

Unit 4: Analyze and Graph Linear Equations, Functions and Relations

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Unit 4: Analyze and Graph Linear Equations, Functions and Relations

Learning Objectives

Lesson 1: Graphing Linear Equations

Topic 1: Rate of Change and Slope

Learning Objectives

- Calculate the rate of change or slope of a linear function given information as sets of ordered pairs, a table, or a graph.
- Apply the slope formula.

Topic 2: Intercepts of Linear Equations

Learning Objectives

- Calculate the intercepts of a line.
- Use the intercepts to plot a line.

Topic 3: Graphing Equations in Slope-Intercept Form

Learning Objectives

- Give the slope-intercept form of a linear equation and define its parts.
- Graph a line using the slope-intercept formula and derive the equation of a line from its graph.

Topic 4: Point-Slope Form and Standard-Form of Linear Equations

Learning Objectives

- Give the point-slope and standard-forms of linear equations and define their parts.
- Convert point-slope and standard-form equations into one another.
- Apply the appropriate linear equation formula to solve problems.

Lesson 2: Parallel and Perpendicular Lines

Topic 1: Parallel Lines

Learning Objectives

- Define parallel lines.
- Recognize and create parallel lines on graphs and with equations.

Topic 2: Perpendicular Lines

Learning Objectives

- Define perpendicular lines.
- Recognize and create graphs and equations of perpendicular lines.

Unit 4

Lesson 1

Topic 1, Presentation – 5.8 minutes

Topic 1, Worked Example 1 – 4.6 minutes

Topic 1, Worked Example 2 – 4 minutes

Topic 2, Presentation – 4.8 minutes

Topic 2, Worked Example 1 – 4.12 minutes

Topic 2, Worked Example 2 – 3.4 minutes

Topic 3, Presentation – 3.8 minutes

Topic 3, Worked Example 1 – 3 minutes

Topic 3, Worked Example 2 – 2.6 minutes

Topic 4, Presentation – 6.1 minutes

Topic 4, Worked Example 1 – 5.1 minutes

Topic 4, Worked Example 2 – 7.9 minutes

Lesson 2

Topic 1, Presentation – 4.6 minutes

Topic 1, Worked Example 1 – missing

Topic 1, Worked Example 2 – 3 minutes

Topic 1, Worked Example 3 – 2.6 minutes

Topic 2, Presentation – 1.4 minutes

Topic 2, Worked Example 1 – 3.4 minutes

Topic 2, Worked Example 2 – 3 minutes

Unit 4: Analyzing and Graphing Linear Equations, Functions, and Relations

Instructor Notes

The Mathematics of Analyzing and Graphing Linear Equations, Functions, and Relations

This unit introduces students to different representations of linear functions:

- verbal descriptions
- graphs
- tables
- equations (slope-intercept, standard, and point-slope forms)

Students will learn key aspects of linear relationships and how to recognize them within the different representations. For example, they'll see that slope may be expressed as a rate within a word problem, a coefficient in a linear equation, the steepness of a line on a graph, and as the constant rate of change of a variable in a table. Students will also learn how to use linear equations to identify and create parallel and perpendicular lines.

After completing the unit, students will be comfortable moving between word problems, graphs, tables, and equations, and be able to identify the components of linear equations and functions.

Teaching Tips: Conceptual Challenges and Approaches

There are several aspects of linear functions that often trip up students. Some of these challenges are conceptual and others are algorithmic. Each type of challenge requires a different approach.

Given the large number of variables and formulas associated with linear functions, it is very easy for students to lose track of what the equations represent and which components of a line they must manipulate to solve problems. It is essential that students have plenty of opportunities to examine and create graphs.

Hands-on Opportunities

The text of this unit includes 3 manipulatives that enable students to play with features such as slope and intercept and see the effect of changing coefficients on the graph and equation of a line. These are:

- Graphing Equations in Slope Intercept Form (Lesson 1, Topic 3)

This manipulative lets students adjust both the slope and y-intercept of a line. This will help students understand how the size and sign of coefficients determine the direction and location of a line.

- Parallel Lines (Lesson 2, Topic 1)

This manipulative allows students to swivel and slide a line and compare its slope and y-intercept to a second, fixed line. This will help them learn to recognize parallel lines.

- Perpendicular Lines (Lesson 2, Topic 2)

This manipulative allows students to swivel and slide a line and compare its slope and y-intercept to a second, fixed line. This will help them learn to recognize perpendicular lines.

As students create graphs and work with the manipulatives, teachers must ask questions to nudge them into understanding and exploring the variables that define a line. Students who spend time discussing the relationships between linear equations and graphs are more likely to make the connections between these representations.

Examples

Ask students to predict the effects of large and small, positive and negative values for the coefficient of x in a linear equation. For example, have them compare the graphs of $y = 10x + 5$, $y = -10x + 5$, and $y = 0.1x + 5$.

Have students explain how the steepness of a graph can be anticipated from looking at its equation.

Ask students why lines that look perpendicular or parallel on paper need to have their equations compared in order to be truly identified.

Teaching Tips: Algorithmic Challenges and Approaches

Students also encounter procedural challenges with this material, due to the complexity of some of the algorithms needed to solve and graph linear functions. For example, finding the standard form equation of a line passing through two points is an involved process. It requires three critical steps, namely

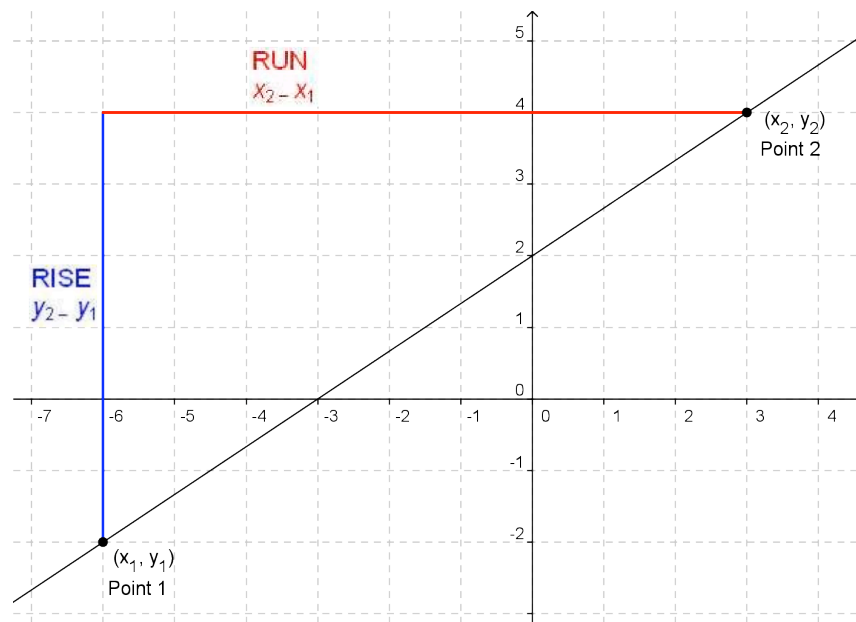
- finding the slope of the line between the points,
- using this slope and one of the points to create the point slope form of a linear equation, and
- converting the point slope equation into standard form.

Faced with a multi-step procedure like this, many students will get stuck in the mathematics of one of these steps, or lose track of the overall goal of the procedure and be unable to follow all the steps in the right order.

Such confusion is common, and the traditional approach is to break problems like this into individual steps (chunking) and make sure students get lots of practice solving each one. Chunking is very useful and should be pursued, but chunking alone isn't enough.

Along with the repeated practice of the small steps it is also critical that students learn the meanings of linear equations and coefficients, to make it easier for them to put the steps back together. For example, most students can memorize the slope formula,

$m = \frac{y_2 - y_1}{x_2 - x_1}$, but if they have no idea why this formula actually produces a value for slope, they're likely to forget it just as easily. Students will do better if they can see how the formula actually works. This is best achieved by frequent reference to visuals like this, from the text of Lesson 1 Topic 1:



By drawing a right triangle under (or above) a line and explaining the mathematical meaning of each leg, you help students grasp why slope is the ratio of the differences between the x and y coordinates of two points. Encourage students to do this on their own graphs if they are having trouble calculating a slope.

To help students move between the different forms of linear equations, use real-life situations in which the variables included in one formula make it more useful in that context than other equations. Guide students through the process of identifying which characteristics of a line they know and which they want to find out, and then choosing the form of linear equation that uses those terms.

Example

In the text of Lesson 2 Topic 4, students are shown how to pick the best equation to solve a problem:

Andre wants to buy an MP3 player. He got \$50 for his birthday, but the player he wants costs \$230, so he's going to have to save up the rest. His plan is to save \$30 a month until he has the money he needs. We'll help him out by writing an equation to analyze this situation. This will help us to figure out when he will have saved up enough to buy the MP3 player.

When we write the equation, we'll let x be the time in months, and y be the amount of money saved. After 1 month, Andre has \$80. That means when $x = 1$, $y = 80$. So we know the line passes through the point $(1, 80)$. Also, we know that Andre hopes to save \$30 per month. This means the rate of change, or slope, is 30.

We have a point and we have a slope—that's all we need to write a point slope formula, so that's the form of linear equation we'll use.

Summary

This unit covers a lot of ground: students must learn to recognize, describe, create, and compare varied and often complex representations of linear functions. They can be made more successful and less intimidated through the use of manipulatives, chunking, visual cues, and practice to teach them not just the procedures but also the meaning of linear equations and graphs.

Unit 4: Analyze and Graph Linear Equations, Functions and Relations

Instructor Overview Tutor Simulation: Fantasy Music Downloads

Purpose

This simulation explores students' understanding of slope by taking them through the solution of a linear relation problem using equations, a table, and a graph. In the process, they'll discover how well they can:

- Create, graph and solve an equation from a word problem
- Extract information from a table
- Grasp the implications of slope/rate of change

Problem

Students are given the following problem:

Three students have downloaded some songs from Fantasymusic.com, but they're not sure why they paid different amounts for their songs. Your challenge is to help them figure out an equation that describes the company's pricing method, and use it to predict how much it will cost to download any number of songs.

| | #Downloads | Cost(\$) |
|----------------|-------------------|-----------------|
| <i>Andre</i> | <i>21</i> | <i>23.15</i> |
| <i>Juanita</i> | <i>35</i> | <i>25.25</i> |
| <i>Serena</i> | <i>58</i> | <i>28.70</i> |

Recommendations

Tutor simulations are designed to give students a chance to assess their understanding of unit material in a personal, risk-free situation. Before directing students to the simulation,

- make sure they have completed all other unit material.
- explain the mechanics of tutor simulations
 - Students will be given a problem and then guided through its solution by a video tutor;
 - After each answer is chosen, students should wait for tutor feedback before continuing;
 - After the simulation is completed, students will be given an assessment of their efforts. If areas of concern are found, the students should review unit materials or seek help from their instructor.
- emphasize that this is an exploration, not an exam.

Unit 4: Analyze and Graph Linear Equations, Functions and Relations

Instructor Overview Puzzle: Bermuda Triangles

Objective

The Bermuda Triangles hidden object puzzle helps students understand the meaning of slope in both numerical and visual form. As students work to match up slopes and lines, they must apply concepts such as rate of change, steepness, and rise over run.



Figure 1. *Bermuda Triangles* hides objects with a given slope in plain sight for the learner to identify.

Description

Three tropical scenes are sprinkled with triangles created by the shapes and arrangements of organisms and objects. Players are given the value of a slope and search the scenes to find a matching line. If they chose correctly, they move on. If they click on a triangle that does not match, a graph of the given slope appears as a guide. If they need further help, a hint button displays a circle that narrows the search area. Players gain points by finding the right slope and lose points for mistaken identifications. The puzzle is suitable for solo play, but group play could spark useful conversations about the relationship between slope and steepness.

Unit 4: Analyzing and Graphing Linear Equations, Functions, and Relations

Instructor Overview

Project: What can you do for your community?

Student Instructions

Introduction

Community service projects allow you to apply the lessons you've learned in the classroom to real-life situations and experiences. They also allow you to raise money for those in need in your community, or help with an environmental cause. Community projects are also a good way to learn to how to work with a team to accomplish a project. For ideas about projects you might pursue in your community visit:

- <http://www.epa.gov/teachers/community-svc-projects.htm> or
- <http://www.groundwater.org/ta/serviceproject.html> or
- <http://www.okcareertech.org/health/HOSA/CommunServIdeas.htm>

Task

For this project you will need to decide what service project you would do for your community. You may do this project alone, but it will be most rewarding to form a small team to figure out how to accomplish your project. The project can be anything that you feel is important, but for the purposes of this activity, it should be a project that requires you to raise money for a cause. You will decide how much money you want to raise, and then you will design a budget for the community service project of your choice. This should include a detailed breakdown of your costs, projected income, and a timeline showing when you expect to reach your target for the amount of money you have decided to raise.

Instructions

Write a brief description of your project, then add information about the money you will raise by solving the following problems:

- 1 First problem:
 - How much money do you need to raise for your community service project? Explain why this amount of money is necessary.
- 2 Second problem:
 - What are the expenses (what you need to spend to raise the money) associated with your community service project? Make sure you provide a detailed spreadsheet (or table) of the costs of all your materials, and any other start-up expenses.
- 3 Third problem:
 - How long will it take you to raise the money you need? Use graphs, and develop an equation (or several equations if necessary) to show how the different variables in your project, the money you need to

raise, the time it will take, the initial expenses, and the cost of any product you make etc. are related to each other.

Collaboration

Discuss the results of your project with your team and add to the description what effect the money you raise may have on your community?

Conclusions

Decide how you will share your project with others. For example, you might:

- Present your project to your class or at a family night.
- Present the information on a Web page. Have other students critique your project and help you to make improvements to your project.
- Write a one-page summary of your project including what you have learned from researching this topic. How has it changed your ideas about serving your community?

Instructor Notes

Assignment Procedures

Recommendations:

- have students work in teams to encourage brainstorming and cooperative learning.
- assign a specific timeline for completion of the project that includes milestone dates.
- provide students feedback as they complete each milestone.
- ensure that each member of student groups has a specific job.

Technology Integration

This project provides abundant opportunities for technology integration, and gives students the chance to research and collaborate using online technology. The following are examples of free internet resources that can be used to support this project:

<http://www.moodle.org>

An Open Source Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE). Moodle has become very popular among educators around the world as a tool for creating online dynamic websites for their students.

<http://www.wikispaces.com/site/for/teachers> or <http://pbworks.com/content/edu+overview>

Lets you create a secure online Wiki workspace in about 60 seconds. Encourage classroom participation with interactive Wiki pages that students can view and edit from any computer. Share class resources and completed student work with parents.

<http://www.docs.google.com>

Allows students to collaborate in real-time from any computer. Google Docs provides free access and storage for word processing, spreadsheets, presentations, and surveys. This is ideal for group projects.

<http://why.openoffice.org/>

The leading open-source office software suite for word processing, spreadsheets, presentations, graphics, databases and more. It can read and write files from other common office software packages like Microsoft Word or Excel and MacWorks. It can be downloaded and used completely free of charge for any purpose.

Rubric

| Score | Content | Presentation |
|-------|--|---|
| 1 | <p>Assigns variables to some quantities.</p> <p>Project does not use linear functions to analyze the situation.</p> | <p>The presentation is difficult to understand because there is no sequence of information.</p> |
| 2 | <p>Assigns variables to quantities. (Some variables should be correctly assigned.)</p> <p>Uses a table, a graph or an equation of a linear function to analyze the time it will take to make the money needed. (Some functions should be correctly applied.)</p> | <p>The presentation is hard to follow because the material is presented in a manner that jumps around between unconnected topics.</p> |
| 3 | <p>Appropriately assigns variables to unknown quantities. (Most variables should be correctly assigned.)</p> <p>Uses either tables or graphs or equations (but not all three) of linear functions to analyze the time it will take to make the money needed. (Most functions should be correctly applied.)</p> | <p>The presentation contains information presented in a logical sequence that is easy to follow.</p> |
| 4 | <p>Appropriately assigns variables to unknown quantities. (All variables should be correctly assigned.)</p> <p>Appropriately uses tables, graphs, and equations of linear functions to analyze the time it will take to make the money needed. (All functions should be correctly applied.)</p> | <p>The presentation contains information shown in a logical and interesting sequence that is easy to follow.</p> |

Unit 4: Algebra - Analyze and Graph Linear Equations, Functions and Relations

Glossary

| | |
|--------------------------------|---|
| coordinates | a pair of numbers that identifies a point on the coordinate plane—the first number is the x-value and the second is the y-value |
| dependent variable | a value or variable that depends upon the independent value |
| independent variable | a value or variable that changes or can be manipulated by circumstances |
| intercept | a point where a line meets or crosses a coordinate axis |
| linear equation | an equation that describes a straight line |
| linear function | a function with a constant rate of change and a straight line graph |
| parallel lines | lines that have the same slope and different y-intercepts |
| perpendicular lines | lines that have opposite reciprocal slopes |
| point-slope formula | a form of linear equation, written as $(y - y_1) = m(x - x_1)$, where m is the slope and (x1, y1) are the co-ordinates of a point |
| rate of change | the constant in a proportional function equation; it describes the ratio or proportional relationship of the independent and dependent variables—also called the constant of variation or the constant of proportionality |
| rise | vertical change between two points |
| run | horizontal change between two points |
| slope | the ratio of the vertical and horizontal changes between two points on a surface or a line |
| slope formula | the equation for the slope of a line, written as $m = \frac{y_2 - y_1}{x_2 - x_1}$, where m is the slope and (x1,y1) and (x2, y2) are the coordinates of two points on the line |
| slope-intercept form | a linear equation, written in the form $y = mx + b$, where m is the slope and b is the y-intercept |
| slope-intercept formula | a linear equation, written as $y = mx + b$, where m is the slope and b is the y-intercept |

| | |
|---|--|
| standard form of a linear equation | a linear equation, written in the form $Ax + By = C$, where x and y are variables and A, B , and C are integers |
| x-intercept | the point where a line meets or crosses the x -axis |
| y-intercept | the point where a line meets or crosses the y -axis |

NROC Algebra 1--An Open Course
Unit 4
Mapped to Common Core State Standards, Mathematics

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Graphing Linear Equations | Rate of Change and Slope

Grade: 7 - Adopted 2010

| | | |
|--------------------|-----------|---|
| STRAND / DOMAIN | CC.7.RP. | Ratios and Proportional Relationships |
| CATEGORY / CLUSTER | | Analyze proportional relationships and use them to solve real-world and mathematical problems. |
| STANDARD | 7.RP.2. | Recognize and represent proportional relationships between quantities. |
| EXPECTATION | 7.RP.2.b. | Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships. |

Grade: 8 - Adopted 2010

| | | |
|--------------------|----------|---|
| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.6. | Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b . |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Use functions to model relationships between quantities. |
| STANDARD | 8.F.4. | Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. |

Grade: 9-12 - Adopted 2010

| | | |
|--------------------|---------|--|
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |
| EXPECTATION | F-IF.6. | Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph. |

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Graphing Linear Equations | Intercepts of Linear Equations

Grade: 7 - Adopted 2010

| | | |
|--------------------|----------|--|
| STRAND / DOMAIN | CC.7.RP. | Ratios and Proportional Relationships |
| CATEGORY / CLUSTER | | Analyze proportional relationships and use them to solve real-world and mathematical problems. |
| STANDARD | 7.RP.2. | Recognize and represent proportional relationships between quantities. |

| | | |
|-------------|-----------|---|
| EXPECTATION | 7.RP.2.d. | Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate. |
|-------------|-----------|---|

Grade: 8 - Adopted 2010

| | | |
|--------------------|----------|---|
| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.5. | Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Use functions to model relationships between quantities. |
| STANDARD | 8.F.4. | Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. |

Grade: 9-12 - Adopted 2010

| | | |
|--------------------|-----------|--|
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-CED. | Creating Equations |
| STANDARD | | Create equations that describe numbers or relationships. |
| EXPECTATION | A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. |
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Understand solving equations as a process of reasoning and explain the reasoning. |
| EXPECTATION | A-REI.1. | Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method. |
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Represent and solve equations and inequalities graphically. |
| EXPECTATION | A-REI.10. | Understand 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). |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |
| EXPECTATION | F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Analyze functions using different representations. |
| EXPECTATION | F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. |

| | | |
|--------------------|-----------|--|
| GRADE EXPECTATION | F-IF.7.a. | Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. |
| GRADE EXPECTATION | F-LE.1.a. | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Interpret expressions for functions in terms of the situation they model. |
| EXPECTATION | F-LE.5. | Interpret the parameters in a linear or exponential function in terms of a context. |

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Graphing Linear Equations | Graphing Equations in Slope Intercept Form

Grade: 8 - Adopted 2010

| | | |
|--------------------|----------|---|
| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.5. | Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. |
| STANDARD | 8.EE.6. | Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b . |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Define, evaluate, and compare functions. |
| STANDARD | 8.F.3. | Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. For example, the function $A = s^2$ giving the area of a square as a function of its side length is not linear because its graph contains the points $(1,1)$, $(2,4)$ and $(3,9)$, which are not on a straight line. |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Use functions to model relationships between quantities. |
| STANDARD | 8.F.4. | Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. |

Grade: 9-12 - Adopted 2010

| | | |
|--------------------|----------|---|
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-CED. | Creating Equations |
| STANDARD | | Create equations that describe numbers or relationships. |
| EXPECTATION | A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. |
| STRAND / DOMAIN | CC.A. | Algebra |

| | | |
|--------------------|-----------|--|
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Represent and solve equations and inequalities graphically. |
| EXPECTATION | A-REI.10. | Understand 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). |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |
| EXPECTATION | F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Analyze functions using different representations. |
| EXPECTATION | F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. |
| GRADE EXPECTATION | F-IF.7.a. | Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. |
| GRADE EXPECTATION | F-LE.1.a. | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.2. | Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). |

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Graphing Linear Equations | Point Slope Form and Standard Form of Linear Equations

Grade: 7 - Adopted 2010

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| STRAND / DOMAIN | CC.7.RP. | Ratios and Proportional Relationships |
| CATEGORY / CLUSTER | | Analyze proportional relationships and use them to solve real-world and mathematical problems. |
| STANDARD | 7.RP.2. | Recognize and represent proportional relationships between quantities. |
| EXPECTATION | 7.RP.2.c. | Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p , the relationship between the total cost and the number of items can be expressed as $t = pn$. |

Grade: 8 - Adopted 2010

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| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.5. | Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. |
| STANDARD | 8.EE.6. | Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b . |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Define, evaluate, and compare functions. |
| STANDARD | 8.F.3. | Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. For example, the function $A = s^2$ giving the area of a square as a function of its side length is not linear because its graph contains the points $(1,1)$, $(2,4)$ and $(3,9)$, which are not on a straight line. |
| STRAND / DOMAIN | CC.8.F. | Functions |
| CATEGORY / CLUSTER | | Use functions to model relationships between quantities. |
| STANDARD | 8.F.4. | Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. |

Grade: 9-12 - Adopted 2010

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| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-CED. | Creating Equations |
| STANDARD | | Create equations that describe numbers or relationships. |
| EXPECTATION | A-CED.1. | Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. |
| EXPECTATION | A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. |
| EXPECTATION | A-CED.3. | Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods. |
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Represent and solve equations and inequalities graphically. |
| EXPECTATION | A-REI.10. | Understand 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). |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |

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| EXPECTATION | F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Analyze functions using different representations. |
| EXPECTATION | F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. |
| GRADE EXPECTATION | F-IF.7.a. | Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-BF. | Building Functions |
| STANDARD | | Build a function that models a relationship between two quantities. |
| EXPECTATION | F-BF.1. | Write a function that describes a relationship between two quantities. |
| GRADE EXPECTATION | F-BF.1.a. | Determine an explicit expression, a recursive process, or steps for calculation from a context. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. |
| GRADE EXPECTATION | F-LE.1.a. | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.2. | Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table). |

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Parallel and Perpendicular Lines | Parallel Lines

Grade: 8 - Adopted 2010

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| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.5. | Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. |

Grade: 9-12 - Adopted 2010

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|--------------------|----------|---|
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-CED. | Creating Equations |
| STANDARD | | Create equations that describe numbers or relationships. |
| EXPECTATION | A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. |

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| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Represent and solve equations and inequalities graphically. |
| EXPECTATION | A-REI.10. | Understand 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). |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |
| EXPECTATION | F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Analyze functions using different representations. |
| EXPECTATION | F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. |
| GRADE EXPECTATION | F-IF.7.a. | Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. |
| GRADE EXPECTATION | F-LE.1.a. | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. |
| STRAND / DOMAIN | CC.G. | Geometry |
| CATEGORY / CLUSTER | G-GPE. | Expressing Geometric Properties with Equations |
| STANDARD | | Use coordinates to prove simple geometric theorems algebraically |
| EXPECTATION | G-GPE.5. | Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point). |

Algebra 1 | Analyze and Graph Linear Equations, Functions and Relations | Parallel and Perpendicular Lines | Perpendicular Lines

Grade: 8 - Adopted 2010

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|--------------------|----------|--|
| STRAND / DOMAIN | CC.8.EE. | Expressions and Equations |
| CATEGORY / CLUSTER | | Understand the connections between proportional relationships, lines, and linear equations. |
| STANDARD | 8.EE.5. | Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. |

Grade: 9-12 - Adopted 2010

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|--------------------|--------|--------------------|
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-CED. | Creating Equations |

| | | |
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| STANDARD | | Create equations that describe numbers or relationships. |
| EXPECTATION | A-CED.2. | Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. |
| STRAND / DOMAIN | CC.A. | Algebra |
| CATEGORY / CLUSTER | A-REI. | Reasoning with Equations and Inequalities |
| STANDARD | | Represent and solve equations and inequalities graphically. |
| EXPECTATION | A-REI.10. | Understand 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). |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Interpret functions that arise in applications in terms of the context. |
| EXPECTATION | F-IF.4. | For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-IF. | Interpreting Functions |
| STANDARD | | Analyze functions using different representations. |
| EXPECTATION | F-IF.7. | Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. |
| GRADE EXPECTATION | F-IF.7.a. | Graph linear and quadratic functions and show intercepts, maxima, and minima. |
| STRAND / DOMAIN | CC.F. | Functions |
| CATEGORY / CLUSTER | F-LE. | Linear and Exponential Models |
| STANDARD | | Construct and compare linear and exponential models and solve problems. |
| EXPECTATION | F-LE.1. | Distinguish between situations that can be modeled with linear functions and with exponential functions. |
| GRADE EXPECTATION | F-LE.1.a. | Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. |
| STRAND / DOMAIN | CC.G. | Geometry |
| CATEGORY / CLUSTER | G-GPE. | Expressing Geometric Properties with Equations |
| STANDARD | | Use coordinates to prove simple geometric theorems algebraically |
| EXPECTATION | G-GPE.5. | Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point). |

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