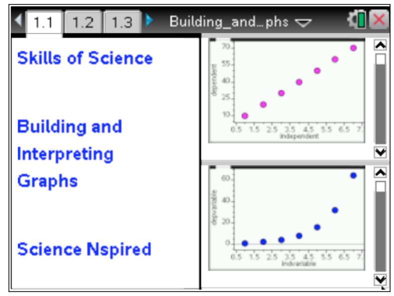


Science Objectives

- Students will develop a practical understanding of the necessary components of a graph in science.
- Students will understand the difference between independent and dependent variables.
- Students will evaluate regression models and understand the concepts of rate of change and *y*-intercept.
- Students will enter, graph, and analyze data.
- Students will evaluate graphs that show different trends—both linear and non-linear.

Vocabulary

- axis scaling
- dependent variable
- independent variable
- linear
- non-linear
- rate of change (slope)
- regression models
- *y*-intercept

About the Lesson

- This lesson involves students in using TI-Nspire technology to understand the fundamentals of good graphing in the science classroom and laboratory.
- As a result, students will:
  - Understand variables, rates of change, and regression models.
  - Accurately graph data in a viewer-friendly, usable way.

TI-Nspire™ Navigator™

- Send out the *Building_and_Interpreting_Graphs*.tns file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- TI-Nspire™ Technology

TI-Nspire™ Technology Skills:

- Open a new TI-Nspire document
- Enter data in a spreadsheet and graph the data in a *Data & Statistics* page
- Generate regression models for data

Tech Tips:

Make sure that students understand how to move between rows and columns in a spreadsheet using ◀, ▶, ▲, ▼, or tab.

Lesson Materials:

Student Activity

- Building_and_Interpreting_Graphs_Student.doc
- Building_and_Interpreting_Graphs_Student.pdf

TI-Nspire document

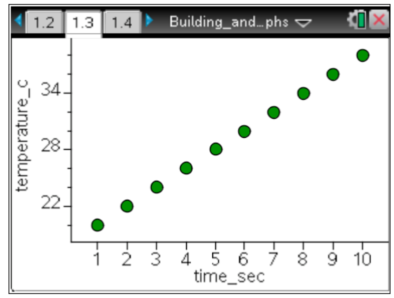
- Building_and_Interpreting_Graphs.tns

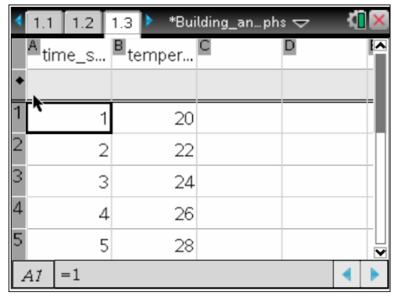
Discussion Points and Possible Answers

Problem 1: Introduction to Graphing

Move to pages 1.2 and 1.3.

1. Problem 1 introduces students to some basics of graphing. Students should read the procedure on page 1.2. The *Data & Statistics* graph on page 1.3 is based on the data shown here in the spreadsheet to the right. In the .tns file the spreadsheet does not appear, and students only see the graph of the data. The main focus of this graph is for students to identify the independent and dependent variables—time and temperature, respectively. They should notice the use of proper scaling of the axes, along with and distinct, easy-to-see data points. In addition to being invisible to students, the points on the graph have been "locked" so students cannot move them around the graph space.





Move to page 1.3.

Have students answer the questions on the activity sheet.

Q1. What is the **independent variable** in the graph shown?

Answer: Time

Q2. What is the **dependent variable**?

Answer: Temperature

Q3. What do you think the **units of measure** are for *time* for this graph?

Answer: Seconds

Q4. What temperature scale do you think is being used for the graph? What range of temperatures is shown on the *y*-axis?

Answer: Celsius; 18 degrees to 40 degrees Celsius

Q5. If this graph represents data collected during an experiment, how long did the experiment run?

Answer: 10 seconds

Q6. What was the **minimum** temperature recorded?

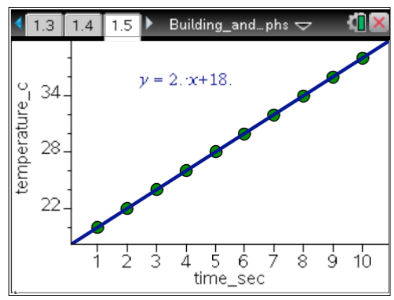
Answer: 20 degrees

Q7. What was the **maximum** temperature recorded?

Answer: 38 degrees

Move to pages 1.4 and 1.5.

Analyzing a Trend in a Graph



The second part of Problem 1 shows the same graph as in the first part, only with a regression (best-fit) line added. The regression equation is shown on the graph for the students to see and evaluate. If a student clicks somewhere in the graph space, the equation may disappear. However, if the student simply clicks on the regression line, the equation will reappear.

The intent of this screen is to show that the data models a linear relationship. Another focus is to analyze the "rate of change". (In this case the rate of change is 2 deg/sec) and the "*y*-intercept" (which is 18 degrees C). The *y*-intercept is the point at which the regression line crosses the *y*-axis and the independent variable is be equal to zero. The algebraic equation for this regression equation is **y = mx + b**, where **m** is the rate of change and **b** is the *y*-intercept. Students need to understand that the term "slope", which they learned in Algebra, is better described as "rate of change" in science.

2. Students should read the introduction on page 1.4. They should use the graph on page 1.5 to answer the questions below.

Have students answer the questions on the activity sheet.

Q8. What is the **rate of change** (slope) for this data set? (Make sure you include the units!)

Answer: 2°C/second

Q9. What is the y-intercept for this graph? (This is the temperature when time = 0 seconds. Make sure you include the units.)

Answer: 18°C

Q10. Estimate what the temperature was at 7.5 seconds.

Answer: 33°C

Q11. Estimate when the temperature was 25°C.

Answer: 3.5 seconds

Q12. If the experiment is continued beyond the data shown, predict the time at which the temperature will be 50°C.

Answer: 16 seconds

Q13. Predict the temperature at 12 seconds.

Answer: 42°C

Q14. Predict how the graph would look if the experiment were run for 20 seconds, and draw this graph to the right. Make sure you label the variables and include appropriate intervals for the scale.

Answer: The drawing should include the components of a good graph listed in the instructions.

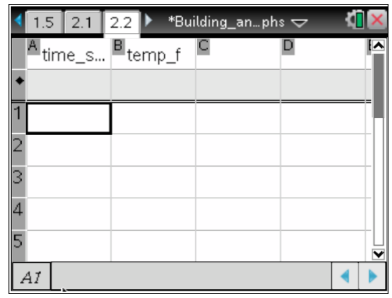
TI-Nspire Navigator Opportunities

If your students are proficient at entering data and/or you want to save class time, you could have one student enter the data and then collect and resend the .tns file to the whole class using TI-Navigator.

Problem 2: You Try It!

Move to pages 2.1 and 2.2.

Have students read the introduction on page 2.1 and move to the spreadsheet on page 2.2. In this exercise, the students use an empty spreadsheet to enter two columns of data. They then select the variables to graph and plot the data. The column headings (variables) have already been included in the spreadsheet, and they are "time_sec" (time in seconds) and "temp_f" (temperature in degrees F).



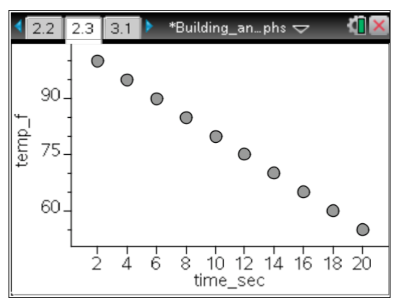
3. In column A, students enter data values from 2 to 20, increasing by 2 with each successive cell.
4. In column B, they enter values from 100 to 55, decreasing by 5 each time. Remind students to make sure they have the same number of values in both columns.
5. Students move to page 2.3, which is a blank *Data & Statistics* page. They create a plot by selecting the independent variable (time) and dependent variable (temperature).

> **Tech Tip:** All of the available regression models can be found under the same menu. Since this is a common application in both science and math, students should become familiar with **Menu > Analyze > Regression**.

Have students answer the questions on the activity sheet.

Q15. Sketch your graph in the space to the right.

Answer: See screen to the right.



Q16. Describe the trend that you see in the data set.

Answer: Steadily decreasing; –2.5°F/sec

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and share their graphing techniques using TI-Nspire.

Move to page 1.3.

Students should follow these steps to generate a linear regression model for the data:

6. Press **menu>Analyze>Regression>Show Linear (mx+b).** A regression line and corresponding equation should appear on the screen.
7. If you accidentally click and the equation disappears, you can fix it easily! Simply move your cursor to the regression line and click on it. All is well!
8. Answer the following questions after you have a graph and a regression line.

Analysis Questions

Q17. What is the rate of change of your graph?

Answer: –2.5°F/sec

Q18. What is the temperature when time = 0 sec?

Answer: 105°F

Q19. What was the change in temperature between each value in the spreadsheet? This is also known as Δtemp (“delta” temperature).

Answer: 5°F (or –5°F)

Q20. What was the change in time between each value in the spreadsheet? This is also known as Δtime (“delta” time).

Answer: 2 seconds

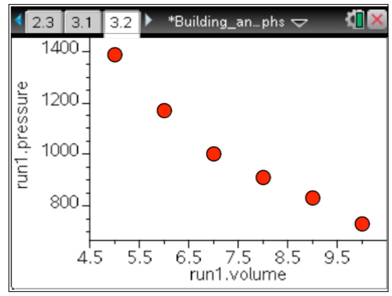
Q21. Divide Δtemp by Δtime. What is your answer? What is another name for this value, as it relates to your data?

Answer: –2.5°F/sec. Rate of change (slope)

Problem 3: Graphing and Analyzing Non-Linear Data

Move to pages 3.1 and 3.2.

Students read the introduction on page 3.1. Then they look at the data graphed on page 3.2, which models Boyle's law. This graph shows the relationship between gas volume and gas pressure in an enclosed space. As in Problem 1, the data table is not available to the students—the graph alone is visible for the purpose of analysis.



Have students answer the question on the activity sheet.

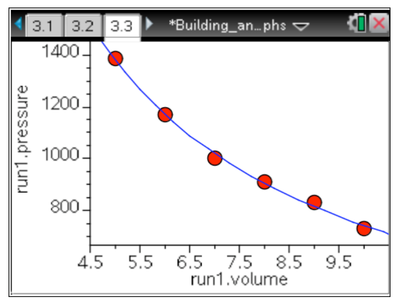
Q22. Describe the trend you see in the graph on Page 3.2.

Answer: As volume increases, the pressure decreases, but not in a linear manner.

Move to page 3.3.

At first the data may look roughly linear. Ask students to think about what happens to gas in a closed container when you exert more and more pressure. There are limits to how low the volume can get when you have a gas in a container of fixed volume. If appropriate, this is a good time to talk about horizontal and vertical asymptotes.

The regression model that best fits Boyle's law data is the "power regression", which is an exponential model. (If the Kelvin temperature scale is used, then there is an inverse relationship.) The big idea for students to understand is that most scientific data are not linear. There are limits to the extremes in the data.



Have students answer the questions on the activity sheet.

Q23. Describe the differences you see between this graph and the graphs you looked at in Problem 2.

Answer: The graph in Problem 3 is not linear. Students may also notice that the axes have much different scales than the axes for the Problem 2 graphs.

Q24. In this graph, what is the independent variable?

Answer: Volume

Q25. What is the dependent variable?

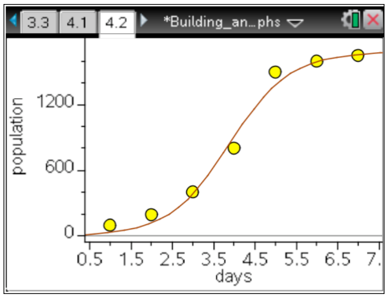
Answer: Pressure

Q26. Describe the relationship between the two variables.

Answer: As volume increased, pressure decreased

Problem 4: A Final Look

Move to pages 4.1 and 4.2.



9. Have students read the introduction on page 4.1 and then move to page 4.2. Page 4.2 provides an example of a population growth curve, showing the classis “S-shape”, or logistic model. The rate of growth is fast at the beginning—nearly exponential—and then the growth rate slows. Limiting factors in the environment keep the population in check. Ask students to name some of these factors—space, food, disease, etc.

Have students answer the questions on the activity sheet.

Q27. What are the independent and dependent variables for this graph?

Answer: Independent = Days; Dependent = Population

Q28. Between which two days was the population growing most rapidly?

Answer: Either Days 3 and 4, or Days 4 and 5

Q29. Between which two days was the population growing most slowly?

Answer: Either Days 1 and 2, or Days 6 and 7

Q30. What do you predict the population will be at Day 10?

Answer: Still about 1600