Physics 213 Laboratory

Hydrostatic Pressure as a Function of Depth

**Purpose:** To determine the hydrostatic pressure of a fluid as a function of depth below the surface to the fluid.

**Theory:** The static pressure caused by a fluid varies with depth according to:

\[ P = \rho gh \]

where:
- \( P \) is the pressure in pascals; 1 pascal = 1 newton /meter\(^2\)
- \( \rho \) is the density of the fluid in kilograms /meter\(^3\)
- \( g \) is gravitational acceleration, 9.8 meters / second\(^2\)
- \( h \) is the depth below the surface of the fluid, in meters

In this experiment, the pressure is measured at several depths. Then, to test the equation above, pressure is plotted versus depth (pressure on the y-axis, depth on the x-axis.) A best linear fit gives the slope. From the equation \( P = \rho gh \) the slope should equal the product \( \rho g \), which theoretically equals \((1000 \text{ kg/m}^3)(9.8 \text{ m/s}^2) = 9800 \text{ N/m}^3\).

**Procedure:**

The apparatus used includes a floating plastic cylinder (a plastic pipe with a rubber stopper), a large glass cylinder, meterstick, ten 50 gram masses, vernier caliper, and water.

1. Fill the glass cylinder about half full of water. Float the plastic cylinder vertically in the water and record the depth of the bottom of the cylinder (from bottom of cylinder to water level.)

2. Add a 50 gram mass to the floating cylinder and record the depth of the bottom of the cylinder.

3. Repeat step 2 until all ten 50 gram masses have been added.

4. Remove the floating cylinder, measure its diameter with a vernier caliper, and weigh it (when empty.)
Calculations:

1. From the measurements of step 4 calculate the area of the bottom of the floating cylinder.

2. When the cylinder is floating, from the first condition of equilibrium, the force of the water pushing up on the bottom of the cylinder must exactly balance the weight of the cylinder and its contents. Then the pressure at that depth (at the bottom of the cylinder) can be found from:

   \[
   \text{Pressure} = \frac{\text{upward force of water}}{\text{area of bottom of cylinder}}
   \]

   and consequently:

   \[
   \text{Pressure} = \frac{\text{weight of cylinder and contents}}{\text{area of bottom of cylinder}}
   \]

For each amount of added load, calculate total mass, total weight = (mass)\( (g) \), and pressure, and complete the attached table, showing all units.

3. Plot the pressure versus depth, obtain a best linear fit, and from it the slope. Compare the slope with the theoretical value as explained in the introduction.
# Hydrostatic Pressure Data Sheet

<table>
<thead>
<tr>
<th>added load (g)</th>
<th>total mass load and cylinder (g)</th>
<th>total mass (kg)</th>
<th>depth (cm)</th>
<th>depth (m)</th>
<th>Force (N)</th>
<th>Pressure (N/m²)</th>
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Archimedes' Principle

Theory: Archimedes' principle states that the buoyant force on a submerged or floating object equals the weight of the displaced fluid. The object of this experiment is to verify Archimedes' principle.

The buoyant force can be found from:

\[ F_{\text{buoyant}} = W - W_{\text{apparent}} \]  

(1)

Where \( W \) is the real weight of the object, and \( W_{\text{apparent}} \) is the object's weight when totally submerged in a fluid (which in our experiment will be water). The weight of the displaced fluid can be found by calculating the volume of the submerged object. Then the fluid previously occupying the object's volume weighs:

\[ W_{\text{displaced fluid}} = \rho_{\text{fluid}} g V_{\text{submerged object}} \]  

(2)

Procedure:

The apparatus used quadruple beam balance with moveable “fixed” table, lead mass, wood mass beaker, and water.

1. Arrange the balance so that it is the “fixed table” is above the sample pan. Objects are to be suspended by a string to measure true and apparent weights. The string should be long enough that water poured into a beaker placed on the “fixed table” will cover the mass.

2. Weigh the metal mass and the wood block separately, and record the values in grams. (see Figure 1).

3. Fill the beaker about three fourths full with water. Suspend the metal from the scale arm and raise the beaker until the metal cylinder is completely submerged. (see Figure 2) The scale reading is used to calculate the "apparent weight".
4a. Suspend the wood block from the string. Suspend the metal from the bottom of the block. Hold the beaker so that just the metal cylinder is submerged (see Figure 3) and record the scale reading.

4b. Repeat as in 4a but raise the beaker until both metal cylinder and wood block are submerged (see Figure 4). Record the scale reading.

**Calculations:**

1. Using the appropriate data calculate the volume of the metal cylinder using Archimede’s Principle.

2. Repeat 1 for the block.

3. Using the mass in air an calculation 1, calculate the density of each object.

4. Look up the density of the metal and wood in an appropriate reference and compare your results to the known values.