to reduce some of the safety hazards that accompany breathing ordinary air during deep dives. Source: Thunder Bay National Marine Sanctuary she left Sault Sainte Marie on August 9, the ship's cargo included a large quantity of copper from Michigan's mines, and (according to some rumors) may also have included 18 kegs of silver.

Rumors of copper and silver were more than enough incentive for treasure hunters to risk their lives in a series of attempts to salvage the precious metals. Long before the invention of SCUBA and long before the hazards of breathing air under pressure were understood, these attempts were extremely dangerous. Within weeks of *Pewabic's* sinking, Billy Pike stepped into a hard-hat diving suit and made the first attempt to retrieve treasure from the ship. The attempt failed and Pike died. In 1891, Oliver Pelkey successfully descended to the shipwreck using an improved diving suit. The suit collapsed on the second dive, killing Pelkey. Six years later, the American Wrecking and Salvage Co. retrieved fifty tons of copper from the wreck. Encouraged by this success, George Campbell and Peter Olson descended in an experimental diving bell in 1898. Both men drowned when the glass porthole shattered. Some subsequently salvage attempts were more successful, but the string of deaths coupled with stories of skeletons in the cabins and other spooky rumors earned *Pewabic* a new nickname: Lake Huron's Death Ship.

The story of the *Pewabic* is only one of more than 200 tales of ships that have ended their days in Lake Huron. The second largest of the Great Lakes and the third largest in t he world, Lake Huron is notorious for its dense fog banks, violent storms, and rocky shoreline. The area surrounding Thunder Bay is so hazardous to shipping that it has earned the nickname Shipwreck Alley, and now represents one of the nation's most historically significant collections of shipwrecks. The Thunder Bay National Marine Sanctuary (TBNMS) was established in 2000 to protect this important cultural resource. The present boundaries of the TBNMS enclose 448 square miles that contain 40 known historic shipwrecks. Plans are well underway, however, to expand these boundaries to include 3,662 square miles (Figure 1). Archival records indicate that the expanded boundaries include more than 100 undiscovered shipwrecks which can provide unique opportunities for historians and archaeologists to study the maritime and cultural history of the Great Lakes region, as well as for recreational explorers. Finding the exact location of these shipwrecks is obviously essential to these kinds of uses, as well as to the protecting these resources.

To help meet this need, in 2008 a remote sensing survey was undertaken in the northern portion of the proposed expansion area. This survey used a side scan sonar towed from a research vessel, as well as a conventional sonar system mounted on an autonomous underwater vehicle (AUV). The 2008 survey covered an area of about 100 square miles and located two new shipwrecks. The total proposed expansion area is much larger, though, so a third survey strategy

Map 1. Great Lakes region, with Thunder Bay National Marine Sanctuary marked with a red dot.

US Army Corps of Engineers, Detroit District. From Wikipedia.

Figure 1. Existing (yellow) and proposed (green) boundaries of the Thunder Bay National Marine Sanctuary. Locations of some known shipwrecks are indicated. Source: Thunder Bay National Marine Sanctuary

is needed to efficiently cover large areas of deep water. As its name suggests, the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition will use state-of-the-art technology that includes a sophisticated AUV carrying a one-of-a-kind precision sonar system to survey up to 200 square nautical miles in the proposed expansion area. Further investigation of shipwrecks located during the survey will be done by marine archaeologists using technical diving procedures. If particularly interesting wrecks are discovered, these "ground truthing" dives may be done during the Thunder Bay 2010 Expedition. Most of these investigations, however, will be done after the expedition's conclusion.

Many ships that are now part of the TBNMS were propelled by steam. In this lesson, students will study some of the science behind steamboats, and participate in constructing a model steam engine.

Learning Procedure

[Note: Portions of this lesson were adapted from Newton's Apple show number 1403, "Riverboats." Visit http://www.newtonsapple.tv/TeacherGuide.php?id=1549 for a complete teacher guide for this show.]

1. To prepare for this lesson:
   (a) Review introductory essays for the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition at http://oceanexplorer.noaa.gov/10thunderbay/welcome.html
   (b) Download a copy of "Full Steam Ahead!" from http://www.blm.gov/education/00_resources/articles/steel_rails_and_iron_horses/posterback.html.
   You may also want to download "Historic Shipwrecks of the Gulf of Mexico: A Teacher's Resource," which has useful background materials on steamboats (http://www.gomr.mms.gov/homepg/lagniapp/shipwreck/).
   (c) You may want to consider showing the DVD, "*Pewabic*: The Death Ship of Lake Huron" (available from http://www.outoftheblueproductions.net/Pewabic.html), and/or the History Channel production of "Great Ships: The Riverboats" and/or the "Steamboats 'A Comin! " episode of "The Mighty Mississippi," (both available from http://shop.history.com/).

2. Briefly review the story of the *Pewabic*, and introduce students to "Shipwreck Alley" and the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition. Discuss the importance of shipwrecks from the standpoint of historical research as well as recreation. Introduce the basic elements of a steam engine: 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 other features that made them more efficient.

3. Work with students to construct the miniature steam engine described in "Full Steam Ahead!" Many students would have difficulty completing this project on their own, but everyone can be involved with some aspects if the project is undertaken as a group effort. You may want to enlist one or more parents or students with shop skills to assist. Have students prepare brief written reports on energy transformations that take place during operation of the miniature steam engine, and possible sources of energy to power steam engines.

4. Lead a discussion of the energy sources and transformations that take place during operation of the miniature steam engine. Chemical energy (in fuels) is converted by combustion to thermal energy; thermal energy is converted to mechanical energy by the increasing the motion of water molecules; and this mechanical energy is transferred by the action of steam on the dowel piston. Ask students what other conversions might be possible. One of the most common conversions is to connect a steam engine to an electric generator, which converts mechanical energy into electrical energy.

   Discuss possible sources of energy for steam engines. These include fossil fuels (which were originally produced by photosynthesis using electromagnetic energy from the sun, 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).

5. Point out that the miniature steam engine produces a back-and-forth type of motion. Tell students that 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. Tell students that their assignment is to design a machine that will convert a back-and-forth motion into a rotary motion that will operate a pencil sharpener. They are to use a chair tipping back and forth on two legs to simulate the piston motion of a steam engine. Tell students they will be provided with meter sticks, tape, coathangers, and chairs, and are free to bring other materials from home. Have each group brainstorm their machine during one class period, and complete their invention during the first half of the next class period. Have each group explain their machine, discuss the problems they encountered, and how these problems were overcome.

6. Show students an illustration of a simple steam engine (there are lots of these on the web; e.g., at http://www.mgsteam.btinternet.co.uk/hditwork.htm; you can also find an animated explanation of how a steam engine works at http://www.howstuffworks.com/steam1.htm). Tell students that 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. Discuss how many simple machines you can find in the illustration. Levers, wheels and axles should be obvious. Some students may realize that parts of the engine are probably held together with various types of screws. Pulleys could be involved in transferring mechanical energy from the engine to a driven machine. Tell students that after the Portland disaster, sidewheel paddle boats were gradually replaced by ships driven with propellers, which are a special type of screw.

   You may want to briefly discuss the history of the steam engine. 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 (this is a good opportunity to review what students know about the relationships between temperature and volume of gases).

   You can demonstrate the principle by filling a 2-liter plastic soda bottle one-fourth full with hot (not boiling) water, and screwing the cap on tightly. When you immerse the bottle in ice cold water, warm air inside the bottle contracts, producing a partial vacuum. Air pressure forces the side of the bottle in to fill the vacuum, just as air pressure forces the piston of a Newcomen engine into the partial vacuum created when the steam-filled cylinder is cooled.

7. You may want to have students investigate other simple machines, such as
   - cam and follower
   - eccentrics
   - scotch yoke
   - universal joint
   - loose-link coupler
   - Geneva wheel
   - Watt's sun-and-planet gear (invented by James Watt as a substitute for the common crankshaft, which had already been patented by someone else)

   See http://ia341314.us.archive.org/2/items/mechanismsmechan00jonerich/mechanismsmechan00jonerich.pdf for a free download of "Mechanisms and Mechanical Movements," a 1919 treatise on mechanisms and methods for transmitting, controlling and modifying motion.

The BRIDGE Connection

www.vims.edu/bridge/archive1200.html/ – Links to information and activities about shipwrecks

The "Me" Connection

Have students write a short essay describing 10 ways that they use simple machines in everyday life.

Connections to Other Subjects

English/Language Arts, Social Studies, Earth Science

Assessment

Written reports prepared in Step 3 and oral presentations in Step 5 provide an opportunity for assessment.

Extensions

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://shop.history.com/); and/or "Pewabic: The Death Ship of Lake Huron" (available from http://www.outoftheblueproductions.net/Pewabic.html)

Other Relevant Lesson Plans from NOAA's Office of Ocean Exploration and Research

I, Robot, Can Do That!
(11 pages, 315 kb) (from the Thunder Bay 2008 Expedition)
http://oceanexplorer.noaa.gov/explorations/08thunderbay/background/edu/media/robot.pdf

Focus: Underwater Robotic Vehicles for Scientific Exploration (Physical Science/Life Science)

Students will be able to describe and contrast at least three types of underwater robots used for scientific explorations, discuss the advantages and disadvantages of using underwater robots in scientific explorations, and identify robotic vehicles best suited to carry out certain tasks.

Ping!
(8 pages, 219 kb) (from the Aegean and Black Sea 2006 Expedition)
http://oceanexplorer.noaa.gov/explorations/06blacksea/background/edu/media/06blacksea_ping.pdf

Focus: Sidescan Sonar (Earth Science/Physical Science)

In this activity, students will describe sidescan sonar, compare and contrast sidescan sonar with other methods used to search for underwater objects, and make inferences about the topography of an unknown and invisible landscape based on systematic discontinuous measurements of surface relief.

This Old Ship
(9 pages, 272 kb) (from the PHAEDRA 2006 Expedition)
http://oceanexplorer.noaa.gov/explorations/06greece/background/edu/media/old_ship.pdf

Focus: Ancient and Prehistoric Shipwrecks

In this activity, students will be able to describe at least three types of artifacts that are typically recovered from ancient shipwrecks, explain the types of information that may be obtained from at least three types of artifacts that are typically recovered from ancient shipwrecks, and compare and contrast, in general terms, technological features of Neolithic, Bronze Age, Hellenistic, and Byzantine period ships.

Paleo-Diving
(12 pages, 552 Kb) (from the Exploring the Submerged New World 2009 Expedition)
http://oceanexplorer.noaa.gov/explorations/09newworld/background/edu/media/paleodiving.pdf

Focus: Underwater Archaeology of Sinkholes (Physical Science/Archaeology)

In this activity, students will be able to explain how sinkholes are formed, why they may be associated with paleoamerican settlements, and how artifacts retrieved from sinkholes may be interpreted.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov/10thunderbay/welcome.html – Web site for the Thunder Bay 2010: Cutting-Edge Technology and the Hunt for Lake Huron's Lost Ships Expedition

http://thunderbay.noaa.gov/welcome.html – Web site for the Thunder Bay National Marine Sanctuary

Stein, Janis. 2009. Sunken Treasure. Huron Shore 2(1):26-28; available online at http://view.digipage.net/?userpath=00000043/00008921/00042491/&page=28

http://celebrating200years.noaa.gov/edufun/book/welcome.html#book - A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

http://thunderbay.noaa.gov/welcome.html – Links to Lesson Plans from the Thunder Bay National Marine Sanctuary; includes grades K - 2 Boat Builder Activity, grades 3 - 5 Photomosaic Activity, grades 3 - 5 Mapping Activity, grades 6+ Mapping Activities, Steamships and Energy Conversions, and Make Your Own Putt-Putt Boat

http://monitor.noaa.gov/publications/education/rov_manual.pdf – Directions for making a simple underwater robot; from NOAA's Monitor National Marine Sanctuary

Jones, F. 1919. Mechanisms and Mechanical Movements. The Industrial Press. New York; a treatise on different types of mechanisms and methods for transmitting, controlling and modifying motion; free pdf download at: http://ia341314.us.archive.org/2/items/mechanismsmechan00jonerich/mechanismsmechan00jonerich.pdf

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

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 2.
The ocean and life in the ocean shape the features of the Earth.
Fundamental Concept Fundamental Concept b. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

Essential Principle 4.
The ocean makes Earth habitable.
Fundamental Concept a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.
Fundamental Concept b. The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

Essential Principle 6.
The ocean and humans are inextricably interconnected.
Fundamental Concept d. Much of the world's population lives in coastal areas.
Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Essential Principle 7.
The ocean is largely unexplored.
Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Send Us Your Feedback

We value your feedback on this lesson.
Please send your comments to:
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