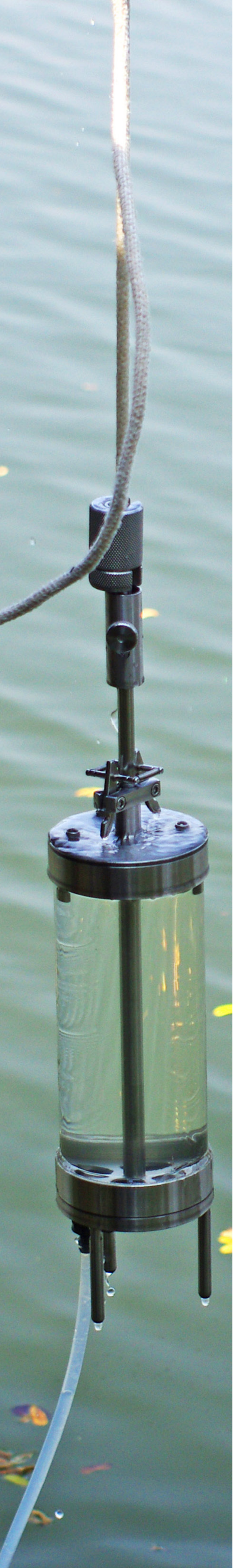

Grades
6–8, 9–12

60
minutes

WATER SAMPLING

DESIGN CHALLENGE

Participants design bottles that can float, sink, or remain suspended to hold simulated sensors that would monitor the health of a river.

SUPPLIES AND EQUIPMENT

Per whole group

- ☐ Basins or buckets deep enough for bottles to float, sink, or be neutrally buoyant (at least 1 basin per every 3 teams)
- ☐ Water to fill the basins or buckets
- ☐ Nuts, metal clips, washers, and other weight sources
- ☐ Fishing bobbers, ping-pong balls, and other floating objects
- ☐ Velcro, string, and twist ties to connect weights and floats to water bottles

Per team

- ☐ 3 identical plastic water bottles (1 or half liter size)
- ☐ 3 identical placeholders for sensors (such as metal spoons)
- ☐ 3 rubber bands for attaching the sensor placeholders to bottles
- ☐ Paper and pen or pencils for sketching and taking notes

GETTING READY

Designate a table for building and a space for the testing basins or buckets. Make sure that these areas are safe to get wet.

Designate a space where a facilitator can introduce the activity to participants; this is where teams can receive their water bottles. The materials should be available on an array of tables where participants construct their water sensor holders.

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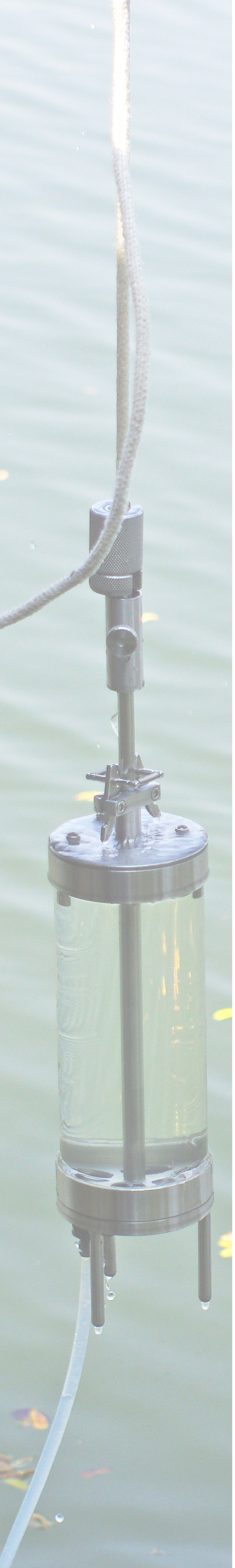


INTRODUCTION

Introduce the activity to participants by saying the following, adapted for your audience:

Environmental engineers and scientists design tools and develop solutions to environmental problems, such as pollution in rivers. River pollutants accumulate at different depths. How might you design an apparatus that can hold a sensor to test for oily pollutants on the surface of the river? How might you design one to test for salt or heavy metals at the bottom of the river? Today you will design bottles that can be attached to sensors and be used to collect a sample from the surface, middle, or bottom of a river.

INSTRUCTIONS

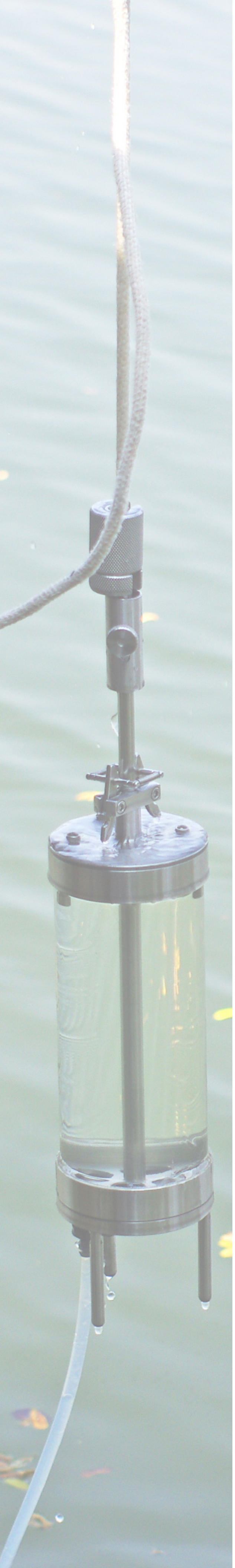
Divide participants into teams of two or three at most. Introduce the design challenge: to design bottles that can have sensors attached outside them to collect samples from the surface, middle, or bottom of a river in order to test for different types of pollutants that accumulate at each of these levels.

Point out the materials participants can use and the water containers that they will use for testing. The first step for each team will be to experiment with their water bottle to determine its initial buoyancy. Does it tend to float or sink with nothing but the simulated sensor attached?

Distribute three water bottles to each team. Instruct them to sketch their designs and take notes, so that they keep track of their ideas for each of the three levels. Remind participants of the steps of the engineering design process:

1. Plan. With your team, sketch ideas and select materials to change the buoyancy of the bottle to make it float, hover midway down the water column, or sink to the bottom. To adjust buoyancy, you may use water and/or weights.
2. Create. Construct your prototypes by adding floats and/or weights to your bottles, in addition to the simulated sensors (which are attached by a rubber band to the outside of each bottle).
3. Test. Place your bottles in the water and observe the results. Record your findings in your notes.
4. Improve. Try to improve your bottles by changing one variable at a time; then test again. What did you learn from your tests? How does your new design compare to the previous version?

As time allows, invite teams to demonstrate their apparatuses and discuss how they made their decisions.



ACTIVITY VARIATIONS

Each team makes only one water bottle sensor holder that can be used to test one level of the river.

Design two different sensor holders that float or hover at the same depth.

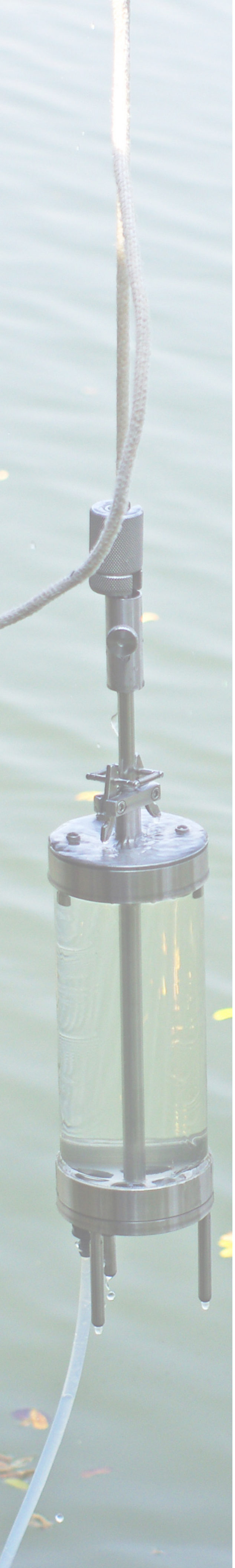
Design a sensor holder that floats horizontally.

Design a sensor holder that floats vertically.

Try a different object to represent the sensor and attach it to the bottle. How do you need to change your design to compensate?

RELEVANT TERMINOLOGY

Buoyancy: An object's ability to float in water or other fluid.
Iteration: The process of repeatedly testing and refining to reach a desired target or result.
Prototype: An initial model of something from which other variations or innovations are developed.



GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

- Which water level was it hardest to develop an apparatus for: surface, submerged, or sunk to the bottom? Why do you think that is?
- What might work better than a water bottle to create a sensor holder?
- If your sensor holder worked horizontally, how could you make it work vertically? Or vice versa?

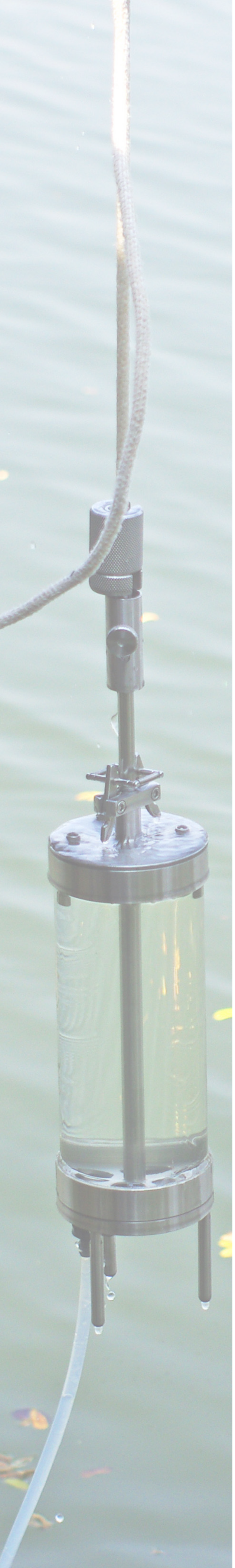
ENGINEERING CONNECTIONS

Engineers work with scientists to find ways to monitor our waterways and make them as clean as possible. This is very important work: the Environmental Protection Agency has determined that over half of the streams and rivers in the United States are in poor condition due to pollution or sediment from erosion.

Engineers who are working on projects that might affect the water quality of a nearby river also have to monitor the river, to make sure their project isn't creating pollution. For example, if a construction project requires dredging—scooping out mud or weeds—a lot of dirt and buried chemicals can swirl up and stay suspended. This cloudy, dirty water kills fish and can make people sick too. Engineers have ways to monitor the situation and to filter the water to make it clean again.

SCIENCE CONNECTIONS

Why does a bottle filled with water sink, while a capped bottle filled with air will float? The laws of buoyancy are known as Archimedes' principle, after the Greek scientist who discovered them. *Buoyancy* is the upward force of the fluid against the object. One of the laws of buoyancy is that something that floats must weigh less than the liquid that it is floating in. If an object has low density, such as wood, cork, or a sponge, it weighs less than water and it will float. If an object has higher density than the water and weighs more, it counteracts this upward force and sinks. Gravity pulls the object downward.



GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

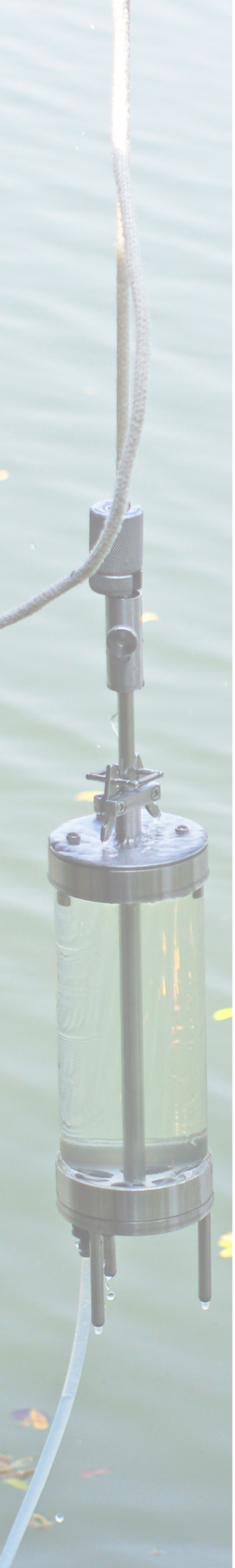
- What factors influence your water bottle's buoyancy?
- How might changing your design affect the way the bottle floats or sinks?
- Did figuring out how to make a sensor holder for one level of the river help you design one for the other two levels? How so?
- Why is it important to make only one modification to a prototype at a time?

ENGINEERING CONNECTIONS

Environmental engineers use the principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. Among the many tools that they have developed are stream gauges, which transmit data that can warn people of impending flooding. Engineers use a device called a sonde to measure water quality and characteristics such as temperature, pH, dissolved oxygen, and other indicators of water health. These devices, which often require sensors at different levels of the river, must take advantage of the laws of buoyancy to achieve the correct depth.

SCIENCE CONNECTIONS

The science of monitoring water is becoming increasingly accurate and sophisticated. The Lawrence Berkeley National Laboratory, for example, has created a DNA-based method of detecting and distinguishing sources of microbial contamination in water. They call it the PhyloChip. Being able to pinpoint exactly what is in the water helps engineers, local governments, and ordinary citizens figure out where the contamination is coming from so that they can put a stop to it. Scientists at the Berkeley Lab have created a reference library of the microbes from a huge range of sources, such as sewage and the excrement of birds and animals. Right now, the PhyloChip can detect the presence of more than 60,000 species of bacteria.



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ACKNOWLEDGMENTS

Activity created by the Museum of Science, Boston.

Supplemental content for this activity adapted by Mindful Solutions.

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