Name:
Class Period:
Date:

Bernoulli's Equation – Energy Conservation

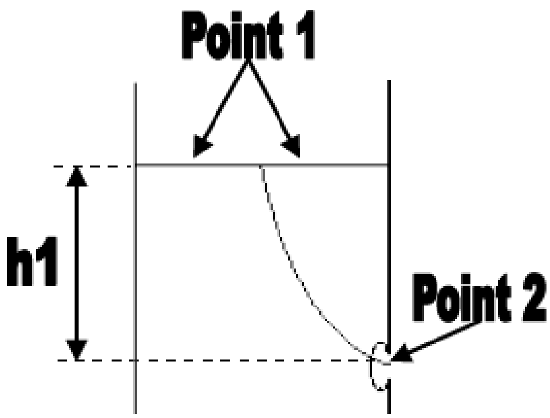
Needed Supplies: Empty 2-liter plastic bottle, scissors, ruler, dye, water

Theoretical Background

- Bernoulli's Equation
    - An increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.
    - The left side of the equation represents point 1, with the right side representing point 2 (before and after)
        - $P_1 + {}^1/_2 pv^2{}_1 + pgh_1 = P_2 + {}^1/_2 pv^2{}_2 + pgh_2$
            - This equation is based on the principle of energy conservation
                - Energy is neither created nor destroyed, but rather changes forms
            - Bernoulli's equation contains three types of energy:
                - **Pressure Energy**
                    - Represented by $\boldsymbol{P_1}$ and $\boldsymbol{P_2}$
                - **Kinetic Energy**
                    - Represented by ${}^1/_2\,\boldsymbol{\rho v^2{}_1}$ and ${}^1/_2\boldsymbol{\rho v^2{}_2}$
                    - $\boldsymbol{\rho}$ is the density of the fluid
                    - $\boldsymbol{v}$ is the velocity of the fluid
                - **Potential Energy**
                    - Represented by $\boldsymbol{\rho g h_1}$ and $\boldsymbol{\rho g h_2}$
                    - $\boldsymbol{\rho}$ is the density of the fluid
                    - **g** is the acceleration due to gravity
                    - **h** is the height of the fluid from the designated zero point

Experiment

- A 2 Liter soda bottle with a hole will be used for this experiment



- Point 1 – The surface of the water in the bottle
  - $\boldsymbol{P1}$ is zero because of atmospheric pressure
  - $\boldsymbol{v1}$ is assumed to be zero for this experiment
  - $\boldsymbol{h1}$ will be recorded as water level decreases
- Point 2 – The hole at the bottom of the bottle
  - $\boldsymbol{P2}$ is zero because of atmospheric pressure
  - $\boldsymbol{v2}$ is unknown but will be calculated
  - $\boldsymbol{h2}$ is zero because $h1$ is measured from point 2
- Solving the equation for v2
  - $\cancel{P_1} + \cancel{\frac{1}{2}\rho v_1} + \boldsymbol{\rho g h_1} = \cancel{P_2} + \boldsymbol{\frac{1}{2}\rho v_2^2} + \cancel{\boldsymbol{\rho g h_2}}$
  - $\boldsymbol{v_2 = \sqrt{2gh_1}}$

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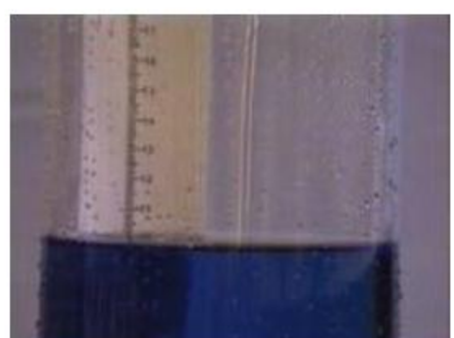

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Procedure

1. Obtain a 2 liter soda bottle and create a small hole on the bottom side
2. Cut off the top of the bottle and insert a ruler
3. Fill with water/dye, keeping the hole plugged
4. Let water flow out
5. Measure the height of the fluid ($h1$) at 10 different points as the water flows out
6. Record results in Data/Calculations section
7. Calculate $\boldsymbol{v2}$ for each point

Data/Calculations

ρ	0.036	lb/in^3
g	386.4	in/sec^2

Point	1	2	3	4	5	6	7	8	9	10
Height (h1)										
Velocity (v2)										

Discussion

- Describe what happens to the velocity of water flowing out of the bottle as the water level (h1) gets lower.
- What assumption becomes invalid when the hole size is large enough to make the water at point 1 move with a significant velocity?
- What would happen to $\boldsymbol{v2}$ if the top of the bottle is sealed and hooked up to an air compressor?