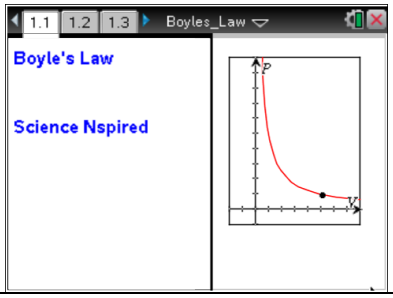
Boyle's Law
Student Activity

Name _____

Class _____

Open the TI-Nspire document *Boyles_Law.tns.*

In this activity, you will use a Gas Pressure Sensor to measure the pressure of an air sample inside a syringe. Using graphs, you will apply your results to real-world examples.



What is the mathematical relation between volume and pressure for a confined gas? To answer this question, you will perform an experiment with air in a syringe connected to a Gas Pressure Sensor. When the volume of the syringe is changed by moving the piston, the change in the pressure will be measured. It is assumed that temperature and moles of gas will be constant throughout the experiment. Pressure and volume data pairs will be collected during this experiment and then analyzed. Using the data and the graph, the type of mathematical relationship between pressure and volume of the confined gas can be determined. Historically, this relationship was first established by Robert Boyle in 1662 and has since been known as Boyle's law.

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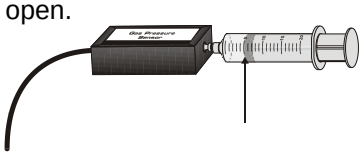
Q1. As volume increases, pressure:

A. increases B. decreases C. remains the same

1. With the syringe disconnected from the Gas Pressure Sensor, move the piston of the syringe until the front edge of the inside black ring (indicated by the arrow in the picture to the right) is positioned at the 10.0 mL mark.
2. Turn on your TI-Nspire handheld, and close any documents that are open.
3. Attach the syringe to the probe as shown to the right. (Do not twist too tightly—the syringe just needs to be secure.)



4. Plug the pressure probe into the EasyLink™, and plug the EasyLink into the USB port in the top of the handheld. The DataQuest APP should open automatically.
   - What is the default unit for collection with this sensor?

5. Select **MENU > Experiment > Collection Mode > Events with Entry**.
6. Type in **volume** for Name, press tab, and type **mL** for Units. Press enter.
7. Click the play button to start data collection.
   Time to collect pressure and volume data. It is best for one person to take care of the syringe and for another to operate the handheld.

8. To collect your first data reading, click on the keep button to save the data. Enter a value of 10, since you set the syringe at 10 mL earlier. Click on OK, or press enter.
9. Depress and hold the plunger to the 9 mL mark. When the pressure value on the left side of the screen has stabilized, click on the keep button and type in 9, and press enter.
10. Continue this procedure, collecting data at 8, 7, 6, and 5 mL. After you have collected data for 5 mL, click on the stop button.

- To view your data in graph form click on the graph view button.

11. Explore the various regression models to determine the best mathematical relationship for your data set.

12. Based on the graph of pressure vs. volume, decide what kind of relationship exists between these two variables—direct or inverse.
    - While on the DataQuest app page, select **MENU > Analyze > CurveFit > Power**.
    - Scroll down to see the curve fit statistics for the equation in the form y = Ax^B , where x is volume, y is Pressure, A is a proportionality constant, and B is the exponent of x (Volume).

Note: The relationship between pressure and volume can be determined from the value and sign of the exponent, B.

- If the mathematical relationship has been correctly determined, the regression line should closely fit the points on the graph (that is, pass through or near all of the plotted points).

Move to page 2.3.

Q2. Which variable is considered to remain constant during a Boyle's Law Experiment?

A. pressure B. volume C. temperature D. all of these

13. To linearize the data and confirm that an inverse relationship exists between pressure and volume, plot a graph of pressure vs. reciprocal of volume (1/Volume) in DataQuest:
    - Select **MENU > Data > New Calculated Column**.
    - Type **InverseV** for Name.
    - Short Name: **1/V**
    - Units: **1/mL**
    - Expression: **1/Volume**
    - Click OK, or press enter.

- Select **MENU > Graph > Select X-axis > InverseV**.

14. Calculate the regression line y = mx + b where x is 1/volume, y is pressure, m is a proportionality constant, and *b* is the *y*-intercept. On the DataQuest page, select **MENU > Analyze > Curve Fit > Linear**.

Q3. When a quantity of gas is compressed, the pressure of the gas is expected to _____.

A. decrease B. remain the same C. increase D. double

Q4. The expected mathematical relationship between pressure and volume is _____.

A. direct B. inverse C. indirect D. impossible to determine

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Q5. If the volume is doubled from 5 to 10 mL, what does the data show happens to the pressure?

A. increases B. decreases C. doubles D. cut in half

Q6. If the volume is halved from 20 to 10 mL, what does the data show happens to the pressure?

A. increases B. decreases C. doubles D. cut in half

Q7. Based on the data, what would be expected to happen to the pressure if the volume in the syringe were increased from 10 to 40 mL?

A. increase B. decrease C. quadruple D. cut to 1/4th

Q8. From the answers to the above three questions and from the shape of the curve of the plot, of pressure vs. volume, what is the relationship between the pressure and volume of a confined gas?

A. inverse B. direct C. quadratic D. impossible to determine

Q9. What two experimental factors are assumed to be constant during this experiment? (select two)

A. pressure B. volume C. moles of the gas D. temperature

Q10. Using P, V, and k, write an equation representing Boyle's Law.

Q11. Which of the following produced a constant value?

A. pressure x volume B. pressure/volume C. volume/pressure D. none of these

Q12. Summarize what you have learned about the relationship between pressure and volume.

Move to page 4.1.

Extension: Effect of Temperature on Boyle's Law

Follow the instructions on Pages 4.1-4.3 for the simulation, and then answer the following questions from Pages 4.4 and 4.5:

Q13. When the temperature is doubled, how does the pressure change?

A. The pressure doubles. B. The pressure is reduced by ½.
C. The pressure is 4X larger. D. The pressure does not change.

Q14. At a higher temperature, the relationship between pressure and volume is a(an) _____ relationship.

A. direct B. inverse C. quadratic D. impossible to determine