Boyle's Law – ID: 16151

By Texas Instruments

TEACHER GUIDE

Time required
45 minutes

Topic: Ideal Gas Laws

- *Describe and apply Boyle's law.*

Activity Overview

In this activity, students explore the relationship between pressure and volume for air. They increase and decrease the volume of air in a syringe and use a pressure sensor to measure the pressure associated with each volume. They use these data to infer Boyle's Law.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *Vernier Pressure sensor*
- *Vernier EasyLink™ or Go!® Link interface*
- *20-mL gas syringe*
- *copy of student worksheet*
- *pen or pencil*

TI-Nspire Applications

Notes, Data & Statistics, Lists & Spreadsheet

Teacher Preparation

Students should be familiar with the properties of gases.

- *The screenshots on pages 2–4 demonstrate expected student results.*
- ***To download the .tns file, go to education.ti.com/exchange and enter "16151" in the search box.***

Classroom Management

- *This activity is designed to be **student-centered**, with the teacher acting as a facilitator while students work cooperatively. The student worksheet guides students through the main steps of the activity and includes questions to guide their exploration. Students may record their answers to the questions on blank paper or answer in the .tns file using the Notes application.*
- *The ideas contained in the following pages are intended to provide a framework as to how the activity will progress. Suggestions are also provided to help ensure that the objectives for this activity are met.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration during this activity:

- How is the pressure of a gas related to its volume if the temperature and number of moles of the gas are kept constant?

Students will use a pressure sensor to measure the pressure exerted by different volumes of air.

Problem 1 – Preliminary Questions

Step 1: Students should open the file **06_Boyles_Law.tns** and answer questions 1–3 based on their existing knowledge.

Q1. Which variable is held constant during a Boyle's law experiment?

A. *temperature*

Q2. When a quantity of gas is compressed, the pressure of the gas will

A. *increase*

Q3. The mathematical relationship between pressure and volume is

A. *inverse*

Problem 2 – Data Collection and Analysis

Step 1: Next, students should set up the syringe so that the plunger is at the 10 mL mark.

Step 2: Next, students should attach the syringe to the pressure sensor.

Step 3: Once the syringe is attached to the sensor, students should plug the sensor into the EasyLink or Go!Link interface. Then, they should plug the interface into their handheld devices or computers.

Step 4: Next, students should move to page 2.1. A data console should automatically appear when they connect the sensor. They should set up the console for **Events with Entry** data collection.

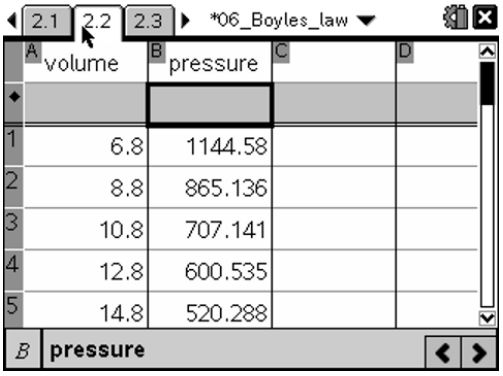
Step 5: Next, students should start the data collection and record the first data point. Be sure that students adjust the volume so that it equals the volume of the syringe neck.

Step 6: Next, students should collect the second data point, at a volume of 8 mL.

Step 7: Next, students should repeat the data collection for the remaining volumes: 6 mL, 12 mL, 14 mL, and 16 mL. Once all of the data have been collected, students can disconnect the pressure sensor.

Step 8: Students should examine the graph of the data on page 2.1 and use the **Graph Trace** tool to determine the pressure and volume values for each data point. They should record the values in the *Lists & Spreadsheet* application on page 2.2.

Step 9: Next, students should use the **Regression** tool to determine the equation of the best-fit curve through the data on page 2.1.

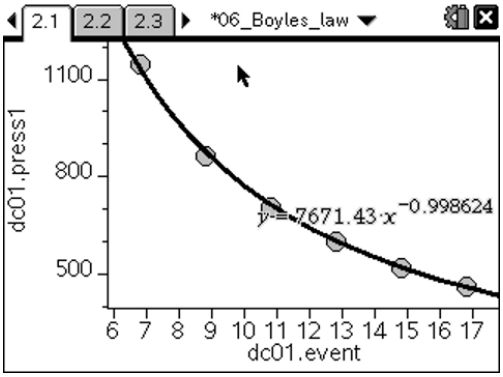


TI-Nspire™ Navigator Opportunity: *Quick Poll*

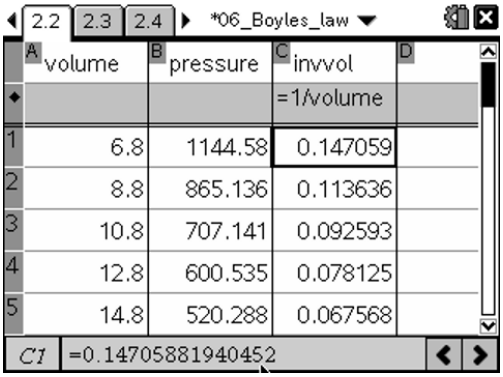
Quick Poll can be used here to have students think about the type of regression tool that is most appropriate for this data set. Ask students to determine which regression tool they will use to determine a best-fit curve for the data. Encourage students to explain their reasoning. Students should note that a power regression will be the most appropriate because the plotted data follow an exponential path, as opposed to a linear path.

Q4. What is best-fit mathematical equation relating pressure and volume?

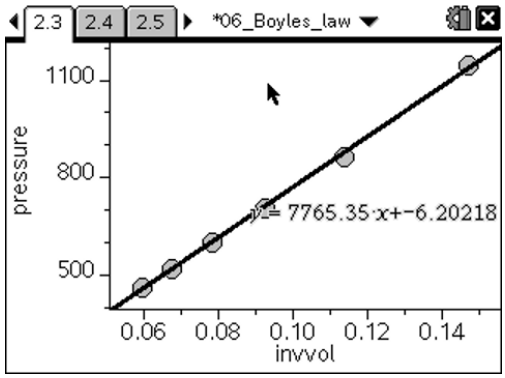
A. *Students' answers will vary, but a* ***Power*** *regression should give the best fit. In the power regression, the equation is displayed in the form* $y = Ax^B$*, where* x *is volume,* y *is pressure,* A *is a proportionality constant, and* B *is the power of* x*. The exponent* B *should be very close to –1, indicating an inverse relationship.*



Step 10: Next, students should move to page 2.2 and calculate the inverse of volume (represented by the variable **invvol**) in column C.



Step 11: Next, students should move to page 2.3 and create a scatter plot of **pressure** vs. **invvol**. Then, they should answer questions 5-12.



Q5. If volume doubles, pressure will

A. *be halved*

Q6. If volume is halved, pressure will

A. *double*

Q7. If volume is tripled, pressure will

A. *be reduced to one-third*

Q8. Based on your data, is the relationship between the pressure and volume of a confined gas direct or inverse? Explain your answer.

A. *It is an inverse relationship, as shown by both the power regression and the linear relationship between pressure and inverse volume.*

Q9. What will happen to pressure if volume increases from 10.0 mL to 40.0 mL?

A. *It will increase to four times its original value.*

Q10. What will happen to pressure if volume decreases from 10.0 mL to 2.5 mL?

A. *It will decrease to one-fourth its original value.*

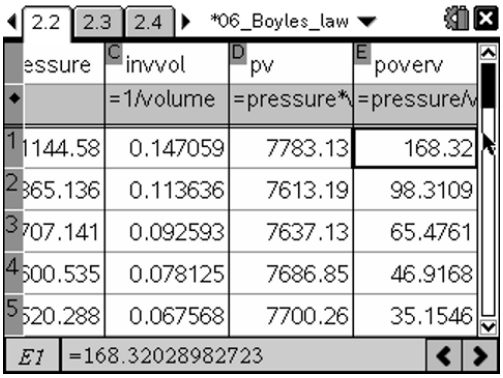
Q11. What two factors are assumed to be constant in this experiment?

A. *temperature and number of moles*

Q12. Write an equation describing the relationship between pressure (*P*) and volume (*V*). Use *k* to represent the proportionality constant.

A. PV = k

Step 12: Next, students should move back to page 2.2 and calculate the product *PV* and the quotient *P/V*. Then, they should answer questions 13–15.



Q13. Which calculation, *PV* or *P/V*, produced the most constant value?

A. PV *should produce a constant value, but* P/V *should not.*

Q14. How constant were the constant values? How could you increase the accuracy of the values?

A. *Answers will vary, but the students should note that the constant values are very similar. The accuracy of these values could be improved by making more precise volume measurements.*

Q15. Summarize what you have learned about the relationship between pressure and volume.

A. *As pressure increases, volume decreases by a proportional amount.*