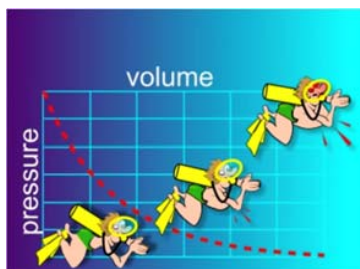# INVESTIGATION WATER DEPTH PRESSURE

Cartoon from http://resources.yesican-science.ca/Bolyes_law/

I am an active scuba diver. When I swim underwater you can feel a slight pressure on my ears. This is due to the weight of the water overhead. The deeper I go the more water is overhead, and so the pressure increases. We are told that at a depth of 33 feet the pressure is twice. Here is a table of pressure and depth.

Total Pressure at Standard Depths*
Depth / Atmospheric Pressure + Water Pressure / Total Pressure
0 feet / 1 ATA + 0 ATA / 1 ATA
15 feet / 1 ATA + 0.45 ATA / 1 .45 ATA
33 feet / 1 ATA + 1 ATA / 2 ATA
40 feet / 1 ATA + 1.21 ATA / 2.2 ATA
66 feet / 1 ATA + 2 ATA / 3 ATA
99 feet / 1 ATA + 3 ATA / 4 ATA

http://scuba.about.com/od/scuba101/a/Under-Pressure.htm

This water pressure can be dangerous for humans but some deep-sea animals have no trouble with high pressure. Whales, for example, can withstand dramatic pressure changes because their bodies are more flexible. Their ribs are bound by loose, bendable cartilage. This allows the rib cage to collapse at pressures that would snake human bones. A whale's lung also collapses safely under pressure. Whales can go as deep as 2.1 km under water. More amazing details can be found in an article "Pressure increase with ocean depth" on the Internet web site from the National Oceanic and Atmospheric Administration.

My teacher showed me an equation that tells me how the pressure is a function of water depth, gravity and water density. Here is the equation: $P = h\rho g$

For the density of water and the value of gravity, we see that pressure is directly proportional to depth. For my physics exploration I will investigate this law of physics in the physics lab, using a pressure gauge and a cylinder of water. My purpose is to prove or disprove the theory.

1

MY SCIENTIFIC METHOD

My physics investigation will measure this equation, and hopefully prove it is true. I will use a computer, a pressure sensor, a measuring cylinder filled with water, and a rubber tube inserted into the water at various depths. I will measure the end of the rubber tube from the water surface. I will keep all my measurements in SI units. I will follow the 100 mL marks on the cylinder but measure the depth with a ruler.

Safety issues were to be careful not to spill or set up the equipment in a dangerous way, and I paid attention to environmental issues, such as not spilling the water so as to waste it.

UNCERTAINTIES

The Vernier pressure sensor is given an uncertainty of only 0.1%, which is too small to think about. The uncertainty in this experiment comes from the depth measurement. First, I have to look through glass, and second, the rubber tube curves slightly, and third, the end opening has a width. Overall, I estimate and uncertainty of depth as 5 mm or ±0.005 m for my graphing works.

PICTURE AND DATA
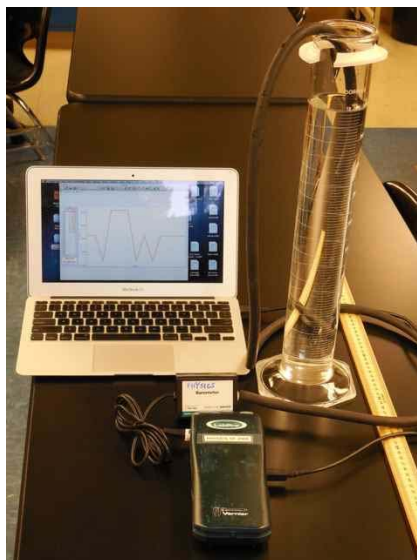
My Experiment

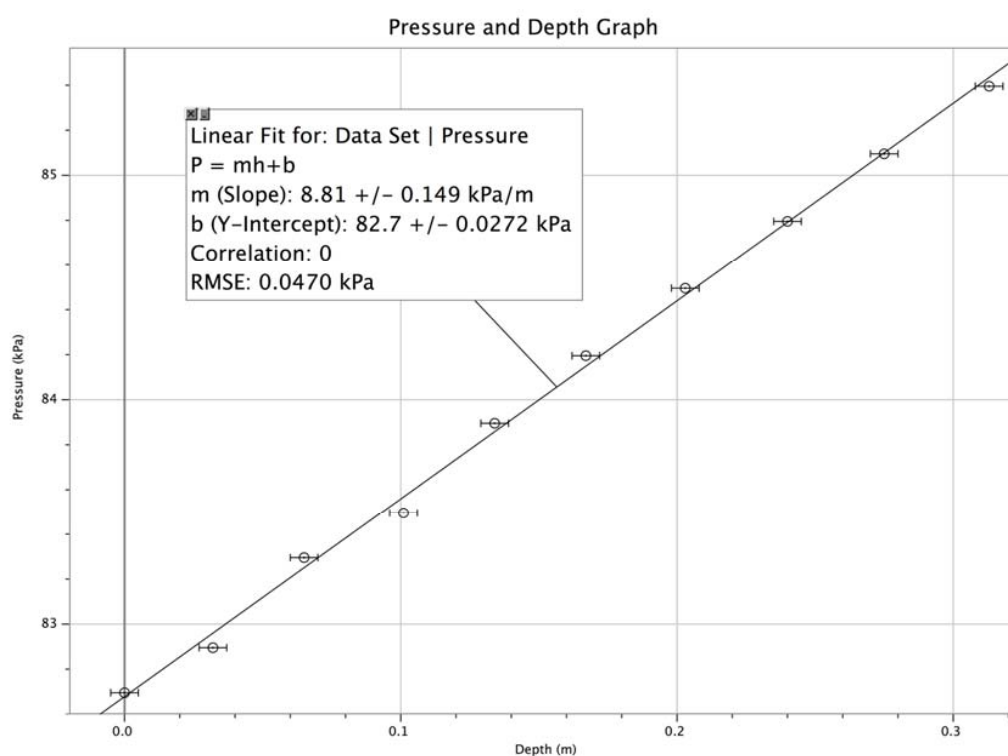|	Data Set	
	Depth (m)	Pressure (kPa)
1	0.000	82.695
2	0.032	82.895
3	0.065	83.295
4	0.101	83.495
5	0.134	83.895
6	0.167	84.195
7	0.203	84.495
8	0.240	84.795
9	0.275	85.095
10	0.313	85.395

My Raw Data.

2

PHYSICS THEORY

The theory is that the water pressure increases the pressure going to the sensor, and this is recorded on the computer. Instead of using a time base, I selected manual data entry, and entered the water depth each time for a given measure of pressure.

In theory, the gradient of the graph should be 9.81 kPa m^{-1}, where gravity is 9.81 m s^{-2} where the density of water is 1000 kg m^{-3}. This theory comes from the equation:

$$P = h\rho g \rightarrow \frac{P}{h} = \rho g$$

$$\text{slope of graph} \left(\frac{\Delta P}{\Delta h}\right) = \rho g = \left(1000\,\text{kg m}^{-3}\right)\left(9.81\,\text{m s}^{-2}\right) = 9810$$

EXPERIMENTAL RESULTS GRAPH

Pressure and Depth Graph

Linear Fit for: Data Set | Pressure
P = mh+b
m (Slope): 8.81 +/- 0.149 kPa/m
b (Y-Intercept): 82.7 +/- 0.0272 kPa
Correlation: 0
RMSE: 0.0470 kPa

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CONCLUSION and EVALUATION

In practice, my experiment yields a slope of (8810) or 8.81 kPa m^{-1}.

This gives me an experimental error of $\dfrac{9.81 - 8.81}{9.81} \times 100 = 10.2\%$

Although 10% is noticeable it is very good for my experiment, as the graph itself is proportional with a zero-zero origin. Almost all the error bars (almost) touch the best straight-line. The computer tells me the graph correlation is 0.999 and that is amazingly good, so my data are precise and accurate.

My conclusion is obvious, namely: that the pressure increases in a proportional way with the depth. And I know for to 10% uncertainty. I was careful to keep SI units throughout the experiment and I appreciated uncertainties.

IMPROVEMENTS AND EXTENSIONS

(1) With more time I would make more measurements. Perhaps I could use a rain barrow with much greater depth.

(2) I should have attached the rubber tube to the zero end of meter stick, immerse the stick with the tube fixed into the water keeping it vertical, and then read the depth from the ruler at the water surface. This would improve the precision by several millimeters I am sure.

(3) I found a web site that calculated the theory of pressure with water depth. I could use this data with my measurement and obtain higher precision, to five decimal places.

REFERENCES

The value of gravity, the density of water and the pressure equations all come form our textbook, "Physics: Principles with Applications" fifth edition by Douglas Giancoli, Prentice Hall Publishers.

And more details about the equations of water depth and simple experiments can be found online at: http://library.thinkquest.org/26586/Pressureunderwater.htm

And even more details can be found at: http://en.wikipedia.org/wiki/Underwater

Web site for calculating water depth pressure:
http://www.calctool.org/CALC/other/games/depth_press

For an article on water depth and whales see:
http://oceanservice.noaa.gov/facts/pressure.html

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