

## Boyle's Law

### Equipment

Required:

1	Ideal Gas Law Syringe	TD-8596
1	Absolute Pressure Sensor	PS-2107
1	Quad Temperature Sensor	PS-2143

Not included, but required:

1	850 Universal Interface	UI-5000
1	PASCO Capstone	UI-5400



*Figure 1: Ideal Gas Law Syringe*

### Introduction

In 1662, Robert Boyle discovered the relationship between the volume and the absolute pressure of a gas that is at a constant temperature. In this experiment, you will rediscover this relationship by holding the temperature of a gas constant and changing the volume of the gas, and measuring the volume and the absolute pressure.

### Setup

The Ideal Gas Law Syringe allows simultaneous measurements of temperature and pressure of a gas as it is compressed. The mini stereo jack is connected to a low thermal mass thermistor built into the end of the syringe to measure temperature changes inside the syringe. The mini stereo jack plugs directly into the sensor.



*Figure 2: Attaching the Sensors*

The white plastic tubing coupler attaches to the pressure port of the sensor: A slight twisting motion locks the coupler onto the port. This white plastic connector can be disconnected and re-connected during the experiment to allow for different initial plunger positions. The plunger is equipped with a mechanical stop that protects the thermistor, and also allows for a quick, predetermined change in volume. Never slam the plunger down on the table. Always grip the syringe and plunger as shown to compress the air.

## Procedure

1. Add a table with temperature, Absolute Pressure, and Syringe Volume (units of ml) (a new user-entered set) in PASCO Capstone. Pre-fill the Syringe Volume with the values 50 ml, 45, 40, 35, 30, 25.
2. Set the sample rate to 20 Hz and change to the Manual Sampling Mode.
3. Set up a graph of Absolute Pressure vs. Syringe Volume.
4. Disconnect the white plastic pressure coupler from the Absolute Pressure Sensor. Calibrate the Absolute Pressure Sensor using a one-point calibration in the Calibration Tool on the left of the page in PASCO Capstone.
5. Set the plunger at 50 ml, and then re-connect the coupler to the sensor.
6. Click on Preview data. Press Keep while the plunger is still at 50 ml. Then compress the plunger to 45 ml and hold it at this position. Watch the temperature on the temperature column and wait until it has dropped down to close to room temperature. Press Keep. Each time you compress the air in this sequence, wait until the temperature returns back down close to this value.
7. Compress the plunger to 40 ml and hold it at this position. Watch the temperature, and hold the plunger at 40 ml until the temperature has dropped to the value you noted in step 3. Do not release the plunger.
8. Compress the plunger to 35 ml, and wait until the temperature drops as before.
9. Repeat for 30 ml and 25 ml.
10. Stop recording data.

## Analysis

1. Looking at the Pressure vs. Volume graph, try various QuickCalcs on the Volume axis to see what results in a straight line. Then do a linear curve-fit to see how well it fits.
2. How are Absolute Pressure and Volume related according to your results? Under what condition is this relationship true?
3. What physical quantities make up the slope of your straight-line graph?
4. Use the value of the slope to determine the number of moles ( $n$ ) of air in the syringe. Pay attention to the units!
5. Look carefully at the graph. Why is there an offset in the axis for the volume? How do you account for this extra volume?

## Further Investigations

1. Disconnect the white plastic pressure coupler from the sensor. Set the plunger at 60 cc, and then re-connect the coupler to the sensor.
2. Repeat the procedure, taking pressure and temperature data at each of the volumes (40cc, 35cc, etc.) as you did before.
3. Put this new data on the same graph. Why is this slope different? Is the volume offset **about** the same as before?

## Conclusion

Write a summary of your results. What general conclusions can you draw from your results? For instance, how does the pressure of a gas change when the volume is decreased at constant temperature? What is Boyle's Law?

