Exploring the Ocean with Robots

A Classroom Activity for Ocean Gazing Episode #15: Gliding on Earth and Episode #24: The little sub that could

Grade Level: 6-12

Lesson Time: 45 min.

Materials Required

large fish tank filled with fresh water, stepstool,
towels, sponges, laptop with glider data and photos, Cartesian divers (1 to 2 L bottles with water tight cap, Glass pipettes), balance, buoyancy "bubbles" (small plastic spheres that snap shut – available from vending machines that dispense toys), rubbing alcohol, kosher salt, large (4 cup) measuring cup, spatula for stirring, glider models (20cc syringes (1 for each model), plexiglas, saw, hot glue, paint or electrical tape, 20cc syringe with plastic tubing

Summary

This lesson will introduce students to robotic submarines, called gliders, including basic properties of buoyancy, types of information the robots gather, and investigate how scientists use that information to understand the ocean.

Objectives

- ✓ Determine whether an object will float or sink by comparing its mass to the same volume of water.
- ✓ Explain why a glider has a sinusoidal (up and down) flight pattern.
- ✓ List examples of information or research gliders can provide.

Vocabulary

Autonomous, AUV, sinusoidal, latitude, longitude

Introduction

Slocum gliders are autonomous underwater vehicles (AUV) used to study ocean water. They are extremely energy efficient since they use small changes in buoyancy to move up and down in a water column instead of a traditional propulsion system. A battery powered piston moves seawater in and out of the glider to change the buoyancy of the craft. Small wings on the sides convert some of the up down motion into horizontal movement, creating a saw-tooth flight path. The scientists program the glider using mission files, which instruct the glider to dive and climb to a predetermined set of waypoints (latitudes and longitudes). Due to their energy efficiency these AUVs can be deployed for extended durations on the order of weeks to months, as well as covering extended distances, thousands of kilometers.

The glider was originally envisioned by Henry Stommel in 1989, and engineered by Doug Webb. Gliders today are operated by

many institutions to monitor waters throughout the world. Gliders can be equipped with a multitude of different sensors to measure temperature, salinity, depth, ocean color, etc. and provide a real time view of ocean conditions below the surface.

Construction

To assemble a glider, first, cut the plunger of a 20cc syringe so it is only about one inch long.

Cut off any of the excess plastic at the back of the syringe. This modified syringe will form the body of the model glider.

Next form the glider wings by cutting Plexiglas into long right triangular shapes that are 4 to 4 ½ inches long and 1 ¼ inches high.

Even though actual slocum gliders only have 2 wings and a tail, for stability the model needs four of these triangular wings for each.

Hot glue the wings to the syringe body at 90° angles and at the positions north, south, east, and west if you look directly down the length of the syringe tube. It is important to make sure that the fins are straight lengthwise on the tube, and as close as possible to a right angle to the syringe.

Lastly use yellow and black electric tape or paint to create the shape of the real glider on the model. If using paint, seal with a waterproof clear spray-paint sealant before use.

For the "bubbles", submerge both plastic halves in the liquid of choice in the large measuring cup (rubbing alcohol for less dense than water, salt water for more dense) and reclose. You may also choose to fill half with corn syrup and half with cooking oil, but as these will be messy if opened, try sealing them closed once filled with a bead of hot glue around where the hemispheres of the dome come together.

To create the Cartesian divers fill a few 1 or 2 liter bottles with fresh water. Place a glass eyedropper partially filled with water in each bottle and cap tightly. Test the diver by squeezing; it should sink to the bottom. If it doesn't, adjust the amount of water inside the dropper so it will sink with a relatively light touch. Also minimize the about of air space left in the top of the bottle before resealing.

Activities

The activities are intended to teach or reinforce the concept of buoyancy, demonstrate an object of changing buoyancy, and show how buoyancy affects a glider's flight path.

I. Preparation:

A. Fill the tank with fresh water to about four inches from the top.

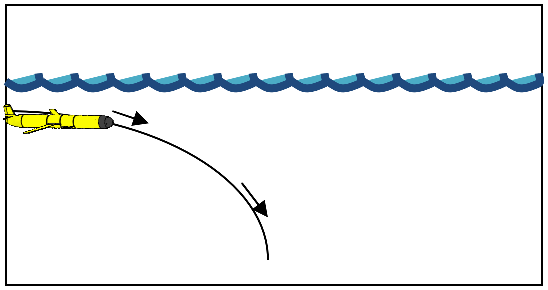
B. Fill the large measuring cup about halfway with fresh water and add a handful or two of kosher salt. Stir well.

C. Use the syringe to fill one or two model gliders with the salt water mixture. Hold them upright and press up on the plunger with your finger to remove any air bubbles.

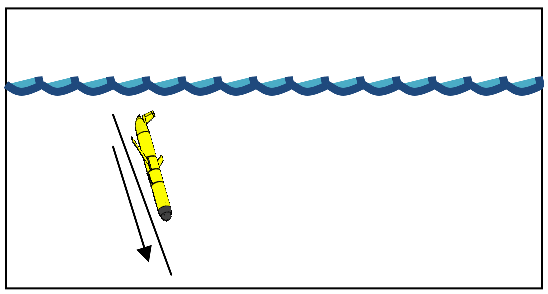
D. Have another one or two model gliders either empty or with a small amount of air inside them.

E. Test fly all gliders by placing each model horizontal in the tank (at the surface if it is water filled or near the bottom if empty/air filled) and giving a slight forward push before releasing, adjust the amount of salt water/air to get a good flight path:

Sinking should be this:

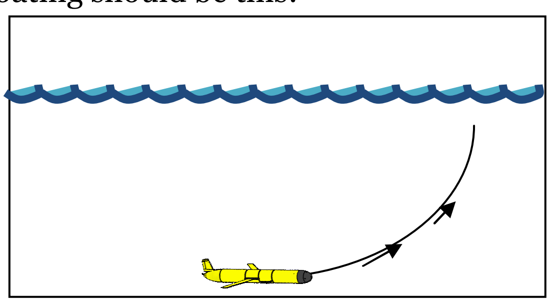


Not this:



The glider should sink nose first, not tail first.

Floating should be this:



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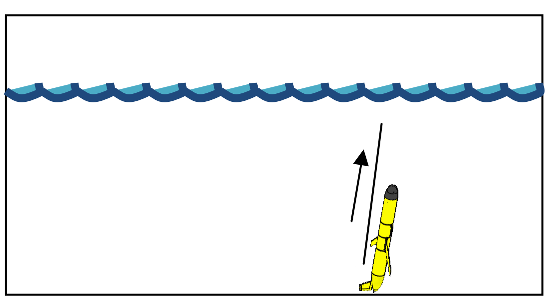

F. Fill one or two plastic "bubbles" with fresh water from the tank.

G. Set up a laptop with glider data and photos ready.

II. Procedure:

A. Ask students what they think of when they think about robots. Give a brief definition of a robot: A machine that can move by itself or by computer control. "Gliders" can be placed in the water already programmed with where to go, or controlled by scientists at a computer in their lab – even thousands of miles away.

B. The experiments relate to how the glider moves through the water – not by using a motor or propeller, but by changing its buoyancy.

Buoyancy – The tendency to float in a liquid, or, whether an object floats. (It is also "The upward force that a fluid exerts on an object less dense than itself.")

C. There are three experiments, which may be done in any order.

1. Buoyancy bubbles

a. Choose a bubble and predict whether they think it will sink or float, and place in the tank to test prediction.

b. Then choose additional bubbles and place one at a time on the balance opposite one filled with fresh water. Ask students to observe whether their selected bubble is heavier or lighter than the same amount of water. (If they are familiar with density, point out that we are comparing mass, volume is the same, so ask them to compare the density of their substance to water as well.)

2. Cartesian divers

a. Invite students to investigate the bottles – you can either ask them to figure out how to make the tube sink, or tell them to squeeze the bottle and see what happens.

b. Hold up one bottle and point out the tube (eyedropper) inside.

c. Point out the air bubble inside the tube.

d. Show students that when you squeeze the bottle, more water is forced inside the tube and the air bubble gets visibly smaller and if you put enough water inside the whole thing will sink.

e. Explain that this is how the gliders work – by changing the amount of water inside, they change whether they are heavier than water (sinking) or lighter (floating).

3. Model gliders

a. Show students one model that is filled with water, and one empty one.

b. Invite them to try placing the filled one in the water and giving it a small push to see what happens

c. Demonstrate, or let them try, placing the empty glider underwater and giving it a small push

d. These two models represent two halves of a glider's flight path – explain that a real one uses a battery powered pump to bring seawater in and out.

D. Explain that the glider communicates with the scientists by using a satellite phone in its tail when at the surface. It also has GPS, so it can let the scientists know where it is, send back data it collected, and get new instructions on where to go.

E. Access the Rutgers University Glider homepage to view real time data generated from gliders deployed all over the world: (http://marine.rutgers.edu/cool/auvs/). Note: if no glider missions are currently underway, please access the glider archives.

National Science Standards

Science as Inquiry
Abilities necessary to do scientific inquiry (K-4, 5-8, 9-12)

Physical Science
Motion and forces (5-8, 9-12)

Science and Technology
Understanding about science and technology (5-8, 9-12)

Science in Personal and Social Perspectives
Science and Technology in Society (5-8, 9-12)

Ocean Gazing Podcast

The related podcast episodes for this activity can be found by going to the podcast section of http://coseenow.net