

AP Physics C – Investigating Water Flow using Integration

Purpose: To experimentally determine a volume of water that is flowing using calculus

Materials: Two liter bottle, small pin, stopwatch, two cups, graduated cylinder, Graphical Analysis

Procedure:

1. Make a small hole on a two liter bottle with a pin approximately higher than the height of a beaker from the bottom of the bottle.
2. Place finger over the hole and completely fill the bottle with water
3. Remove the finger and allow the water to shoot out of the bottle.
4. Start the stopwatch and collect the water in a small cup.
5. After thirty seconds, replace the cup with a new cup.
6. Pour the water from the first cup into a graduated cylinder.
7. Measure and record the volume in milliliters.
8. Do this EVERY thirty seconds. You have measure and record the VOLUME quickly!

Data Table

Time (min:sec)	Volume (ml)	Volume x 2 (ml/minute)
30 (0.5 min)		
1:00		
1:30 (1.5 min)		
2:00		
2:30		
3:00		
3:30		
4:00		
4:30		
5:00		
5:30		
6:00		
6:30		
7:00		
7:30		
8:00		
8:30		
9:00		
9:30		
10:00		
10:30		
11:00		
11:30		
12:00		

Analysis and Calculations

1. Take each volume measurement and double its value. This is basically the amount of water PER minute. So you now have what is called a RATE. **More specifically a VOLUME FLOW RATE.**
2. Open up Graphical Analysis for Windows
3. Enter the TIME in (0.5 increments) minutes on the X axis and the VOLUME FLOW RATE on the y axis.

What are the units of the Y-Axis?

What are the units of the X-Axis?

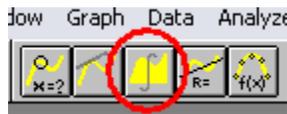
Does the graph represent LINEAR character? Explain why or why not.

Suppose we had a STRAIGHT LINE and we wanted to find the AREA under the line. List a way we could find the area.

What represents the HEIGHT in this experiment?

What represents the BASE in this experiment?

What would be the result of multiplying the UNITS of the HEIGHT AND BASE?



Click on the graph at your first data point. HOLD the mouse button down and DRAG to make a box that squares all of your data. Locate the INTEGRATION SYMBOL at the top of the toolbar, as shown in the figure to the left. With your data highlighted, click the

INTEGRAL symbol and record below.

Integral = _____

Add up all of the measured volumes from your data table and record below.

Total Measured Volume = _____

Calculate a % difference between the Integral and the Measured Value for the VOLUME of water collected.

$$\% \text{ difference} = \left| \frac{\text{Value1} - \text{Value2}}{\text{Average}} \right| \times 100$$

Explain one PRACTICAL example of the usefulness of this experiment?