4.3.2 How Does Water Pressure Vary with Depth?

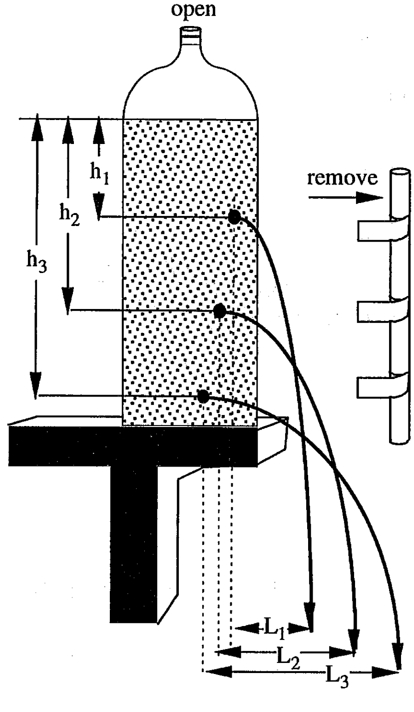
Concepts to Investigate: Pressure, water pressure and depth, pressure and fluid flow.

Materials: Two-liter soft-drink container, tape, pencil or glass rod, ruler, pliers, nail, burner, large pan.

Principles and Procedures: You may have felt pain or pressure in your ears when swimming near the bottom of a deep pool, but not when swimming near the surface. The pain you experience in deep water results from the pressure water exerts on your eardrums. Water pressure increases with depth according to the equation:

$$P_{(fluid)} = \rho g h$$

where ρ is the density of the fluid, g is the acceleration due to gravity, and h is the height of the water column above the point in question. Since the density of water is constant ($\rho = 1$ g/cm^3) and the acceleration due to gravity at Earth's surface is constant ($g = 9.8$ m/s^2), the only variable is depth. Thus, fluid pressure is directly proportional to depth. This can be tested using the apparatus shown in Figure E.



E

Obtain a clear two-liter soft-drink container. While holding the head of a nail with pliers, heat the tip in the flame of a Bunsen burner and then use it to melt three holes of equal diameter in the container, as shown in Figure E. The holes should be slightly offset from each other as illustrated. Wrap the ends of three pieces of tape around a rod so they are spaced the same distance from one another as the holes in the container. Place the other ends of the tape over the holes. Fill the container with water, leave it uncapped, and mark the water level on the bottle. Measure the distance from the water level to each hole and record these in the table as h_1, h_2, and h_3. The initial pressure may be calculated using the equation $P = \rho gh$. To quickly calculate the pressure (measured in Pascals) multiply the depth (h, measured in centimeters) by 98 Pa/cm. Place the bottle at least one meter above a pan. Pull the rod away from the bottle so all three holes are opened simultaneously and record the maximum horizontal distance each stream of water moves before reaching the pan. From your data, does it appear as though the relationship between fluid depth and fluid pressure $P = \rho gh$ is valid? Explain.

	Depth (cm)	*Initial Pressure (Pa)*	*Length of Water Stream (cm)*
Upper hole	h_1 = ________	p_1 = ________	l_1 = ________
Middle hole	h_2 = ________	p_2 = ________	l_2 = ________
Lower hole	h_3 = ________	p_3 = ________	l_3 = ________

Questions

(1) Do your data validate the pressure equation: $P = \rho gh$? Explain.

(2) Describe what would happen to a strong, flexible volleyball if you released it from a submarine at the bottom of the ocean.

(3) The Marianas Trench is the deepest known portion of the Earth's surface, with a maximum depth of 11,034 m (36,201 ft). In 1960, Jaques Piccard and Don Walsh descended to a depth of 10,912 m (35,800 ft) in the bathyscaph *Trieste*. Use the pressure equation to determine the approximate pressure in kiloPascals (1 Pascal = 1 newton/m^2 = 1 kg/ms^2) experienced by the bathyscaph at this depth. Assume that ocean water has a density of 1 g/cm^3 and that density does not vary with depth. How many times greater is the pressure at this depth than at the surface?