

SPINOFFS

Spinoffs are relatively short learning modules inspired by the LTAs. They can be easily implemented to support student learning in courses ranging from prealgebra through calculus. The Spinoffs typically give students an opportunity to use mathematics in a real world context.

LTA - SPINOFF 19A

Bubbles

LTA - SPINOFF 19B

Designing the Scott Carpenter
Space Analog Station

LTA - SPINOFF 19C

Carbon Dioxide Buildup in the
Scott Carpenter Space Analog Station

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SPINOFF 19A

Bubbles

Spinoff 19A is closely related to LTA 19. As a result, you should complete LTA 19 before undertaking the following work.

This Spinoff explores the behavior of bubbles at various pressures that might occur in the Scott Carpenter Underwater Station. Because of the air flowing into and out of the Station, a stream of bubbles flows from the hatch at the bottom of the cabin to the surface of the water. In reality the bubbles often break or join with other bubbles, so let's consider the case of an ideal bubble.

Part A Pressure and Volume

Suppose that a bubble with a diameter of 2 inches is formed at the bottom of the cabin, at a depth of 21 feet.

- 1) Find the volume of the bubble.

As the bubble rises to the surface, the size of the bubble changes. We want to compute the volume and diameter of this bubble as it passes the top of the cabin and heads toward the surface.

If the temperature is relatively constant, Boyle's Law can be written as $P_1V_1 = P_2V_2$ where P is the pressure and V is the volume. You calculated the pressure in the water at the top and bottom of the cabin in Table 2 of LTA 19. You have already found V_1 .

- 2) P_1 (the pressure at the outside of the bottom of the cabin) = _____
 V_1 (the volume of the bubble at the bottom of the cabin) = _____
 P_2 (the pressure at the outside of the top of the cabin) = _____
- 3) Using these values, calculate V_2 (the volume of the bubble on the outside of the top of the cabin).
- 4) Now that you know the volume of the bubble as it passes the top of the cabin (Is it bigger or smaller?) you can calculate its diameter.
- 5) What was the percent change in the diameter?

Part B Volume of an ascending bubble

Let's now generalize the process for finding the volume of the bubble for any distance, X , that the bubble has risen from a depth of 21 feet. (So at the bottom of the cabin $X = 0$ and at the surface $X = 21$.) That is, we would like to have a function that we can use to find V_2 . We will do this in several steps.

- 1) First, solve the equation $P_1 V_1 = P_2 V_2$ for V_2 .
- 2) If the bubble forms at the bottom of the cabin, write a function representing the distance between the bubble and the surface.
- 3) Now use this function to write another function to determine the pressure of the water X feet above the bottom of the cabin. Remember that the change in pressure in pounds per square inch (psi) is _____ for each one-foot change in depth, and the pressure at sea level is _____. We want to use this function as P_2 in Boyle's Law so $P_2 =$ _____.
- 4) We already know that
 P_1 (the pressure at the outside of the bottom of the cabin) = _____
 V_1 (the volume of the bubble at the bottom of the cabin) = _____
- 5) So our function for $V_2 =$ _____
- 6) Sketch the graph of this function as X , the distance between the bottom of the cabin and the bubble, goes from a depth of 21 feet to the surface. (What is the domain of this function?)
- 7) Use the function to find the volume of the bubble as it passes the top of the cabin. (What is the value of X at that depth?) Does your answer agree with your answer from Part A above?