Group Member Names: Neptune, Pearl, Cyrus, Brianna, Emilie, Jasmine

LAB: PRESSURE VS. DEPTH

Purpose

How is static pressure related to depth in a column of water? Experimentally determine the mathematical relationship between static pressure and depth in a column of water.

Materials and Equipment

- Data collection system
- PASCO Pressure Sensor[1]
- Tubing, 1/4" diameter, longer than 30-cm[1]
- Water reservoir, transparent, over 30 cm high
- Ruler

Background

Anyone who has tried to swim to the bottom of a deep swimming pool has experienced the sensation of pressure on their body. The deeper you swim, the greater the pressure. So if you swim to twice the depth, would you feel twice the pressure? What is the mathematical relationship between the pressure on your body and the depth in the pool?

In this activity, you will measure the pressure at different depths using a pressure sensor to determine a mathematical relationship between pressure and depth.

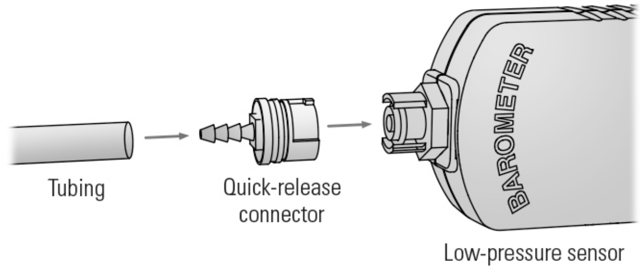
Safety

Follow this important safety precaution in addition to your regular classroom procedures:

- Make necessary arrangements to your workstation to avoid getting water on any electronic equipment.

Procedure

Set Up



1. Cut a length of 1/4" plastic tubing approximately as long as the water reservoir is deep and connect the tubing to the valve on the low-pressure sensor using the corresponding barbed quick-snap tubing connector.

2. Connect the absolute-pressure sensor to the PASCO interface.

3. Connect the USB cable to your laptop and open the “Absolute Pressure Sensor” file within the Schoology Assignment.

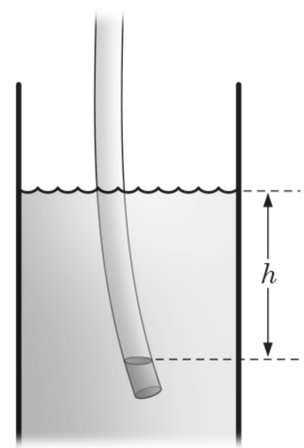
4. Fill the water reservoir approximately 3/4 full with distilled water.

Collect Data

5. Hold the low-pressure sensor and the attached tubing above the water level in the reservoir, and then record the first pressure measurement and corresponding depth (0 cm) in Table 1.

6. Submerge the open end of the tubing from the low-pressure sensor into the water.

   NOTE: The tubing may not be straight, which is not a problem as long as the depth is measured at the point of the open end of the tubing.



7. Record the pressure P and depth h in Table 1.

   NOTE: At greater depths, a small volume of water may creep up the tubing as the air inside the tubing compresses. In this case, measure the depth h from the surface of the water to the water level inside the tubing.

8. Lower the tube into the water.

9. Repeat the previous steps until you have recorded the pressure at six depths:

10. Empty your water reservoir.

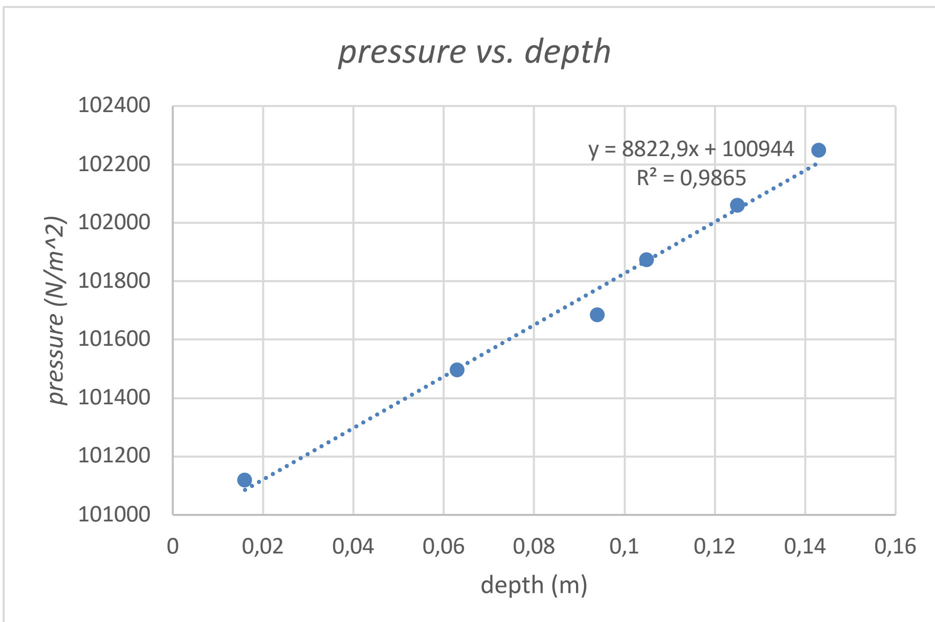
Data Analysis

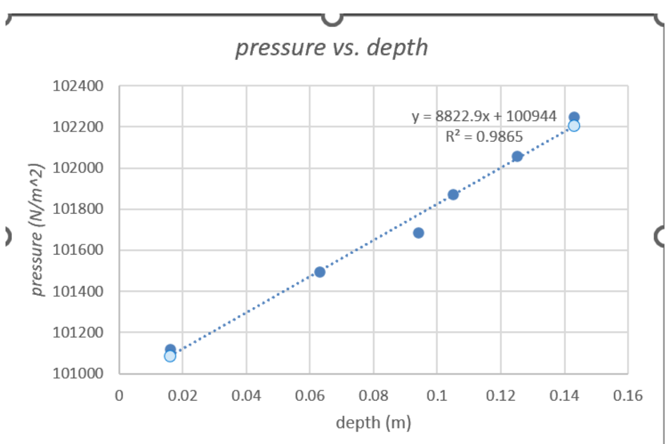
Table 1: Pressure versus depth in a water column

Depth (m)	Pressure (N/m^2)
0.016	101120
0.063	101496
0.094	101685
0.105	101873
0.125	102061
0.143	102249

1. Plot a graph of *pressure* versus *depth* in the blank Graph 1 axes. Be sure to label both axes with the correct scale and units.

Graph 1: Pressure versus depth in a water column





2. Draw a line of best fit through your data in Graph 1

Analysis Questions – Include in Conclusion

- 1. What type of relationship exists between pressure and depth of a liquid? Would this relationship hold true for a gas? Why or why not?

There is a linear relationship between pressure and depth of a liquid. This relationship would not hold true for a gas because since gases are compressible, a gas will have increasing density with increasing depth.

- 2. Identify all important values if they represent a physical quantity (slope, area, y-intercept, x intercept, etc.)

The y-intercept represents the atmospheric pressure on Earth because at a depth of 0, it experiences no pressure from the water because it is not submerged into it, so the y-intercept is simply the pressure of the atmosphere (P_0). The x-intercept would represent the depth at which pressure is equal to 0 N/m^2. This would technically be a negative depth value, which does not make sense in the context of our lab since a "negative depth" would mean the pressure-measuring instrument is out of the water, which means it would measure the atmospheric pressure instead of 0 N/m^2. The slope is pressure/depth, which is equal to density of the liquid times the gravitational field. The area is pressure*depth, which is not a particularly important value. (Solving the equation mathematically for pressure*depth would give us P_0*d + ρgd^2.)

- 2. Static pressure is related to depth according to the equation,

where P is pressure, P_0 is the atmospheric pressure, ρ is fluid density, g is acceleration due to gravity, and h is depth. From a linear graph relating pressure to depth, extrapolate a value for the density of the fluid in the reservoir (water).

Our equation is 8822.9x+100944.
The static pressure equation is p = p0 + pgd.
Since the y-intercept of our equation is 100944, that is equal to atmospheric pressure. This means that 8822.9x is equal to pgd, and since x is equal to depth, 8822.9 is equal to pg. Dividing 8822.9 by g, or 9.8 m/s^2, gives us a value of 900.30 kg/m^3 for our density of the fluid, which is similar to the accepted value of 1000 kg/m^3 for water.

- 3. If the theoretical value of the density of water is 1,000 kg/m^3, calculate the percent error between your experimental value and the actual value. Show your work.

Percent error = 100* (|900.30-1000|/1000)
Percent error = 9.97%

- 4. If you performed this same experiment using liquid iodine (density ≈ 4,900 kg/m^3) instead of water, how would a graph of pressure versus depth be different?

The slope of the pressure vs. depth would be steeper because the slope is equal to density of the liquid * the gravitational field. Since liquid iodine has a greater density and gravity stays constant, the slope will have a higher value, meaning that it will be steeper on the graph. This means that at the same depth, the pressure of liquid iodine would be higher than the pressure of water because of its higher density. The y-intercept would remain the same because atmospheric pressure remains constant no matter the liquid. The x-intercept would differ because it has the same y-intercept but different slope.