

# Section II: Investigating Invented Clocks

## LESSON 7

### Using Water to Measure Time

#### Overview and Objectives

In this first lesson of **Section II: Investigating Time with Invented Clocks**, students investigate one way to use water to measure time. They construct a sinking water clock capable of timing an interval of 15 seconds, and they begin identifying the variables involved in determining how rapidly or slowly the clock sinks. In Lessons 8 and 9, students will plan and conduct an investigation of how changing one of the variables affects the time it takes a funnel to sink. This cycle of exploration and investigation will be repeated in Lessons 10, 11, and 12, when students plan and conduct experiments with pendulums.

- Students construct sinking water clocks.
- Students identify the variables that have an effect on the time it takes their water clocks to sink.
- Students read about water clocks used by early cultures.

#### Background

This lesson marks the beginning of a new section of the unit. In this section, instead of observing the natural cycles of the sun and the moon, students begin to manipulate variables to change the rate at which observable events, such as sinking objects and swinging pendulums, take place. This shift in focus corresponds with the historical shift in timekeeping methods that occurred when people first looked for improvements to the methods that relied on the sun and moon. Through ongoing observations of the moon's phases and appropriate reading selections, students will be given a context for comparing timekeeping methods.

For your information, background about the history of water clocks has been included below. The **Reading Selection** on pg. 71 of the Teacher's Guide and pg. 30 of the Student Activity Book, includes additional information.

Water clocks have been in use in one form or another for more than three thousand years. They were developed to meet a real need: how to tell time on cloudy days and at night. First used in Egypt and Babylonia, water clocks were brought across the Mediterranean by the Greeks. The Greeks called water clocks **klepsydra**, which means "thief of water."

The use of water clocks shifted people's thinking about time. Sun clocks were good for telling the time of day, but water clocks could be used easily to measure the length of shorter intervals of time. For example, in ancient Greece, citizens were allotted a certain amount of time—measured by sinking water clocks—to address the Senate or a jury. In China and in the Middle East, people created very elaborate water clocks. The most elaborate used gears and simple machines.

## Materials

### *For each student*

- 1 science notebook
- 1 piece of aluminum foil, 10 cm (4") square

### *For every two students*

- 1 plastic flex tank, 4 liters (1 gal), with water
- 3 brass washers, 9 mm ( $\frac{3}{8}$ ") diameter

### *For the class*

- 1 clock with a sweep second hand
- 1 class list, "What We Know about Measuring Time" (from Lesson 1), and a marker of a different color from previous entries
- 3 buckets with handles, each approx. 4 liters (1 gal)
- Several sponges
- Several sheets of newsprint and marker(s)

## Preparation

1. Cut one 10-cm (4") square piece of aluminum foil for each student.
2. Fill each plastic tank about three-fourths full with water. You may want to ask students to help with this task. If your classroom is not equipped with a sink, buckets with handles are one way to transport and pour water efficiently.
3. Display a clock with a sweep second hand in the classroom.

## Procedure

1. Remind students to continue recording their observations of the moon for the next several weeks. The record of moon observations will be important evidence of the pattern of the moon's phases.
2. Ask students to describe some of the problems they encountered using the sun and moon to keep track of time. Here are some of the things they are likely to come up with:
  - It is impossible to tell time when it is dark or cloudy.
  - Sun clocks aren't portable.
  - It is hard to be precise.
3. Show students the "What We Know about Measuring Time" list from Lesson 1. Ask students whether the list includes ways to keep track of time without depending only on the sun or moon. Encourage them to brainstorm new ideas to add to the list.
4. Explain to students that because people had problems keeping time with the sun and moon, they began to make different types of clocks. One type—sinking water clocks—used objects sinking in water to keep track of the passage of time.
5. Ask students to discuss with their partners their ideas about how to use water to keep track of time. Have them sketch a few possible designs in their notebooks and write explanations for their sketches.
6. Now ask students to use a piece of aluminum foil and brass washers to construct a sinking water clock. Challenge them to try to find a way to make a clock that will sink in 15 seconds. Have students use the clock on the wall to compare how long it takes their water clocks to sink. Encourage a variety of designs.

Figure 7-1

Constructing a  
sinking water clock



7. Distribute the materials to students. Ask them to take turns testing their sinking clocks. Encourage them to talk with each other about what they are trying to accomplish.
8. After students have completed their work with water clocks, ask them to return the materials to the storage area and dry off their work area.
9. Have students describe and illustrate in their notebooks how they made their sinking water clocks. What worked? What didn't work?

### Final Activities

1. Discuss with students the various strategies they used to construct their water clocks. Have students share one of their designs. Ask questions such as the following to focus the discussion. List students' responses on a sheet of newsprint.
  - What are some things you did to make the clock sink more quickly? More slowly?

- How do you know that your sinking clock is consistent—that it sinks at the same rate each time?
- How would you change your clock if you did this activity again?

**Note:** Save this class list to use in Lesson 8.

2. Explain that the things students changed to make the clock sink faster or slower are called **variables**, because they are able to be “varied.” Tell students that in the next two lessons they will plan and conduct an experiment with sinking water clocks. The experiment will provide evidence of what happens when one variable is changed. Students can use this evidence to design different kinds of sinking water clocks.
3. Ask students to read “Water Clocks,” on pg. 30 of the Student Activity Book (pg. 71 of the Teacher’s Guide). Ask them to focus on the following questions as they read.
  - What are some advantages and disadvantages of water clocks compared with sun clocks?
  - What are some types of water clocks that have been invented other than those that sink?

## Extensions



1. Encourage students to design and build timers that use water to keep track of the passage of time. Ask them to explain and demonstrate their timers for the rest of the class.
2. Ask students to create advertisements to sell their sinking water clocks. Have them include at least three good reasons why someone should buy them.

## Assessment

This lesson is the first of a sequence of three lessons involving the investigation of sinking water clocks and the planning and carrying out of water clock experiments.

The specific process skills involved in these three lessons are listed below.

- Planning an experiment
- Identifying and controlling variables
- Collecting and interpreting data
- Presenting results in graph form

Because development of these skills requires practice, students apply them again with pendulums in Lessons 10, 11, and 12.

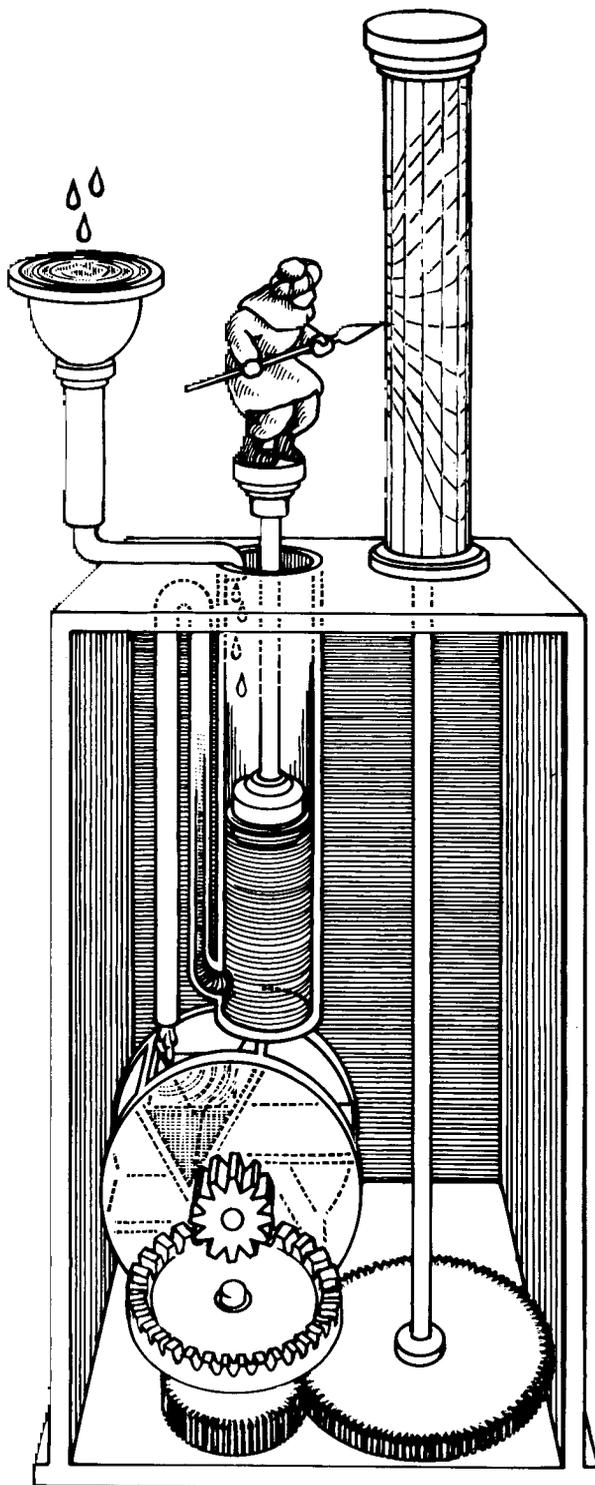
At the end of Lesson 9, you will have information with which to assess students’ ability to plan and conduct an experiment. For example, the plan and graph students construct in Lessons 8 and 9 will provide information about questions such as the following.

- Is the plan reasonable? Can the students do it?
- Do students select one and only one variable to investigate? Have students controlled all but one variable in carrying out their experiments?
- Do the experiments carry out the plan?
- Are the graphs that students construct labeled?

By comparing your assessment of students’ skills at the end of Lesson 9 with your assessment at the end of Lesson 12, you may be able to document changes in students’ skill development.

## Reading Selection

## Water Clocks



People have used many different kinds of water clocks throughout the ages. Some were technical wonders; others were as simple as bowls with holes in them.

One of the earliest sinking clocks was devised by the Saxons, a Germanic people who conquered England in the fifth century. The Saxon clock was a bronze bowl with a hole in the bottom, designed to sink at a steady pace in a pool of water. The length of time it took for the bowl to sink became the Saxon's standard unit of time.

At the time of the Roman Empire, the Egyptians were making elaborate flowing water clocks, such as the one on the left. This particular clock, which was constructed in Alexandria, Egypt, could measure 24-hour days and 365-day years. As the water flowed into a chamber and the pointer rose, it showed on the cylinder what hour it was, and, at the end of the day, how far they had come in the passage of a year.

Later, toward the end of the early Middle Ages, the Chinese were telling time with a water-wheel clock. The most well-known Chinese water-wheel clock was designed by a man named Su Song, and it was 40 feet high. The Chinese believed that time, like flowing water, has no beginning and no end. The wheel shape of Su Song's clock reflected that belief. This clock could mark the passage of hours and quarter hours.

*Egyptian water clock*

Other cultures used dripping water clocks. For example, the Romans were known to use clay pots, one suspended above the other, to keep track of how much time had passed. And they figured out one way to keep the water flowing from the upper container into the lower container at a fairly consistent and reliable rate. When the flow quickened because the opening in the clay pot had eroded, they lined the opening with gold or jewels so that the opening would stay the same size. (This design innovation has continued; today, jewels are used for the parts of watches that get a lot of wear.)

But there were other drawbacks to water clocks. There were times of drought, which meant that no water was available. And, too often, the clocks were unreliable because the

temperature of the water had changed, making the water flow faster or more slowly. By the end of the Middle Ages in Europe, it was just these kinds of drawbacks that encouraged people to invent clocks that didn't depend on water.

*Chinese water-wheel clock*

