From Lazy River to Deep Water

Students calculate volume and create a model lock study how it works.

Teacher Notes for Discussion

Discuss how a lock and dam works. Students should understand that locks maintain channel depth and are not a flood control structure. They should also understand that the Mississippi River is sloped. Locks and dams help boats get "up" or "down" the river. Discuss the different valves that let water in or drain water out.

There are 29 locks and dams on the upper Mississippi River, built and maintained by the Army Corps of Engineers. The system has two basic purposes. First, it maintains a nine foot channel making the river navigable for barge traffic. Second, it lessens the steep grade of the upper river.

The lock and dam system works like filling and draining a bunch of bathtubs. The system features a series of underground tunnels equipped with filling and emptying valves. Before a boat enters the lock, the lock is filled with water moving through an underground tunnel. The water fills the lock, the upper gates are opened, and the boat enters. Once inside, the upper gates are closed, and the emptying valves are opened. The water slowly drains inside the lock, lowering the boat "down a step." The lower gates are opened and the boat leaves the lock to continue down river.

Discuss Newton's third law of motion and how it applies to this activity.

Objectives

After completing this lesson, students should be able to:

- explain how locks work
- explain how a series of locks and dams maintain a channel depth of nine feet
- calculate volume

Time Considerations

Instructor preparation: one hour

Student activity: two classes

Preparation and Facilitation Suggestions

- Run through the activity once before class time.
- Have each student collect and rinse a one-half pint milk carton.
- The entire activity may be completed as a demonstration project, individually or in collaborative pairs. For the assessment, students should draw their conclusions independently.

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Related Standards and Benchmarks

Science

Standard 12. Understands motion and the principles that explain it

- knows that an object's motion can be described according to its position, direction of motion, and/or speed

Standard 15. Understands the nature of things

- uses appropriate tools and techniques to gather, analyze, and interpret scientific data
- knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists
- establishes relationships based on evidence and logical argument
- knows possible outcomes of scientific investigations

Math

Standard 1. Uses a variety of strategies in the problem-solving process

- uses a variety of strategies to understand problem-solving situation and processes

Standard 3. Uses basic and advanced procedures while performing the processes of computation

- adds, subtracts, multiples, and divides whole numbers, fractions, decimals, integers, and rational numbers

Standard 4. Understands and applies basic and advanced properties and concepts of measurement.

- selects and uses appropriate units and tools, depending on degree of accuracy required, to find measurements for real-world problems
- understands formulas for finding measures

Language Arts

Standard 1. Demonstrates competencies in the general skills and strategies of the writing process.

- writes expository compositions

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Understand Your Mission

In this activity, you will create a model that will demonstrate how a river lock works.

Learn the Lingo

chamber	the enclosed space between the walls, gates, and floor of the lock
channel	the deeper part of the river
gate	a moveable structure that swings on hinges and controls the entrance to the lock
gravity	a force that defines the attraction between any two objects
levee	an embankment built alongside a river to prevent high water from flooding bordering land
lock	an enclosure with gates at each end used to raise and lower boats
navigation	the act of steering or directing a ship
valve	any device in a pipe or tube that permits a flow in one direction only
wing dams	a dam angled out from the bank of the river

Gather Your Supplies

- ❑ clay
- ❑ graph paper
- ❑ grease pencil or permanent marker
- ❑ half-pint milk carton
- ❑ cat litter box (or similarly sized container)
- ❑ ruler
- ❑ scissors
- ❑ small boat (made from 1x1cm styrofoam)
- ❑ water

Background

The upper Mississippi River includes the area from Lake Itasca to Cairo, Illinois. Between these two places the river flows for 860 miles. Today there are twenty-nine locks and dams from Minneapolis to St. Louis to accommodate the various elevations of the river channel. This allows river vessels that measure to nine feet deep, 195 feet long, and thirty-five feet wide to travel the upper portion of the river.

From St. Louis to Minneapolis, 29 locks raise barges and boats approximately seven-and-a-half feet at each dam. Going up river, filling valves do the job. If the barge wants to go downriver, drain valves are opened.

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Chart a Course for Exploration

Assembling your lock and river pool

1. Using the scissors, cut the top off your milk carton.
2. Working with one side of the carton, cut a 3 x 3 cm three-sided flap along the bottom edge of the carton. Leave the right side uncut to serve as the hinge and fold that side back. This is your gate.
3. Turn the carton to the opposite side. This time cut a 3 x 3 cm gate along the top edge, leaving one side uncut to serve as the hinge. Fold that side back. You should now have two gates on opposite sides of the milk carton, one at the top edge and one at the bottom edge.
4. Line the cut edges of the gates with clay. Seal both gates closed. Fill your carton with water to test for leakage. Add more clay if the gates leak. Empty the carton. This is your lock with gates.
5. On a third side, use scissors to poke three holes, one centimeter from the top of the carton. Plug them with clay. Fill it with water and test for leakage again. Empty the carton. These holes are the filling valves.
6. Create a boat from a walnut shell, cork, or another material that floats.
7. Fill the pan with water up to 2 cm from the brim of the pan. The pan will serve as the river pool where the boats pass. (At an actual lock and dam site, you would have two pools of water—an upper pool and a lower pool with a dam holding the water in the upper pool from flowing into the lower pool.)
8. Place your lock into the river and weigh it down with pennies or a rock until it rests on the bottom of the river.

2 gates each 3x3 cm

three holes and gates plugged with clay

final lock weighed with pennies

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Locking Your Boat Through

1. Determine the volume of water in the river pool in cubic centimeters (cc). volume = length x width x depth.
2. Before placing the lock in the river pool, determine the maximum volume your lock chamber will hold.
3. Fill the lock chamber to the top of the lower gate. Measure its volume at this level.
4. Mark the waterline on the inside of the chamber with the letter "A."
5. Place the boat into the lock and place the lock in the middle of the river pool. The top of the lock chamber should be 1 cm above the water level in the pool (you may need to add or remove water). Make sure water from the pool does not enter the lock.
6. Look at the boat. This is how a boat entering from the lower level pool (heading upriver) would appear in the lock chamber.
7. Simulate how the water level rises to bring the boat up even with the water level in the pool. Gradually open the three plugs along the top of the lock chamber.
8. Watch the boat rise in the chamber. When the water stops rising, mark the waterline height on the inside of the lock with the letter "B."
9. Measure the volume of water in the lock chamber.
10. Open your upper gate and allow the boat to move out into the pan. This simulates the boat passing through the lock to the higher elevation.

Go Beyond

Draw a lock and dam from a side view showing how it works. Use your drawing to explain how locks work to someone not in your class.

Data

Volume in pan _____cc
Total volume in lock _____cc
Volume in lock at the lower gate _____cc
Volume in lock at the upper gate _____cc
Difference in depth of water from A to B _____cm
Difference in volume of water at upper and lower gates
_____cc

Conclusion A

Write one to three paragraphs explaining how a boat traveling north, up the Mississippi River, is raised up over a dam to the higher elevaiton on the other side. Use the data you gathered in your explanation. Include a description of the motion of the boat.

Conclusion B

Write one to three paragraphs explaining your changes in the lock to allow a boat to enter at the higher gate and exit at the lower gate. Use the data you gathered in your explanation. Include a description of the motion of the boat.

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	EXPERT	PROFICIENT	NOVICE
ACCURACY OF DATA	❑ computations are correct and correctly labeled	❑ computations are correct	❑ some computations are incorrect
MODEL	❑ accurately demonstrates the locking through process	❑ adequately demonstrates how a ship or barge can enter at a lower level and exit at an upper level	❑ does not demonstrate how ships and barges enter at a lower level and exit at an upper level
PARAGRAPHS	❑ correctly explain how a lock and dam function as ships and barges are moved from one level to another	❑ discuss how a lock and dam work and mentions direction and level	❑ do not correctly explain how a lock and dam works to move ships either up or down the river

References

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Ward, Randi. *How Locks Work.* <http://members.aol.com/RandiWard/locks.htm>, March 15, 2000.

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