From Data to Information

Graphing and Reading Data

Subject Area(s) Algebra

Associated Unit N/A

Lesson Title **Reading Graphs**

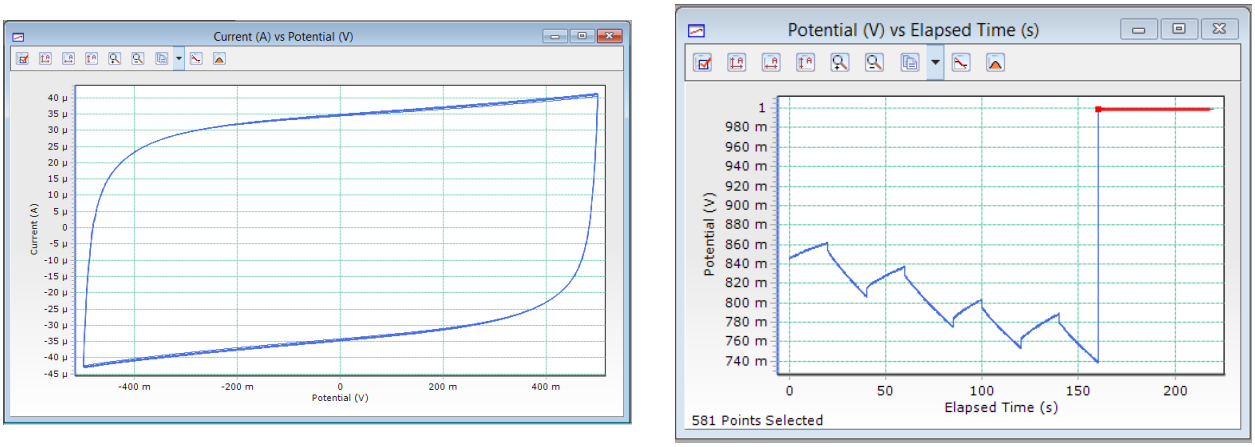


Image 1

Image files: CNT CV test.png & CNT GCD test.png

ADA Description: The graphs above disply the results of two different electrochemical tests performed on a carbon nanotube electrode as part of a study on supercapacitors (supercaps.) The graph to the left shows the CNT density (charge per gram of material.) The graph on the right graph represents the CNT resistance and capacitance.

Grade Level 10-12

Time Required 90 minutes

Summary

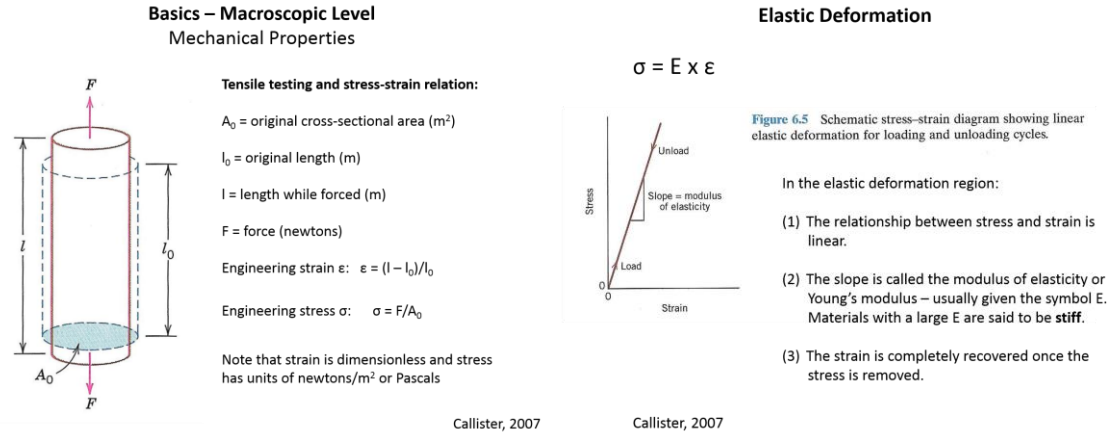
This lesson planned for second quarter during the chapter Graphing Linear Equations, allow students to use previous knowledge of graphs, linear functions and slope to familiarize themselves with the interpretation of information represented in graphs. Reading graphs is a skill that allows STEM students and regular individuals to analyze, make educated predictions, understand behavior, etc. Students will get several graphs to learn how to identify and interpret them.

Students will also review linear graphs for which they will then receive data to create scatterplots which they will use to get their own approximation to a linear function using slope definitions. A more accurate method best fit line will be introduced and discussed.

Engineering Connection

Successful engineers need to develop skills in presenting and interpreting graphical data. For example, during our study of several materials as supercapacitors, our team used equipment and a computer application to generate different functionality graphs. Those graphs allowed us to determine which material had better characteristics as a supercapacitor.

On the example below, the mechanical properties of stress and strain on materials are being related as a function that provides an Elastic Deformation diagram. The graph happens to be a linear representation that helps engineers study the behavior of materials and classify them as brittle, ductile, etc.



Successful interpretation of graphs [also] leads to understanding of engineering results and their economic implications.[2]

Engineering Category = 1

Choose the category that best describes this lesson's amount/depth of engineering content:

1. ***Relating science and/or math concept(s) to engineering***
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Graph, Slope, Line of best fit, Dependent Variable, Independent variable, Linear data, Rate of change

Educational Standards (List 2-4)

State STEM Standard (required)

> Common Core State Standards for Mathematics: Math [2010]

ITEEA Standard (required)

> K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. (Grades 9 - 12) [2000]

CCSS Standard – Mathematics Florida Standards

> MAFS.K12.MP.1.1: Make sense of problems and persevere in solving them.

MAFS.K12.MP.2.1: Reason abstractly and quantitatively.
MAFS.K12.MP.3.1: Construct viable arguments and critique the reasoning of others.
MAFS.K12.MP.4.1: Model with mathematics.
MAFS.K12.MP.5.1: Use appropriate tools strategically.
MAFS.K12.MP.6.1: Attend to precision.
MAFS.K12.MP.7.1: Look for and make use of structure

Learning Objectives

After this lesson, students will be able to:

- Identify the different parts that make up a graph
- Interpret with certain degree of accuracy the data presented in a graph
- Interpret the rate of change of linear data with appropriate mathematical language
- Use the line of best fit to make predictions.
- Analyze a line of best fit to interpret the slope and y-intercept.
- Use the slope and y-intercept to write an equation for a line of best fit.
- Use the equation for a line of best fit to make predictions.

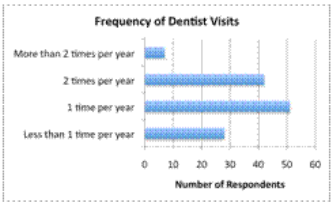
Introduction / Motivation (5E – Engage)

Problem

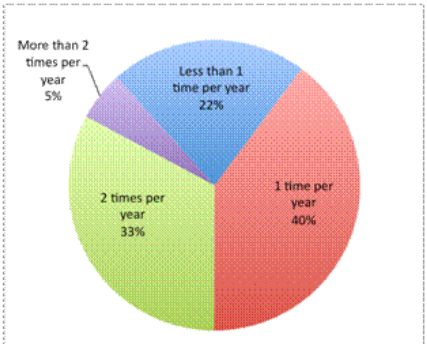
A statistician is collecting data on the frequency with which adults go to the dentist. She surveys 128 people and finds the following information.

Less than 1 time per year: 28 respondents
1 time per year: 51 respondents
2 times per year: 42 respondents
More than 2 times per year: 7 respondents

In a presentation to dentists, she especially wants to highlight the population that visits the dentist less than 1 time per year. What type of graph should she use to represent the data?



To show her findings, the statistician could use a couple of different graphs. A bar graph would be fine to use here since the data is categorical—she has grouped her findings into 4 categories.



A circle graph may be even better. The statistician is interested in the *percentage* or *share* of people who responded to each question. A circle graph allows for easy comparison among the categories surveyed.

Reference for graph [3]

The same data can be represented as:

Times per year	2+	2	1	<1
Respondents	7	42	51	28

Which data representation has more visual appealing? Do you agree or disagree with the recommendation suggested by the author?

Graphs are also used in STEM fields being the line graph one of the representations of a relationship between variables for example:

Elastic Deformation

$\sigma = E \times \varepsilon$

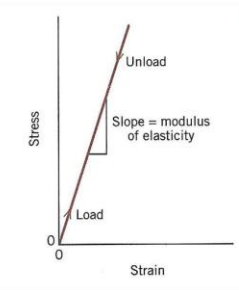


Figure 6.5 Schematic stress–strain diagram showing linear elastic deformation for loading and unloading cycles.

In the elastic deformation region:

(1) The relationship between stress and strain is linear.

(2) The slope is called the modulus of elasticity or Young's modulus – usually given the symbol E. Materials with a large E are said to be **stiff**.

(3) The strain is completely recovered once the stress is removed.

Callister, 2007

Sometimes the graphical relationship needs to be derived by the data gather from experiments. In this case a regression method, also known as the line-of-best-fit method, is used to approximate the function that best represents the relationship. For example:

Hardness

Hardness is the ability to resist scratches or indentations. It is correlated to strength. It is generally measured using an indentation test.

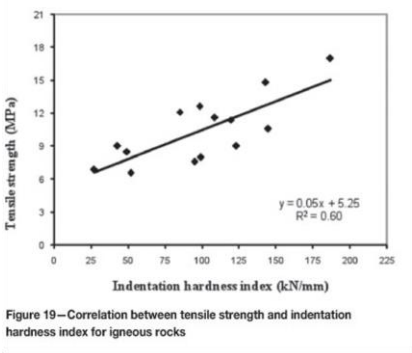


Figure 19—Correlation between tensile strength and indentation hardness index for igneous rocks

http://www.scielo.org.za

Lesson Background & Concepts for Teachers (5E – Explain)

Teachers need to know how to

- Identify different kind of graphs (not functional graphs) and their characteristics that could include:
  - Line graphs
  - Pie charts
  - Bar graph
  - Scatter plot

- Stem and plot
- Histogram
- Frequency polygon
- Frequency curve

- Recognize independent and dependent variables [8]

  Question: What's a variable?
  Answer: A variable is an object, event, idea, feeling, time period, or any other type of category you are trying to measure. There are two types of variables- independent and dependent.

  Question: What's an independent variable?
  Answer: An independent variable is exactly what it sounds like. It is a variable that stands alone and isn't changed by the other variables you are trying to measure. For example, someone's age might be an independent variable. Other factors (such as what they eat, how much they go to school, how much television they watch) aren't going to change a person's age. In fact, when you are looking for some kind of relationship between variables you are trying to see if the independent variable causes some kind of change in the other variables, or dependent variables.

  Question: What's a dependent variable?
  Answer: Just like an independent variable, a dependent variable is exactly what it sounds like. It is something that depends on other factors. For example, a test score could be a dependent variable because it could change depending on several factors such as how much you studied, how much sleep you got the night before you took the test, or even how hungry you were when you took it. Usually when you are looking for a relationship between two things you are trying to find out what makes the dependent variable change the way it does.

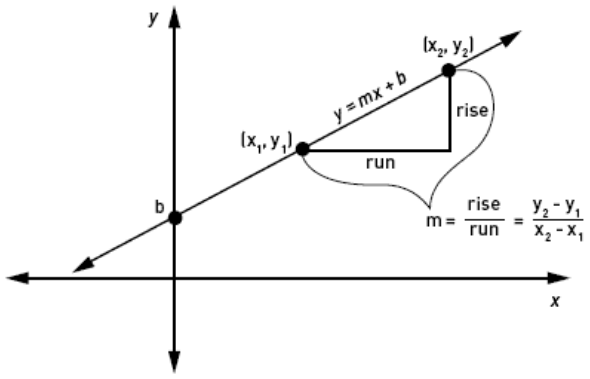
  Many people have trouble remembering which is the independent variable and which is the dependent variable. An easy way to remember is to insert the names of the two variables you are using in this sentence in they way that makes the most sense. Then you can figure out which is the independent variable and which is the dependent variable:

  (Independent variable) causes a change in (Dependent Variable) and it isn't possible that (Dependent Variable) could cause a change in (Independent Variable).

  For example:
  (Time Spent Studying) causes a change in (Test Score) and it isn't possible that (Test Score) could cause a change in (Time Spent Studying).

  We see that "Time Spent Studying" must be the independent variable and "Test Score" must be the dependent variable because the sentence doesn't make sense the other way around.

- Calculate the slope of a line [9]



- Calculate the line of best fit (students are not expected to calculate the line of best fit, but they must understand how to identify a line that travels through the center of the linear trend of data. [1])

Line of Best Fit (Least Square Method)[10]

A **line of best fit** is a straight line that is the best approximation of the given set of data. It is used to study the nature of the relation between two variables.

A line of best fit can be roughly determined using an eyeball method by drawing a straight line on a scatter plot so that the number of points above the line and below the line is about equal (and the line passes through as many points as possible).

A more accurate way of finding the line of best fit is the **least square method**.

Use the following steps to find the equation of line of best fit for a set of ordered pairs (x_1, y_1), (x_2, y_2), ..., (x_n, y_n).

Step 1: Calculate the mean of the x-values and the mean of the y-values.

$$\overline{X} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \overline{Y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

Step 2: The following formula gives the slope of the line of best fit:

$$m = \frac{\sum_{i=1}^{n} \left(x_i - \overline{X}\right)\left(y_i - \overline{Y}\right)}{\sum_{i=1}^{n} \left(x_i - \overline{X}\right)^2}$$

Step 3: Compute the y-intercept of the line by using the formula:

$$b = \overline{Y} - m\overline{X}$$

Step 4: Use the slope m and the y-intercept b to form the equation of the line.

Vocabulary / Definitions

Word	Definition [6]
Graph	a diagram (as a series of one or more points, lines, line segments, curves, or areas) that represents the variation of a variable in comparison with that of one or more other variables
Data	facts or information used usually to calculate, analyze, or plan something
Axis	one of the reference lines of a coordinate system
Slope	the ratio of the change in a vertical direction to the change in a horizontal direction between any two points on the graph of a straight line
Line of best fit	A line of best fit (or "trend" line) is a straight line that best represents the data on a scatter plot. This line may pass through some of the points, none of the points, or all of the points.
Trend line	A line on a graph showing the general direction that a group of points seem to be heading.
Dependent Variable	a mathematical variable whose value is determined by that of one or more other variables in a function
Independent variable	a mathematical variable that is independent of the other variables in an expression or function and whose value determines one or more of the values of the other variables
Rate of change	a value that results from dividing the change in a function of a variable by the change in the variable <velocity is the rate of change in distance with respect to time>
Interpolation	to estimate values of (data or a function) between two known values
Extrapolation	to project, extend, or expand (known data or experience) into an area not known or experienced so as to arrive at a usually conjectural knowledge of the unknown area <*extrapolates*present trends to construct an image of the future>

Associated Activities (5E – Explore)

Review with students the different types of graph

Activity 1: Before moving to Variables and Graphs discussion, distribute worksheet Graph Reading Activity [4]. Work the answers with the students. Move to assessment and move to next activity.

Activity 2: Distribute Introduction to Variables and Graphs Handout [1]. Work the handout with the students to make sure they feel comfortable with the types of variables. The third graph transitions students into the line of best fit analysis. Move to assessment and move to next activity.

Activity 3: Distribute the Guided Practice for Line of Best Fit [5]. Work out each example with the students making sure they understand how to find the line of best fit from data collected by the researchers.

Assessment (5E – Evaluate)

Post-Introduction (Formative) Assessment

a) IDENTIFYING GRAPHS
For activities 1 & 2
Sample questions found embedded in activities

Activity 1 [4]
Given a graph
- What are the components of a graph?
  - Title, axes, labels, scales, dependent and independent variables
- What does the title indicate?
- What is your interpretation of the graph?
- Which events could influence the data on the graph?

Activity 2 [1]
- What is the independent variable for this graph?
- What is the dependent variable for this graph?
- Write a two-sentence explanation for what the graph is attempting to describe.

b) FIND THE LINE-OF-BEST-FIT [6]
For Activity 3 [5]
Sample questions found embedded in activities

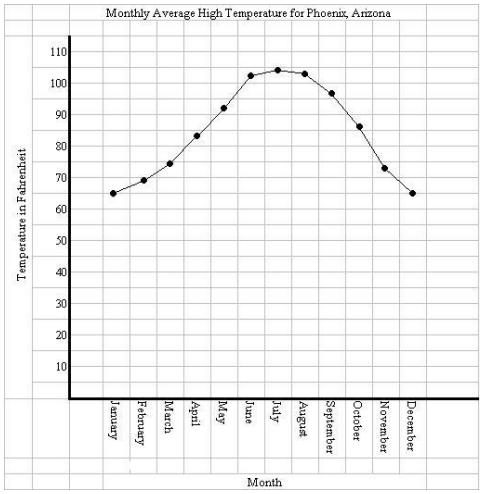
Example One: STEM Connection-Biology
- What type of relationship does the scatterplot show?
- What does the slope tell us about the growth of a giraffe?
- Is the y-intercept meaningful to this data set? Why or why not?

Example Three: Altitude and Temperature (Gradual Release)
- What type of relationship does the scatterplot show?
- Will the temperature always show a decrease when the altitude decreases?
- If the temperature was plotted on the x-axis and the altitude was plotted on the y-axis would the correlation still be the same?
- Will the temperature always show a decrease when the altitude decreases?
- What does the y-intercept represent in this case?

Lesson Summary (Summative) Assessment

a) Identify graphs [4]

1. **What are graphs used for? _____**
2. **Name three types of graphs. _____**
3. **Refer to the graph below to answer the questions.**

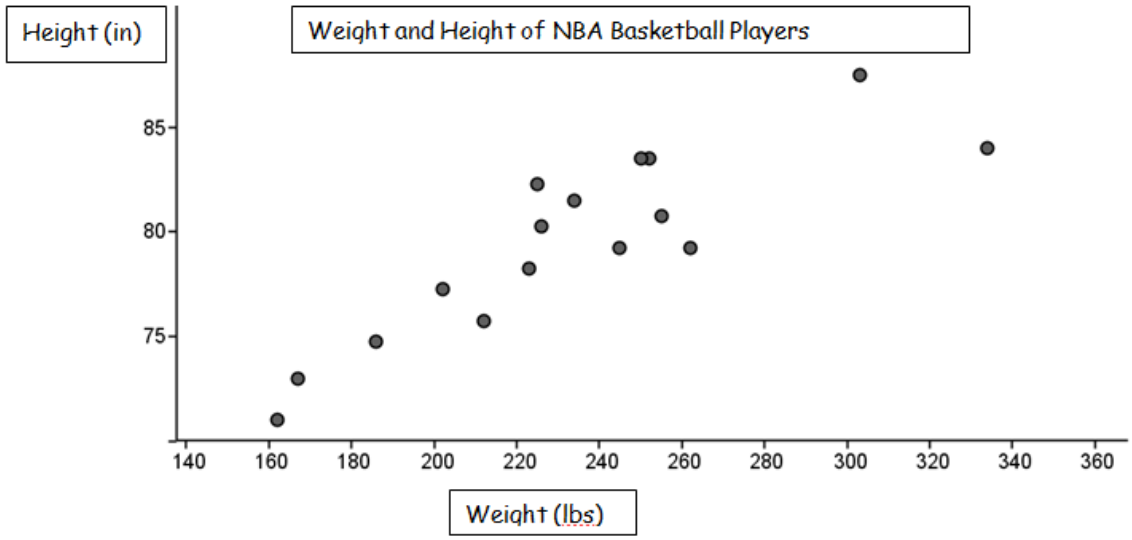


   a. **What is the title of the graph?**
   b. **What information is on the vertical axis?**
   c. **What is the average high temperature in Phoenix in November?**
   d. **Which month has an average high temperature of 83 degree F?**

b) Find the Line-of-Best-Fit [5]

Line of Best Fit Summative (30 points)

1. The scatter plot and table show the height and weight of 16 randomly selected NBA basketball players. Use the data on the scatterplot to draw a line of best fit.



Weight(lbs)	233	225	255	234	162	186	202	245	252	334	250	303	167	262	212	226
Height (in)	78.3	82.3	79.8	81.5	71	74.8	77.3	79.3	83.5	84	83.5	87.5	73	79.3	75.8	80.3

2. Use the scatter plot to make a prediction about how tall you would expect a 280 pound player to be.
3. Use two points on your line of best fit to calculate the slope of the line.
4. What does the slope of the line of best fit tell you about the mean height and weight of NBA basketball players?

5. Use the slope and a point on the line of best fit to write an equation for the line.

6. What does the y-intercept tell us about the relationship between a player's weight and height? Is this information useful?

Lesson Extension Activities (5E – Extension)

1) Using a graphing calculator to get the line of best fit [11]

2) Graph the line of best fit for other types of data (quadratic, exponential equations) [7]

References

1) Variables and Graphs: What's Our Story? - VU Bioengineering RET Program, School of Engineering, Vanderbilt University, Web July 10th, 2015.
2) Teaching Graphical Data Presentation Techniques in an Introductory Materials Course - Barry Dupen, Indiana University - Purdue University Fort Wayne, Web July 25th, 2015.
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6) Dictionary Merriam-Webster, An Encyclopædia Britannica Company Web July 10th, 2015.
7) "Fitting Functions to Data" MathBitsNotebook.com Donna Roberts, Web July 25th, 2015.
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9) Unit 12 Section 3 Get in line - Annenberg Learner, Web July 30th, 2015
10) Line of Best Fit (Least Square Method) – Hotmath.com, Web July 30th, 2015
11) Line of Best Fit with Calculator - Regents Exam Prep Center, Web July 30th, 2015

Attachments

Follow the links in the lesson plan.

Contributors

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Fellow participants to the Research Experience for Teachers at the Functional Materials Research Institute, Summer 2015

Supporting Program

Research Experience For Teachers at the Functional Materials Research Institute, Summer 2014; Space Research group; Department of Chemistry; University of South Florida

Acknowledgements

Thanks to my student mentor, Fatemeh Rahimi and Dr. Arash Takshi for their support and suggestions.

Classroom Testing Information

TBD