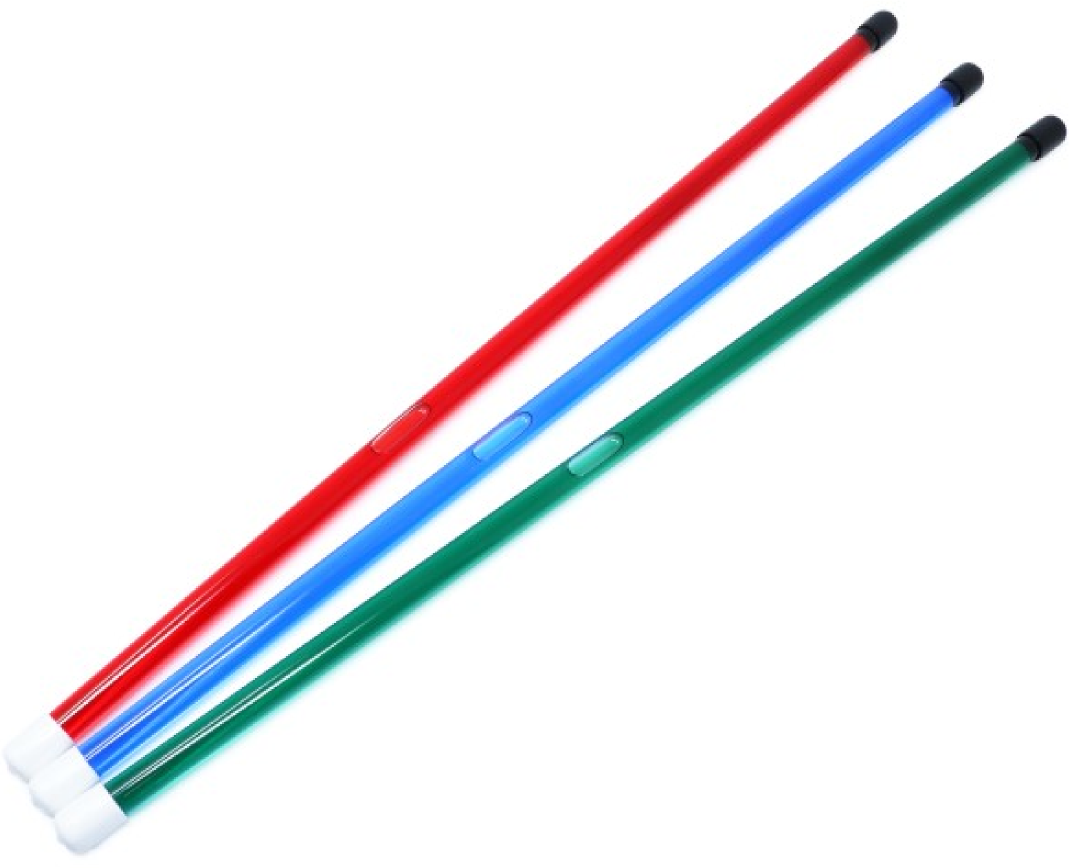
Andrews University
PHYSICS ENTERPRISES

Speed of the Bubble Tube Set

Experiment Guide



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Introduction

Description

The Speed of the Bubble Tube Set consists of three transparent plastic tubes filled with liquid. These are simple devices that students can use to generate distance vs. time data to explore constant motion and improve their graphing skills. The tubes contain colored oils of different viscosities. A bubble of air in each tube rises at a constant speed that is determined by the viscosity of the liquid, the angle at which the tube is inclined, and the temperature.

Purpose

The Speed of the Bubble Tube Set provides students with practice setting up experiments and graphing data. Students discover that the slope of a distance vs. time graph is the speed of the moving object, and verify graphically that the bubbles travel at constant speeds.

Other Experiments and Demonstrations

- Students may be challenged to predict and test the effect of angle on the velocity of the bubble. The results may be somewhat surprising.

- Students may test the effect of temperature on the velocity of the bubble. Different speeds can be safely determined between the temperatures of 10°C and 40°C using an ice bath and hot tap water. Do NOT use heating/cooling methods that exceed this temperature range.

- Centrifugal force can be demonstrated by observing the location of the bubble when the tube is spun. Hold a tube horizontally in the middle and gently rotate your wrist back and forth. The oil moves to the ends of the tube, displacing the bubble and causing it to move to the middle.

Care and Use

Although plastic, the tubes may crack or break as a result of rough treatment. Some simple precautions will help ensure the tubes provide years of use:

- Caution students not to place tubes where they may fall, such as by rolling off a table.
- Do NOT expose the tubes to heat, chemicals, or other extreme conditions.
- Store the tubes out of direct sunlight.
- Do NOT store the tubes in a chemical storeroom.
- Clean the tubes, if necessary, with mild, nonabrasive dish soap.
- The tubes contain hydraulic oils. If a tube should crack or break, absorb the spilled fluid with rags, and clean up with soapy water. For more information, refer to the safety data sheets listed below (available online at PhysicsEnterprises.com).
- The fluids might stain some materials. Stains may often be removed by ordinary procedures such as laundry stain removers.

Safety

Please teach and expect safe behavior in your classroom and lab. Safety considerations call for supervision of students at all times: safety eyewear, no horseplay, immediate reporting to the instructor of accidents or breakage, among others.

This product is intended for use by students age 13 years and older, under competent adult supervision.

Safety data sheets for oils available at PhysicsEnterprises.com on the appropriate product page.

SDS (ISO 22 oil - red tube)
SDS (ISO 32 oil - blue tube)
SDS (ISO 68 oil - green tube)

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Experiment

Speed of the Bubble

Purpose

The purpose of this experiment is to study the motion of a bubble rising in a tube of oil and show how graphs connect ideas from math and science.

Safety

Follow proper lab behavior rules, such as wearing safety glasses. Ask your teacher if you do not know these rules, or do not understand them.

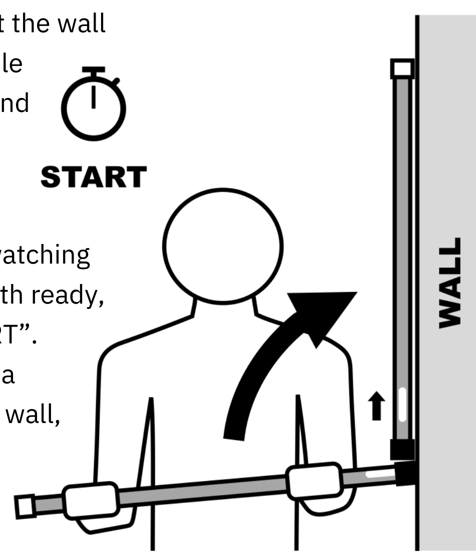
These tubes are breakable. Treat them with care. Tell your teacher immediately if a tube cracks, breaks, or leaks. Then take the proper clean-up steps.

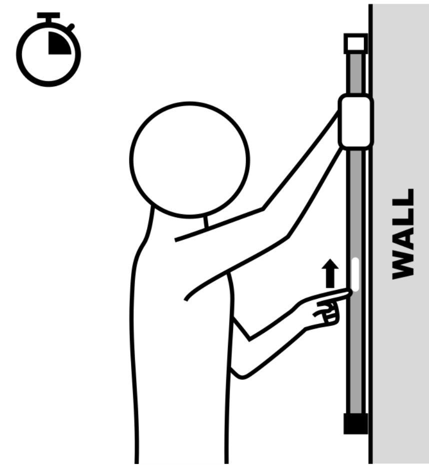
Equipment

- 3 tubes filled with colored oils (red, green, blue)
- Meter stick (preferred) or metric measuring tape
- Stopwatch (preferred) or clock

Procedure

1. Obtain one of the 3 colored tubes.
2. Work with a partner to record the motion of the bubble as follows:
   a. Hold the tube nearly horizontal with the black-capped end slightly elevated and resting against the wall as shown. Wait for the bubble to travel all the way to the end of the tube.
   b. Your partner should be operating a stopwatch (or watching the clock). When you are both ready, your partner will say, “START”. Quickly rotate the tube into a vertical position against the wall, pivoting around the black-capped end. The tube should now be vertical.



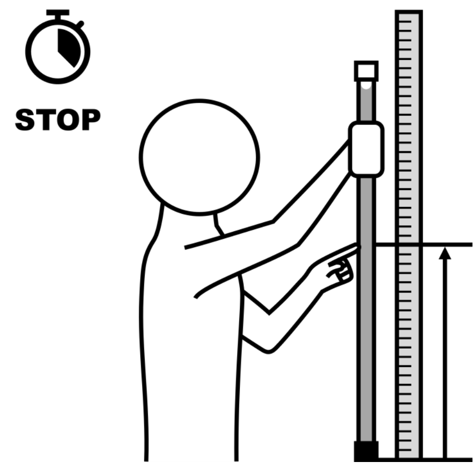


c. As soon as the bubble begins to rise, follow the bottom of the bubble with your finger.

d. When your partner says, “STOP”, stop moving your finger and hold it on the tube to mark the position. At the same time, your partner will stop the stopwatch (or note the time on the clock).

   For this first stopping point, choose a time such that the bubble nearly reaches the top of the tube.

e. Use a meter stick (or metric measuring tape) to measure the position of your finger (relative to the end of the tube as shown).



f. Record the time and position in the table on page 5. If you measured the time with a clock, record the difference of the two clock readings.

g. Carefully plot the data point (time and distance) on the graph on page 5. Identify the point by drawing a small circle, square, or triangle around it. For consistency, use a circle for the red tube, a square for green, and a triangle for blue.

4. Repeat the previous steps with a stop position such that the bubble has not risen very far, perhaps about 10 cm.

5. Choose 3-5 additional stop times spaced evenly between the first two times. Record the time and distance data in the table, and plot the points as you go.

6. Use a straightedge to draw a “best-fit line” through the points to represent the pattern of your data. Extend the line to meet the vertical axis. Label the line “red tube”, “green tube”, or “blue tube”. Ideally, the points should fall exactly on the line, however, in practice, this rarely happens. All measurements contain uncertainty which prevent them from perfectly matching predictions.

7. For this experiment, we also expect the best-fit line to pass through the origin (0,0). Can you explain why? If your line does not pass through the origin, what might cause it to deviate?

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8. Repeat the previous steps with each of the remaining tubes and plot the data on the same graph.

Experiment Data

Table 1 - Red Tube

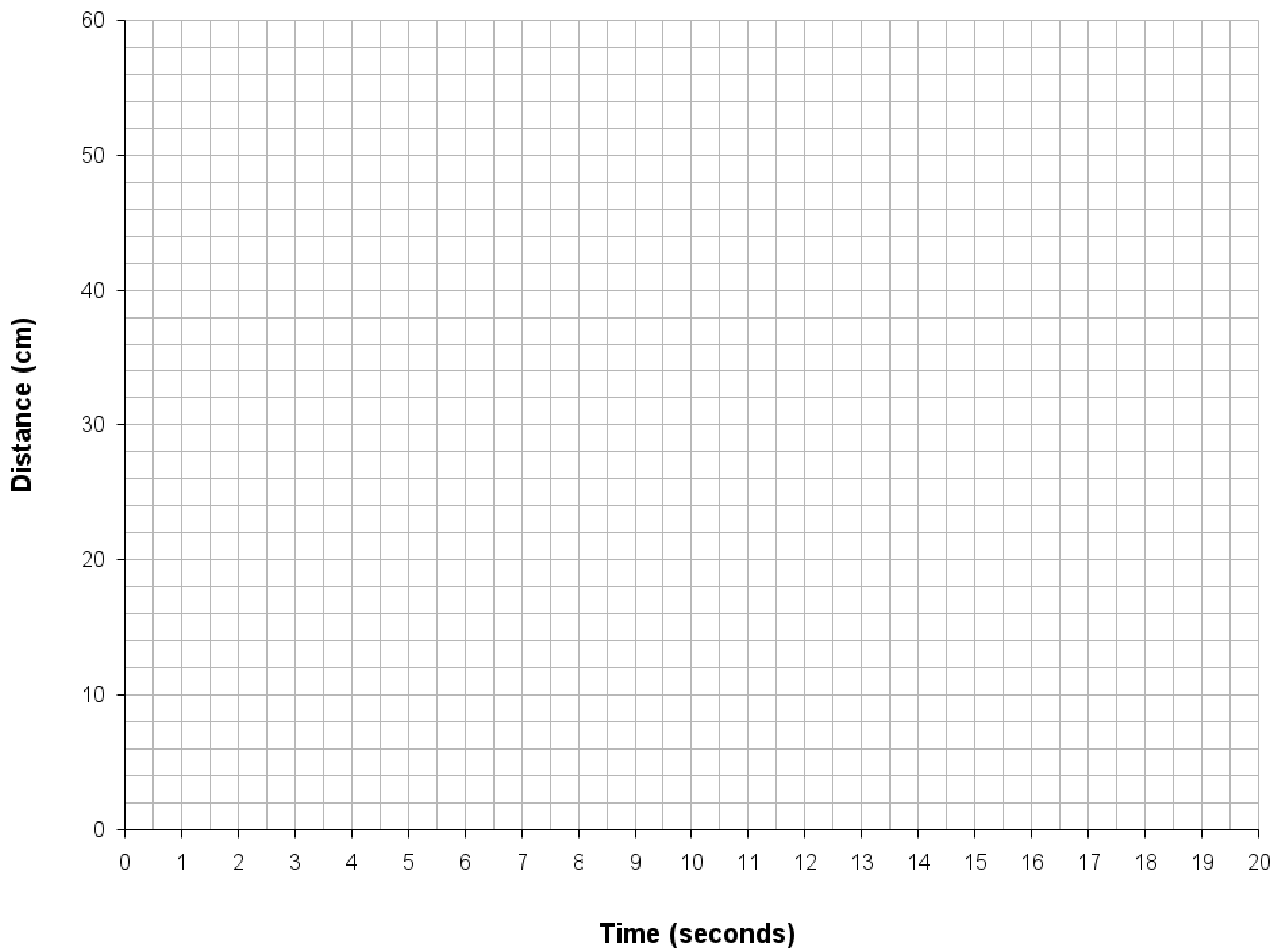
Time (s)	Distance (cm)

Table 2 - Green Tube

Time (s)	Distance (cm)

Table 3 - Blue Tube

Time (s)	Distance (cm)



Analysis

1. How far did the bubble in the red tube travel in 4.5 seconds? ___________________________________
(*Find the point on the best-fit line that is directly above the 4.5 second mark on the bottom of the graph. Then trace horizontally to the left side to find the corresponding distance.*)

2. How far did the bubble in the green tube travel in 4.5 seconds? ________________________________

3. How far did the bubble in the blue tube travel in 4.5 seconds? ________________________________

4. In which tube was the bubble the fastest? _______________________________________

5. Which tube has the steepest best-fit line? _______________________________________

6. Is there a connection between your answers to questions 4 and 5?

____

7. In the field of mathematics, we often use the word "slope" to describe how steep something is. Slope is defined as *Rise* divided by *Run*, where rise is the vertical difference between two points, and run is the horizontal difference.

   Follow the steps to find the slope of the best-fit line for <u>each</u> tube:

   a. Mark two points on the line, and label them "A" and "B." The points should be on the line and far apart from each other. Try to choose points that will make it easy to read the distance and time measurements. Record the values in the table below.

	Point A		**Point B**	
Tube	**Time (s)**	**Distance (cm)**	**Time (s)**	**Distance (cm)**
Red				
Green				
Blue				

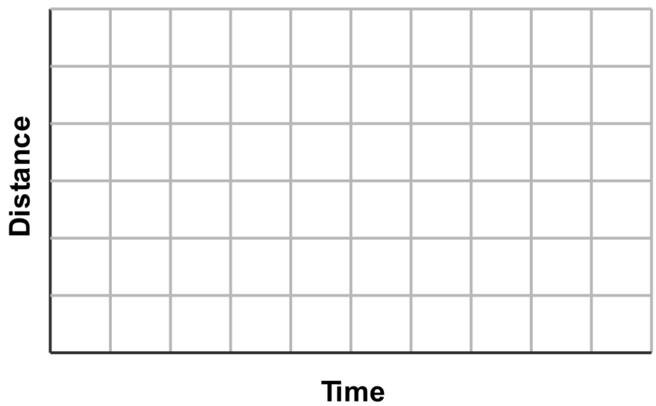
   b. Rise is the vertical difference between A and B. Run is the horizontal difference. Calculate the rise and run for each tube in the table below. Include measurement units.

   c. Calculate the slope (rise/run) for each tube in the table below. Include measurement units.

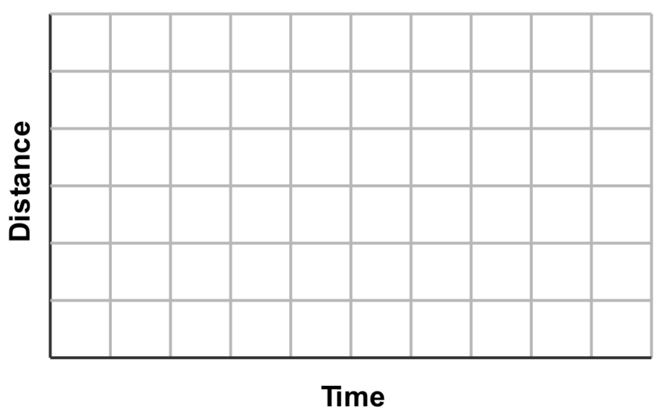
Tube	**Rise = Distance B - Distance A**	**Run = Time B - Time A**	**Slope = Rise / Run**
Red			
Green			
Blue			

8. In the previous calculations, you divided rise by run. The rise was a distance, and the run was a time.
   "Distance divided by time" is the formula for calculating ____________________.
   Therefore, the slope of a distance vs. time graph is the ____________________ of the moving object.

9. Imagine an object that traveled at a steady speed, then stopped and remained motionless for a while.
   Sketch the shape of graph that would result.



10. Imagine an object that goes faster and faster as it travels.
    Sketch of the shape of graph that would result.



11. What feature of the graph from this experiment shows that the bubbles traveled at constant speeds?

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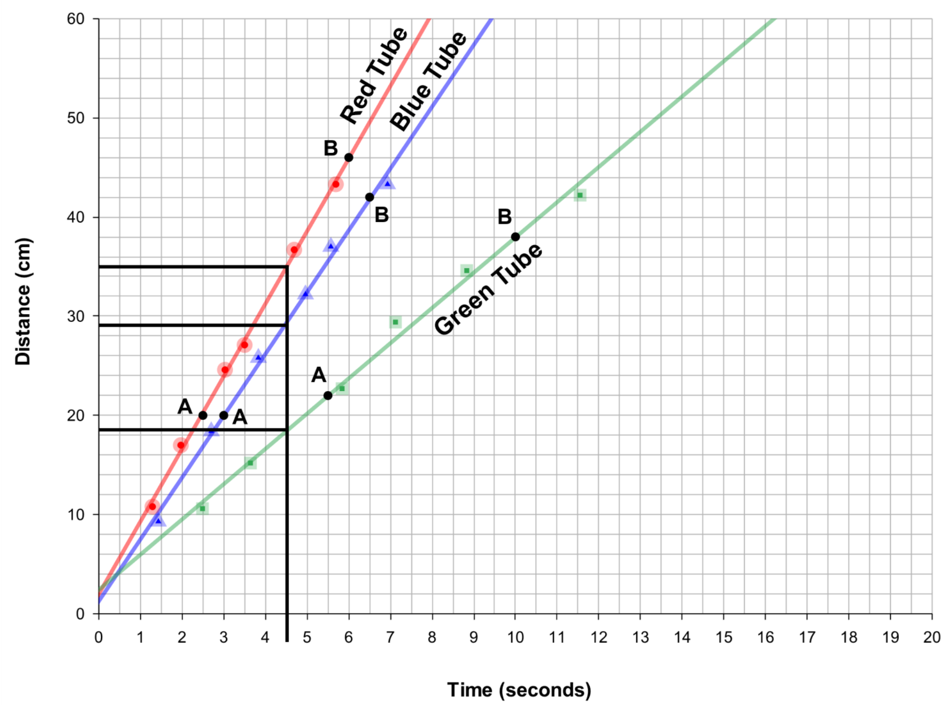
Answer Key

Typical Results & Answers

Procedure

Sample Graph:



7. The best-fit line passes through the origin, because the timer started (time = 0) when the bubble was at the bottom of the tube (distance = 0). If the experimental data does not pass through the origin, this could be caused by several factors: The liquid does not extend to the end of the tube, because there is a stopper in the end to contain the liquid. The student may have delayed starting/stopping or started/stopped prematurely. The bubble must accelerate to its constant velocity (minor effect, but a reasonable response).

Analysis (typical results based on sample graph)

1. The bubble in the red tube traveled 35 cm in 4.5 seconds.
2. The bubble in the green tube traveled 18.5 cm in 4.5 seconds.
3. The bubble in the blue tube traveled 29 cm in 4.5 seconds.
4. The bubble in the red tube was the fastest.
5. The red tube had the steepest best-fit line.
6. Students should see a connection between "steepness" and speed.

7. Slope calculation for each tube:

   a. Mark and record two points on each line (see sample graph and table below).

	Point A		Point B	
Tube	**Time (s)**	**Distance (cm)**	**Time (s)**	**Distance (cm)**
Red	2.5	20	6	46
Green	5.5	22	10	38
Blue	3	20	6.5	42

   b. Calculate rise and run (see table below).

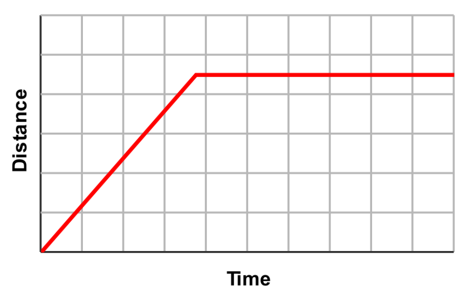
   c. Calculate slope (see table below).

Tube	Rise = Distance B - Distance A	Run = Time B - Time A	Slope = Rise / Run
Red	46 cm - 20 cm = 26 cm	6 s - 2.5 s = 3.5 s	26 cm / 3.5 s = 7.4 cm/s
Green	38 cm - 22 cm = 16 cm	10 s - 5.5 s = 4.5 s	16 cm / 4.5 s = 3.6 cm/s
Blue	42 cm - 20 cm = 22 cm	6.5 s - 3 s = 3.5 s	22 cm / 3.5 s = 6.3 cm/s

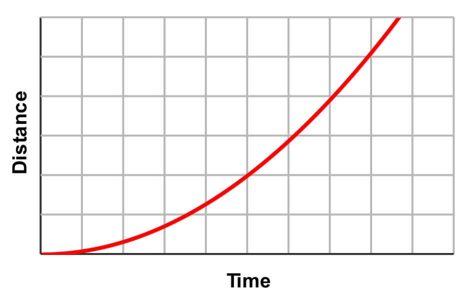
8. "Distance divided by time" is the formula for calculating speed.
   Therefore, the slope of a distance vs. time graph is the speed of the moving object.

   This is the key idea from this experiment. It is worthwhile to point out that the measurement units of the slope calculation turn out to be appropriate units for speed.

9. Sample Sketch:



10. Sample Sketch:



11. The data points from each tube follow straight lines. Straight lines have constant slope, and since the slope was the speed, the speed was constant.

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