

## # 23 Pressure vs. Volume (Boyle's Law)

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**Purpose:** The relationship between pressure and volume is investigated using a gas pressure sensor probe interfaced with LabQuest and a syringe.

### Introduction

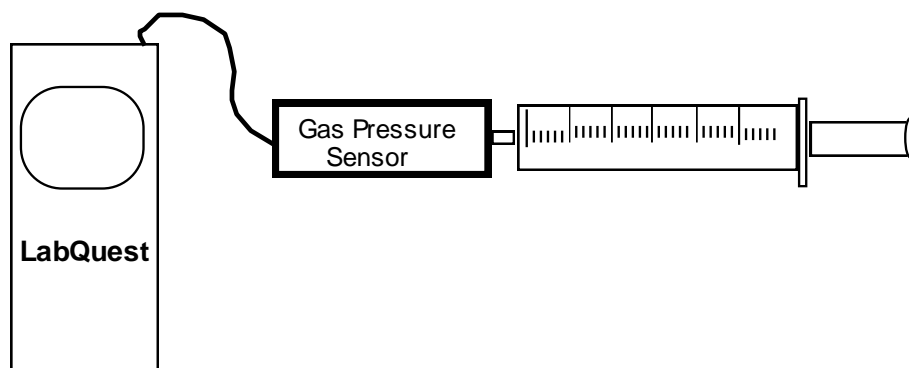
According to Boyle's Law the pressure of a gas at constant temperature is inversely proportional to its volume, that is, as the pressure is increased, the volume must decrease, and vice versa.

$$P = \frac{\text{constant}}{V} \quad \text{or } PV = \text{constant}$$

This experiment will be done with air, a mixture of gases that follows Boyle's law very well.

### Apparatus

Air pressure is measured using a gas pressure sensor probe. The gas pressure sensor probe will be connected to a LabQuest device. The syringe is attached directly to the pressure sensor.



### Procedure

#### Part A Setting up the Probe

1. Plug in the LabQuest. Connect the gas pressure sensor probe to analog Channel 1.
2. Select a pressure range by tapping **Sensors** in the top toolbar. Select **Change Units**. Choose desired unit, **mmHg**.
3. The pressure values will be displayed on the LabQuest screen.

#### Part B Measuring Gas Pressure and Volume

1. Set the plunger of the syringe to the 10-mL mark, using the top of the black rubber fitting to mark the volume.

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2. Connect the plastic syringe to the white stem on the end of the Gas Pressure Sensor. The white stem has a small threaded end called a luer lock. Connect the plastic syringe to the white stem *gently*.

CAUTION! It is very easy to damage the connector.

3. Select **Mode** by tapping (side menu) and a data collection screen will open. Change mode to **Events with Entry**. For **Units**, enter *ml*. Close screen. Select the chart icon on the top right menu. Tap on the arrow on the bottom left of the screen. **Keep** will appear and the arrow will become a red square.

4. The first volume will be 10 ml. Tap **Keep**. Enter **10**, by using the alphanumeric keypad, then press **OK**. A pressure point should appear on the graph.

5. Repeat step 4, replacing **10** with the new volume for every 1 mL increment between 4 and 20.

CAUTION! Do not try to decrease the volume below 4 mL. The maximum pressure that can be recorded without damaging the sensor is about 2100 mmHg or less than 3 atm.

6. When complete tap red square on bottom left to stop.

7. Pressure vs. Volume is plotted on the LabQuest graph. However, you will need to make another plot using the tabulated data, which will appear when you tap the “table” icon. Enter data on your data and results page. Calculate  $1/V$ . Plot P vs.  $1/V$ .

Be sure the plotted points reflect the uncertainty in the measurement. For example, the pressure sensor reads to the nearest:  $\pm 0.40$  mmHg. The volume reading is to the nearest 0.2 ml.

Note: One member of the group can adjust the syringe volume while another enters the value.

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## Data and Results (Boyle's Law)

Name(s) \_\_\_\_\_

### Part A Setting up the Probe

Pressure Unit: \_\_\_\_\_

### Part B Measuring Gas Pressure and Volume

Pressure	Volume mL	Reciprocal of volume 1/mL

\*Room pressure

Attach printout of P vs. V and your plot of P vs. 1/V.

### **Question**

What volume mark on the syringe would correspond to a pressure of 3.0 atm? (You can use a set of data points and Boyle's Law,  $P_1V_1 = P_2V_2$ )

# Instructor's Guide

## (#23 Boyle's Law)

### Part A Setting up the Computer-Interfaced Probe

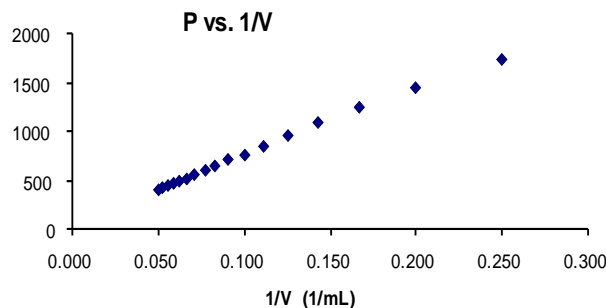
Pressure Unit: mmHg

### Part B Measuring Gas Pressure and Volume

Pressure <i>mmHg</i>	Volume mL	Reciprocal of volume 1/mL
763.9*	10.0	0.100
850.3	9.0	0.11
950.3	8.0	0.12
1084.0	7.0	0.14
1235.5	6.0	0.17
1454.6	5.0	0.20
1742.7	4.0	0.25
703.9	11.0	0.0909
646.5	12.0	0.0833
600.5	13.0	0.0769
557.1	14.0	0.0714
520.9	15.0	0.0667
489.4	16.0	0.0625
462.2	17.0	0.0588
436.7	18.0	0.0556
417.1	19.0	0.0526
396.2	20.0	0.0500

\*Room pressure

Attach printout of P vs. V and your plot of P vs. 1/V. The plot of P vs. 1/V is linear as predicted by Boyle's Law.



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### Question

What volume mark on the syringe would correspond to a pressure of 3.0 atm? (You can use a set of data points and Boyle's Law,  $P_1V_1 = P_2V_2$ )

Ans:  $2.00 \text{ atm} \times 760 \text{ mmHg/atm} = 2280 \text{ mmHg}$   
 $(763.9 \text{ mmHg}) \times (10.0 \text{ mL}) = (2280 \text{ mmHg}) \times V_2 \quad V_2 = 3.4 \text{ mL}$

### Equipment and Materials per group

Items	Number	Comment
Gas Pressure Sensor probes	1	
LabQuest	1	instead of laptops
Syringe	1	
Printer	1 per class	