Pool Plunge:
The Relationship between Depth and Pressure

If you dive to the bottom of a swimming pool you will feel an increasing pressure on your eardrums as you descend. The deeper you dive, the more water there is above you to push down on your body and your eardrums, so the more pressure you experience. There is a mathematical relationship between your depth in the pool and the pressure you feel.

In this activity you will collect pressure readings at different depths with the use of a Gas Pressure Sensor. You will then find a model for your data and use this model to understand the relationship between depth and pressure.

OBJECTIVES

- Record pressure *vs*. depth data for water.
- Model pressure *vs*. depth data with a mathematical relationship.
- Interpret the fit parameters of the mathematical model.

MATERIALS

Graphical Analysis App
Go Direct Gas Pressure or
Vernier Gas Pressure Sensor
Vernier data-collection interface
(if required for your sensor)
Resonance Apparatus (base container only)
meter stick
clear tape
1 m clear aquarium tubing (⅛ inch ID)
Luer-lock connector
beaker
water

PROCEDURE

1. Use the Luer-lock connector to attach the aquarium tubing to the gas pressure sensor.

2. Use the clear tape to secure the aquarium tubing to the meter stick, with the open end of the tube at the 0 cm end of the meter stick.

3. Place the meter stick and tubing into the base of the Resonance Apparatus (the base container), with the open end of the tubing at the bottom.

4. Launch Graphical Analysis. Connect the gas pressure sensor to your device.

5. Set up the mode.

   a. Click or tap Mode to open Data Collection Settings.
   b. Change Mode to Event Based.
   c. Enter **Depth** as the Event Name and **m** as the Units, then click or tap Done.

6. You are now ready to collect pressure and depth data.

   a. Click or tap Collect to begin data collection.
   b. Click or tap Keep.
   c. Enter **0** for the depth, then click or tap Keep Point.
   d. Pour a small amount of water into the base container, so that the water reaches between the 5 cm and 10 cm mark on the meter stick.
   e. Click or tap Keep and enter the water depth in meters. Click or tap Keep Point.
   f. To collect another data point, add additional water to the base container. When the pressure reading stabilizes, click or tap Keep and enter the new depth in meters. Click or tap Keep Point.

      Note: as the depth of the water increases, the air in the tubing will compress allowing some water to enter the tubing. To get an accurate measure of the depth of water related to the pressure in the air tubing, you need to measure the water depth as the distance between the water surface and the water level inside the tubing.
   g. Continue adding water and making measurements in 5 to 10 cm increments until you have filled the base container within 10 cm of the top.
   h. Click Stop when you have finished collecting data.

7. Inspect your graph. Do your data points appear to match a mathematical model you are familiar with? If not, check for errors and consult with other groups. If necessary, pour out the water and repeat step 6.

ANALYSIS

1. Fit a curve to the data points on your graph.
   a. Click or tap Graph Tools, , and choose Apply Curve Fit.
   b. Select the function that best describes your data. Click or tap Apply.

ANALYSIS QUESTIONS

1. Does your selected function fit your data points well? Explain what convinces you the function is a good fit.
2. What is the expression that can be written from the curve fit parameters given by Graphical Analysis?
3. How does the value of the density of water relate to your fit parameters?
4. What do the fit parameters of your curve fit indicate? Does this make sense?

APPLICATIONS

Use the curve fit equation you developed in this activity to solve the following problems.

1. Recall that the first pressure reading in this activity was without any water. This pressure is known to be 1 atmosphere (atm). How many kPa (kiloPascals) are equal to 1 atm?
2. Your cousin Diana is always exaggerating. When you tell her that you sat on the bottom of the 1.5 m deep community swimming pool, she quickly responds that her pool is three times that deep, and she often lays down on the bottom. Use your model to find the (assumed) pressure at the bottom of Diana's pool. (Also, you should question Diana's assertion that she has an Olympic diving pool.)
3. Beginning SCUBA divers reach a maximum pressure of about 280 kPa during their certification dive. Use your model to determine the approximate depth a novice SCUBA diver reaches in this dive.
4. The Mariana Trench contains some of the deepest waters ever measured on Earth. One location, called the Challenger Deep, was found to be 11,033 m. Use your model to predict the pressure at this depth.

   At this depth, assuming the surface pressure is 1 atm, what is the pressure in atmospheres?

EXTENSION

Repeat this experiment using salt water to mimic ocean water. You will need to look up an appropriate amount of salt to add to water to come close to the density of "typical" ocean water.

Once you have repeated the experiment, revisit your answers to Application questions 3 and 4. How much do they change when ocean water is used?