

## FUNCTIONS EXPERIMENT PRESSURE AND VOLUME: BOYLE'S LAW

### Introduction

The textbook gives many examples of power functions in Sections 5.1 and 5.2. In this experiment you will see an example of a power function in physics as you investigate Boyle's law, which describes the relationship between the pressure and the volume of a fixed mass of gas at a constant temperature. Boyle discovered that pressure  $P$  is a power function of volume  $V$ , with power  $-1$ . Thus the formula is

$$P = cV^{-1}$$

for some constant  $c$ . We will test this relationship by using a large syringe with a plunger that is attached to a pressure sensor. By pushing the plunger in, we can vary the volume of air in the syringe and measure the resulting pressure with the pressure sensor. Here the volume of air in the syringe is measured in cubic centimeters, and pressure is measured in atm. For comparison, one atm is the pressure exerted by the atmosphere at sea level.

### Equipment and Setup

For this experiment you will need a TI calculator with the Vernier PHYSICS program loaded, a CBL unit, and a Vernier pressure sensor with large syringe. Plug the pressure sensor into channel 1 on the CBL unit. Disconnect the syringe from the pressure sensor and set the plunger at 20 cubic centimeters. Reconnect the syringe to the pressure sensor. Begin the PHYSICS program on the calculator and follow the instructions on the screen for setting up the probe. Under CALIBRATION choose USE STORED, and for the units choose ATM. You are now ready to collect data.

### Procedure

You will collect measurements for volume and pressure, starting with the volume at 20 cubic centimeters and then decreasing the volume of air in the syringe by 2 cubic centimeters each time until you have a total of 6 sets of measurements.

In the PHYSICS program main menu, choose COLLECT DATA. In the DATA COLLECTION MENU, choose TRIGGER/PROMPT. The CBL unit shows the current pressure measurement. Press [TRIGGER] on the CBL unit to record the data. On the calculator, at the prompt enter the volume of air in the syringe. When you press ENTER, you will have the option of collecting more data or stopping. Choose MORE DATA and repeat the data collection procedure, this time decreasing the volume of air in the syringe by 2 cubic centimeters. Continue this procedure, each time decreasing the volume of air in the syringe by 2 cubic centimeters, until you have a total of 6 sets of measurements.

### Data

You will need to add 1 cubic centimeter to your volume values to allow for the volume of air in the tubing. Record the adjusted volume data and the pressure data you collected in the table below.

Pressure Versus Volume

$V =$ volume (cc)						
$P =$ pressure (atm)						

### Analysis

1. Sketch below the graph of the data for  $P$  versus  $V$ . Describe what the graph shows.
2. By plotting  $\ln P$  versus  $\ln V$ , determine if it is reasonable to model  $P$  as a power function of  $V$ .
3. Find a formula for the regression line of  $\ln P$  against  $\ln V$ .
4. Find a formula which models  $P$  as a power function of  $V$ .
5. Check that your formula approximates the data in the table above by adding the graph of your formula to the graph in Part 1.
6. Does the data that you collected support Boyle's law? Explain.

## **Conclusions**

7. Based on the formula you found, answer the following.

(a) What happens to the pressure in the syringe if we double the volume of air in the syringe?

(b) What happens to the pressure if we triple the volume of air?

(c) What happens to the pressure if we quadruple the volume of air?

(d) Describe Boyle's law in words.