

CURRIKI ALGEBRA UNIT 2
Linear and Exponential Relationships
Lesson 2.4: Graphs of Exponential Functions

Unit 2: Linear and Exponential Relationships

The first nine lessons (2.1-2.9) provide the instruction and practice that supports the culminating two-day final unit project.

Lesson 2.4: Graphs of Exponential Functions

In this lesson we represent and solve equations and inequalities graphically. We focus on linear and exponential equations. Also we develop the understanding that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve, which could be a line.

Common Core State Standards by Cluster: Linear and Exponential Relationships

Grade Level	Cluster	CCS Standard
9	Represent and solve equations and inequalities graphically	A.REI.10 (<u>Note</u> : linear equations are covered in the activity; exponential equations are provided in the warm-up; an exponential graphing activity is included.)
9	Understand the concept of a function and use function notation	F.IF.1, F.IF.2, F.IF.3
9	Construct and compare linear, quadratic, and exponential models and solve problems	F.BF.3, F.LE.2

Lesson Preparation Resources for Teachers

To prepare for delivering this lesson, teachers may choose to review graphing a function in [Sal Khan's video](#) located in Curriki.

Tables Graphs and Equations Oh My, PowerPoint created by Luke Lang, located on Curriki

[Tables Graphs and Equations Oh My, PDF](#) created by Luke Lang, this PDF file contains the PowerPoint slides and instructional notes.

[Inquiry Eight: Using Graphs, Words and Pictures to Describe Functions](#) in Curriki

[Understanding Graphs](#) located in Curriki

TE_Vocabulary 2.4 Worksheet

TE_GraphsExponentialFuncwksheet

Graphing Linear Equations, located in Curriki by NROC

[Use Exponential Functions worksheet](#) (Found in Curriki, one copy per student)

Instructional Materials for Students: (print one copy for each student)

SE_Vocabulary 2.4 Student Worksheet

SE_GraphsExponentialFunctionWorksheet

SE_Small Group Practice Sheet

SE_Individual Practice Sheet

[Graphing Linear Equations, located in Curriki by NROC](#)

Time: 50-minute session

Lesson Objectives:

Students will be able to:

- create graphs of exponential functions
- convert linear relationships between any representations
- apply the Rule of Four: linear relationships can be represented in graphs, equations, tables, and verbal descriptions

Lesson Content:

1. Background Building Activity for Students (10 minutes)

a. Vocabulary Building

Print out one copy of the Vocabulary Page for each student.

Review the five math-specific vocabulary words on the attached vocabulary page with the whole class prior to the warm up problem. Ask students to write out examples of each vocabulary term.

b. Warm up problem

A real life example of using exponential functions:

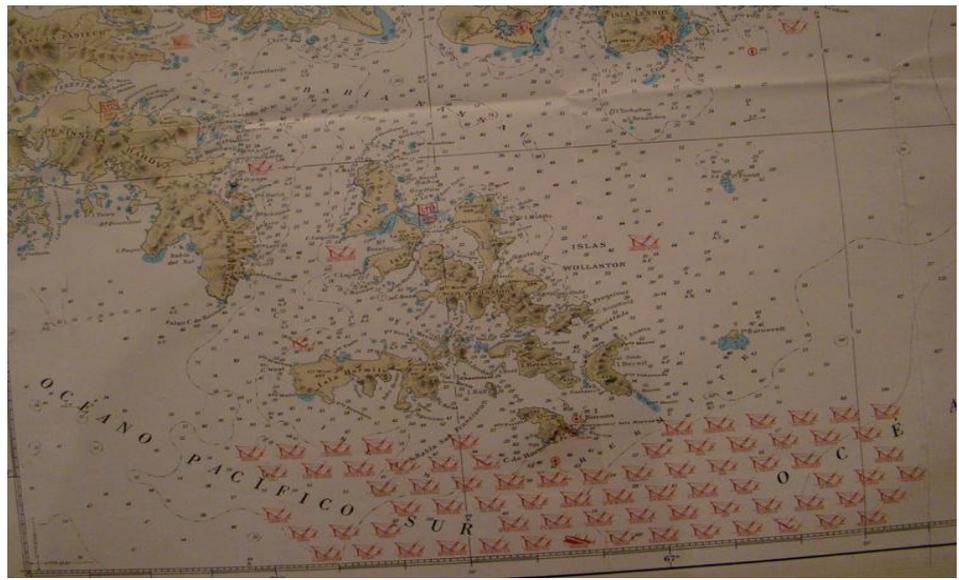
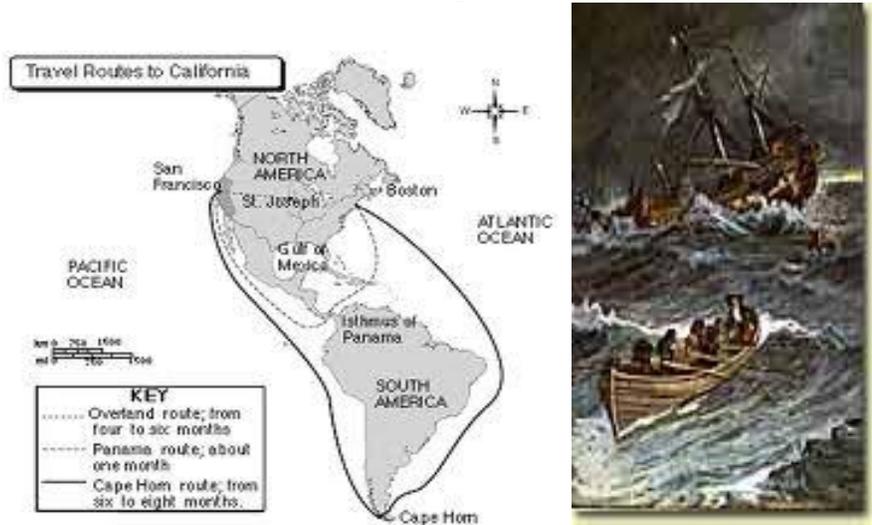
The amount of shipwrecks off Cape Horn in South America during the California Gold Rush from 1849 to 1855 can be modeled by an exponential function.

Many people traveled from Boston to San Francisco in 1849 and for the next five years after people discovered gold in the mountains near Sacramento (the capitol of California). People on the East Coast of America paid huge sums to sail aboard crowded cargo ships in very poor conditions for the 8-month journey. They wanted to have a chance to find gold in California and to become rich.

The most dangerous leg of the voyage from Boston Harbor to San Francisco was the passage around the very tip of Cape Horn in South America. Monstrous waves, terrifying winds, and frigid temperatures challenged even the most experienced ship's captains. Many ships were wrecked and sank off Cape Horn.

The red ships on the chart indicate shipwrecks during the time people participated in the Gold Rush in California. There were approximately 65 shipwrecks off Cape Horn from 1829 to 1959. The number of shipwrecks per 10 year period that occurred off the coast of the tip of Cape Horn in South America can be modeled by $S = 114(1.2)^t$, where S is the number of shipwrecks and $t = 0$ represents the 10 year period from 1849-1859.

Ask students to create a table of values for the years 1849-1859; provide graph paper for students to graph this relationship. Discuss the relationship between the tabular representation and the graphical representation



(From http://pbskids.org/wayback/goldrush/journey_capehorn.html)

Another great way to address the standards in this lesson is to ask students to find data for the date range that would be linear, such as the United States population data range. In 1840, the U.S. population was 17 million people. In 1850, the U.S. population was 23.2 million people. In 1860, the U.S. population was 31 million. ([U.S. Population Census, National Humanities Center](#)). In 1870, the U.S. population was about 39.8 million. In 1880, the U.S. population was about 50.1 million. In 1890, the population was 63 million. In 1900, the population was 76 million ([National Humanities Center](#)). Ask students to put this data in a chart and then graph this data and compare the relationships between the date and the population. Students can discuss the differences between an exponential function and its graph as found in the shipwreck data and a linear function and its graph as found in the population data.

2. Focus Question based on today's lesson (25 minutes)

Today's focus question (Write it on the board.):

Which graph matches the information in the table of ages? Which table matches the information in the graph of temperatures in Wichita? How many bottles are needed to fill the tank? What is the meaning of the y-intercept in a miles-per-gallon problem?

Desired Learner Outcomes for Focus Question Activity:

Students will:

- Be able to convert linear relationships between any representations.
- Know how to apply the rule of four: linear relationships can be represented in graphs, equations, tables and verbal descriptions.

Download and show the PowerPoint presentation, *Tables Graphs and Equations Oh My*, created by Luke Lang, located on Curriki. There are presenter notes on some pages. The instructional notes are located on the *Tables, Graphs and Equations Oh My PDF* file.

a. Whole Class Activity

Use the PowerPoint to show the process to visualize the change using tables, graphs and equations.

1. Marcus and Janine made the table shown to represent the difference between their ages during different years. Find which graph matches the information in the table.

In Algebra, we use multiple representations to describe data or a relationship between inputs and outputs. This lesson develops the skill of transferring

between these representations. The answer is D and this skill (table to graph) is fundamental to the rest of the lesson.

2. Ethan heard a weather report that stated the temperature in Wichita would drop from 5 degrees Fahrenheit at a rate of 2 degrees every hour. Find which table matches the information in the graph.

(Think, Pair, Share) This question is the same type as the last, but backwards. The answer is A, but have students think on their own, then compare answers with a neighbor, and finally tally the results as a class.

3. A 50-gallon fish tank is being filled with water with two-liter pop bottles. There are already 16 liters of water in the fish tank. When will the fish tank be full? How many bottles are needed to fill the tank?

Use Luke Lange's "DANG" formula:

Descriptive - verbal description (as above)

Analytic - an algebraic representation, such as an equation

Numeric - a table or set of points

Graphical - a picture or graph that represents the situation

Answer: +173.25 liters needed

2 liters per bottle = 86.625 bottles

(Round up 86.625 bottles...)

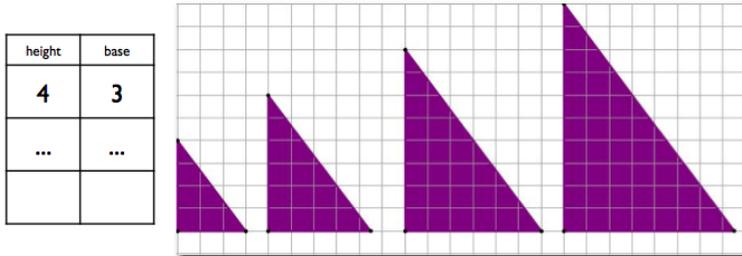
We need 87 two-liter bottles of water in order to fill up the rest of the 50-gallon tank.

1. Find the meaning of the y-intercept. The number of gallons of gas remaining in Antonius' car is a function of how many miles (m) the car is driven. What is the value and meaning of the y-intercept in this problem?
2. To reinforce graphing exponential functions give each student copies of the [Use Exponential Functions worksheet](#) found in Curriki. Ask students to work in small groups to answer the problems then review the solutions in the whole class. Student groups should take turns explaining their solutions to the whole class.

b. Small Group Practice activity (Teacher checks for understanding by observing students while they work in groups.) Ask students to work in groups of four (two sets of pairs) to solve the #1 and #2 problems on the Small Group Practice sheet.

#1

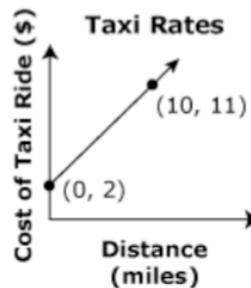
The sides of the similar triangles below form a pattern. Create a table, graph, and equation that represents the relationship between the heights and bases.



#2

The graph below shows the relationship between the cost of a taxi ride and the distance of the taxi ride.

Explain the meaning of the y-intercept and the point (10,11).



An example of an answer is “the y-intercept is eleven and that means that Antonius’ car has eleven gallons of gas in the tank before he begins driving”.

Ask students to solve the two problems as a group. Ask groups to present their solutions to the two questions.

c. Individual activity (Teacher checks for understanding by observing students while they work in groups.)

1. Ask students to continue with the activity and to solve Homework #3 on the Individual Practice sheet.

After paying an enrollment fee at the community center, the cost for any classes is \$5 per class. The enrollment fee is \$10.

This situation is modeled by the equation: $y=5x+10$, where the number of classes taken is (x) and the total cost is (y).

Create a table and a graph that represents this situation.

3. Whole Class Discussion (10 minutes)

Students share their solutions to the problems above.

Select a few students to share one of their own equations and to explain how to solve it.

4. Assessment (5 minutes)

The teacher should follow the directions for [Inquiry Eight: Using Graphs, Words and Pictures to Describe Functions](#) located in Curriki. Demonstrate relationships between objects or events and the variables, factors, functions or patterns that describe them.

The objectives of this activity:

Represent data in an organized, graphic way in order to see patterns between variables and factors

Use graphs, words, mathematic symbols and/or pictures to describe relationships between observed phenomena

Gain experience using spreadsheet software to input data and generate a graph or graphs

This activity will serve as a culmination of the lesson. The teacher can observe level of participation and informally assess student understanding.

5. Extension Activity (Optional)

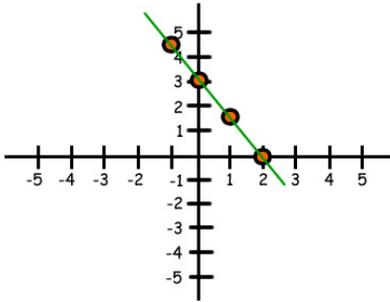
Students work in pairs at the computer to learn more about algebraic thinking through understanding graphs. These interactive games give students practice in understanding graphs. [Understanding Graphs](#) is located in Curriki. Graphing holds a central place in algebra. It connects the algebraic statement to a geometric representation. These resources begin at the beginning—plotting points—then move on to examining slope and the graphs of linear and nonlinear functions.

6. **Homework assignment for additional independent practice** (Note: This homework assignment can be done during a subsequent class period if you have the time, or it can be done as a homework assignment.)

Distribute the [Graphs Practice Worksheet](#) to each student. Introduce the worksheet by solving this problem on the board.

Graph the function $3x + 2y = 6$ for the domain: $D:\{-1, 0, 1, 2\}$

Solution:



Explain the solution and ask students to complete the worksheet as homework.