

**Mathematics Standards**

**Algebra 2**

**Course Overview:** This course will include the study of functions using multiple representations, linear and quadratic functions, arithmetic and geometric sequences, discrete and continuous functions, exponential functions, transformations of graphs including parabolas, cubics, exponentials, and rational functions, linear systems, logarithms and other inverse functions, polynomials, and general systems of equations.

**Bold standards are essential standards that all students will learn as they complete the course.**

**Unit 1 – Investigating Functions (approximately 18 days)**

**Description:** This unit will introduce students to the ways they will be working as well as several of the big ideas in this course. They will share their current mathematical knowledge with their study team as they work together to solve problems. Some of these ideas will be revisited later in the course with connections to new mathematical ideas. They will learn to work with a graphing calculator to help them to discover qualities of functions and systems of functions.

**Standards**

1. Students will describe the range, domain, intercepts, and use sketches to investigate functions and form complete graph. (A-APR3, A-REI-10, F-IF-1)

2. Students will analyze functions written in function notation and y-form for both the input and output of the function. (A-IF-2)

3. Students will evaluate functions on a graphing calculator, zoom in on them, set a window range and domain, trace a function, find the intercepts of functions, and examine tables of values. (A-REI-11)

4. Students will find points of intersection using multiple representations and will learn how to use the [TABLE], [TBLSET], and [CALC] functions of their graphing calculators. (F-IF-9)

5. **Students will utilize the properties of algebra to reorganize algebraic expressions in order to put them into more useful forms.** (A-CED-4)

6. **Students will generate multiple algebraic representations for the function.** (F-IF-4, F-IF-5)

7. Students will identify what all linear functions have in common and will determine whether relationships in tables and situations are linear. (F-IF-9, F-LE-5)

**Unit 2 – Sequences (approximately 16 days)**

**Description:** This unit provides students with an opportunity to strengthen their algebra skills while you learn about arithmetic and geometric sequences. They will use familiar strategies such as looking for patterns and making tables to write algebraic equations describing sequences of numbers and they will develop shortcuts for writing equations for certain kinds of sequences.

**Standards**

1. Students will represent exponential growth with a diagram, table, and graph and they will write descriptions of exponential growth based on the patterns in their tables, recognize patterns of exponential growth, and use their descriptions to make predictions. (N-Q-2, F-LE-1c)

2. Students will generate data and model the data collected with tables, equations, and graphs. (F-IF-7e, F-LE-1c)

3. Students will be introduced to an example of exponential decay and compare it to the linear function from the previous lesson. (F-IF-7e, F-LE-1c)

4. Students will analyze sequences, determine whether a sequence is arithmetic or geometric, and then write equations to model each. (F-BR-1a, F-LE-1a-c, F-LE-2, F-LE-3, A-CED-2, F-IF-3, FBF-2)

5. Students will relate a common difference and initial value to an arithmetic sequence and write a model for the *n*th term of the sequence, then use that model to predict values of the sequence. (A-CED-2, F-IF-3, F-BF-2, F-LE-2)

6. Students will relate multipliers, initial value, and percent increase or decrease, then produce and evaluate a geometric model for the nth term of the geometric sequence. (A-CED-2, F-IF- 3, F-BF-2, F-IF-8b)

7. Students will write sequences from recursive equations.  They will write recursive equations for arithmetic sequences, and convert between explicit and recursive equations for arithmetic sequences. (F-IF-3, F-BF-2, F-LE-2)

8. Students will look at and compare patterns of growth in linear and exponential tables. (F-IF-6, F-LE-1a, F-LE-3)

9. Students will find equations for geometric sequences and see relationships between geometric sequences and exponential functions.  Students will use geometric sequences to solve problems involving percent increase and decrease. (F-IF-6, F-LE-1c, F-LE-2)

10. Students will recognize that all sequences are functions with domains limited to positive integers.  Students will use graphical methods to solve exponential equations. (F-IF-3)

**Unit 3 – Exponential Functions** **(approximately 16 days)**

**Description:** This unit provides an opportunity for students to learn more about the family of exponential functions. They will also build more advanced algebra skills, such as solving for an indicated variable, simplifying or rewriting exponential expressions, working with fractional exponents, and finding the exponential function that passes exactly through any pair of given points. They will also learn about several important applications of exponential functions.

**Standards**

1. Students will identify the relationship between geometric sequences and exponential functions. (F-BF-2, F-BF-1a, F-LE-1a, b, c, 2, 3, F-IF-8)
2. Students will investigate the family of functions y = bx. They will make and justify statements about the behaviors of graphs in this family. (F-IF-4, F-IF-7e)
3. Students will deepen and extend their understanding of exponential functions by examining the multiplier (“b”) and starting point (“a”) in different representations and they will generalize the roles of a and b for the equation y = a · bx. (A-CED-1, A-CED-2, F-IF-6,  F‑IF-7e, F‑IF-8b, F‑LE-1a, F‑LE-1c, F‑LE-2, F‑LE-5)
4. Students will apply exponential functions to model growth and decay. (F-BF-2, F-BF-1a, FLE-1a, b, c, 2, 3, F-IF-8b)
5. Students will use what they know about linear and exponential functions to investigate the relationship between simple and compound interest. (A‑SSE-1b, A‑CED-1, A‑CED-2, F‑IF-6, F‑IF-7b, F‑IF-7e, F‑IF-8b, F‑LE-1a, F‑LE-1c, F‑LE-2, F‑LE-5)
6. Students will represent exponential decay in multiple ways and will further investigate the effect when the exponent is 0 or negative. (A‑SSE-3c, A‑CED-1, A‑CED-2, F‑IF-7e, F‑IF-8b, F‑LE-1c, F‑LE-2, F‑LE-5)
7. Students will interpret and analyze negative, fractional, and zero exponents. (A-SSE-3c, N‑RN-1, N‑RN-2)
8. Students will choose variables to represent relations from tables, graphs, verbally stated problems, and geometric diagrams (F-IF, N-RN)
9. Students will use what they know about exponential growth to write equations for exponential functions presented as graphs. (A‑CED-1, A‑CED-2, F‑IF-4, F‑IF-5, F‑IF-7b, F‑IF-7e, F‑IF-8b, F‑LE-1c, F‑LE-2, F‑LE-5)
10. Students will complete the exponential multiple representations web, solidifying connections between the table, equation, graph, and situation representations of an exponential function. (N‑Q-1, N‑Q-2, A‑CED-1, A‑CED-2, F‑IF-4, F‑IF-5, F‑IF-7e, F‑IF-8b, F‑IF-9, F‑LE-1c, F‑LE-2, F‑LE-5)
11. Students will find equations of linear and exponential functions by using known quantities to solve for a missing parameter. (F‑IF-5, F‑IF-7e, F‑BF-1a, F‑LE-2)
12. Students will find linear functions and exponential equations of the form y = ax given two points. **(**A‑REI.10, F‑IF.7e, F‑BF.1a, F‑LE.2)
13. Students will demonstrate that algebraic relations can be tested by substitution of numbers. (F-IF, N-RN)

**Unit 4 – Transformations of Parent Graphs** **(approximately 24 days)**

**Description:** In this unit, students will learn how to change the equation of a parabola to make it fit a set of nonlinear data. After learning how to stretch, compress, reflect, and shift the graph of f (x) = x2, students will be able to create a variety of parabolic shapes and sizes. Students will learn that a graph’s transformations are clearly recognizable when its equation is written in graphing form. Understanding this form will help them to learn how to rewrite equations so that they are easier to graph. They will also use the quadratic family of functions to model physical situations, such as the arc of a jumping rabbit and the path of a soccer ball. They will then apply these same types of transformations to other parent functions.

**Standards**

1. Students will connect transformations of parabolas with their equations in graphing form. (A-CED-2, A-SSE-1b, F-IF-8a, F-IF-9, F-BF-3)
2. Students will graph quadratic equations without making tables and students will rewrite quadratic equations from standard form into graphing form. (A-CED-2, A-SSE-1b, F-IF-4, F-IF-8a, F-IF-9, F-BF-3)
3. Students will use and compare two methods for rewriting quadratic equations from standard form to graphing form, averaging the intercepts and completing the square. (A-CED-2, A-SSE-1b, A-SSE-3a, A-REI-4a, b, F-IF-8a, F-IF-9. F-BF-3)
4. Students will learn how to write quadratic equations for situations using the graphing form of the parabola y = a(x− h) 2 + k.  Specifically, students will develop an algebraic strategy for finding the value of the stretch factor, a. (A-CED-2, A-SSE-1b, F-IF-8a, F-BF-3)
5. **Given the equation of a line, parabola, cubic, exponential, inverse, absolute value, square root, or circle, students will predict its location, stretch or compression factor, orientation, and sketch the shape of the figure.** (A-CED-2, A-SSE-1b, F-IF-4,7a,b,c,e,8a,9, F-BF-3, G-GPE-1)
6. Students will identify the point (h, k) for graphs of parabolic, hyperbolic, cubic, absolute value, exponential, and square root functions and relate it to the point-slope form of a line and they will consolidate their understanding of parent graphs and general equations in the [Parent Graph Toolkit](http://pdfs.cpm.org/stuRes/CCA2/chapter_02/CCA2%20Lesson%202.2.2%20RP.pdf). (A-CED-2, A-SSE-1a, A-SSE-1b, F-IF-7b, F-IF-7e, F-IF-9)
7. Given the graph of a function, students will predict an equation to represent it. (A-CED-2, F-IF-7a, b, c, 8a, G-GPE-1)
8. Students investigate one more transformation, f (−x), the reflection of f(x) across the y-axis and then they will compare f (−x) and −f(x), for a variety of parent graphs and develop the definitions for even and odd functions. (F-IF-9)
9. Students will use what they know about transforming parabolas to make conjectures about transforming non-functions, specifically a circle. (F-BF-3, F-IF-9)
10. Students will use what they know about transformations to relocate and reorient a piecewise-defined function. (F-IF-7b, F-IF-9, F-BF-3)

**Unit 5 – Equivalent Forms** **(approximately 16 days)**

**Description:** In this unit, students will focus on rewriting expressions in order to have more useful equivalent forms. They will remind themselves what it means for two expressions or equations to be equivalent. They will then rewrite equations to solve them more easily. Then students will learn how to combine algebraic fractions (called “rational expressions”) and expressions with exponents. By using the special properties of the number 1 and the meaning of exponents, they will be able rewrite long, complicated expressions into simpler forms. They will then multiply, divide, add, and subtract rational expressions.

**Standards**

1. **Students will identify equivalent expressions and develop algebraic strategies for demonstrating equivalence.** (A-APR.1, A-APR.4, A-SSE.2)
2. Students will use an area model to multiply expressions.  They will factor expressions and demonstrate equivalence. (**A-APR.1, A-APR.4, A-SSE.2)**

3. Students will rewrite and solve equations and systems of equations, sometimes using substitution. (**A-SSE.1a, A-SSE.1b, A-APR.1, A-APR.4, A-SSE.2)**

4. Students will explore the graphs of several rational functions in order to visualize some of the effects of dividing by polynomials. (A-APR-1)

5. Students will analyze and compare rational expressions. (A-APR-7+)

6. Students will understand how to multiply and divide rational expressions and will continue to learn how to simplify rational expressions. (A-APR-7+)

7. Students will learn how to add and subtract rational expressions. (A-APR-7+)

8. Students will consider problems involving all four operations with rational expressions and consolidate their understanding.  They will learn how to check their work when simplifying rational expressions. (A-APR-7+)

**Unit 6 – Solving and Intersections (approximately 15 days)**

**Description:** This unit begins with a focus on two ways to solve equations and systems of equations: algebraically and graphically. Students will build on their understanding of solving and solutions from previous courses to gain a broader and stronger understanding of the meaning of solutions. They will expand their understanding of solving and solutions to include inequalities and they will solve problems designed to illustrate how inequalities might be used for more complicated applications.

**Standards**

1. **Students will solve a variety of equations, discuss different methods for solving them, justify their strategies, and develop a strategy for checking their solutions.** (A-SSE-1b, A-SSE-2, A-REI-2)

2. Students will use graphs to validate algebraic solutions and to approximate solutions when no algebraic method is available, and they will use two different methods to solve one‑variable equations graphically. (A-REI.2, A-REI.11)

3. Students will solve systems of linear and non‑linear equations using multiple strategies, determine the number of solutions for systems, and interpret solutions graphically. (A-REI-11)

4. Students will use their problem-solving skills to write equations and find solutions for real-life applications. (A-CED-2)

5. Students will extend what they learned about solving systems of equations graphically to solving systems of inequalities. (A-CED-3)

6. Students will apply systems of linear inequalities to solve a problem involving an everyday situation. (A-CED-3, F-IF-5)

7. Students will consider two functions and identify the relationships between the functions and the system from which they come. (A-CED-3, A-REI-11)

**Unit 7 – Inverses and Logarithms** **(approximately 16 days)**

**Description:** In this unit, students will investigate some new functions that “undo” each other. They will learn about inverse relationships and investigate the relationships between functions and their inverses. They will also learn about compositions of functions. They will find the inverses of many parent graphs and add them to the tools they have for working with parent graphs. They will find inverses for exponential functions, which are called logarithmic functions and they will then investigate this family of functions and transform its graphs.

**Standards**

1. Students will learn to find equations that “undo” functions, develop strategies to justify that each equation undoes the other, graph functions along with their inverses, and make observations about the relationships between the graphs. (F-BF-4a)

2. **Students will be introduced to the term “inverse” to describe undo rules. They will also be able to graph the inverse of a function by reflecting it across the line of symmetry, y = x, and they will write equations for inverses.** (F-BF-4a, F-IF-5)

3. Students will use their ideas about switching x‑ and y‑values to learn how to find an inverse algebraically, learn about compositions of functions, and will use compositions f(g(x)) and(f(x)) to test algebraically whether two functions are inverses of each other. (F-BF-4a, A-CED-4)

4. Students will apply their strategies for finding inverses to parent graph equations and they will begin to think of the inverse function for y = 3x as “the exponent for 3 that will give x,” or “What I would get if I could change x = 3y into y = form?” as a precursor for learning about logarithms. (F-BF-4a, F-LE-4)

5. **Students will define the term logarithm as the inverse exponential function.** (F-BF-4a, F-LE-4)

6. Students will develop methods to graph logarithmic functions with different bases and they will rewrite logarithmic equations as exponential equations and find inverses of logarithmic functions. (F-IF-4, F-IF-7e)

7. Students look into the base of the log key on their calculator and will extend their knowledge of general equations for parent functions to transform the graph of y = log x. (F-IF-7e, F-IF-9, F-BF-3)

8. Students will write functions that are compositions of two functions.  Students will make predictions about how, when composing functions, the second function changes the graph of the first. (F-IF-4, F-IF-5, F-IF-8, F-BF-1b)

**Unit 8 – 3D Graphing and Logarithms** **(approximately 15 days)**

**Description:** In this unit, students will expand their understanding of graphing equations and systems of equations to three dimensions and they will broaden their understanding of solutions to include solutions to systems in three dimensions. Then they will return to logarithms to learn more about their properties and why they are useful.

**Standards**

1. Students will create and use a model to locate points in three-dimensional space and will plot points in three dimensions on isometric dot paper. (A-CED.2)

2. Students will graph planes on three-dimensional axes. (A-CED.2)

3. Students will investigate the graphs of systems of equations with three variables.  They will find points that lie on two planes simultaneously. (A-CED.2)

4. Students will develop an algebraic strategy to solve systems of three equations with three variables.  Students will also determine the different ways three planes can intersect and will investigate the graphs of three-dimensional systems. (A-CED.2)

5. Students will work in teams to find the equation of a quadratic function
y = ax2 + bx + c that passes through three given points when graphed. (A-CED.2)

6. **Students develop the Power Property of Logs and use it to develop an efficient method to solve exponential equations in ax= b form.** (F-LE.4)

7. Students will learn the Product and Quotient Properties of logs and how to rewrite equations with different bases. (F-LE.4)

8. Students will develop strategies for finding the equation of an exponential function given two points and an asymptote. (F-LE.4, F-LE.5, F-BF.1b)

9. Students will apply their knowledge of exponential functions to solve an interesting application problem. (F-LE.4, F-LE.5, F-IF.7e, F-BF.1b)

**Unit 9 – Polynomials** **(approximately 18 days)**

**Description:** In this unit, students will expand their knowledge of families of functions to include polynomial functions. As they investigate the equation ↔ graph connection for polynomials, they will learn how to search for factors (which can help you find x-intercepts) and how to use division to find additional factors. When they investigate the graphs of polynomials and systems involving polynomials, they will see many that appear not to intersect. As they investigate these systems further, they will learn about imaginary and complex numbers. In the last section of the chapter, they will apply their knowledge of polynomials to model some of the attractions at a county fair.

**Standards**

1. Students will describe the graph of a polynomial given its equation in factored form. (A-APR.3, F-IF.4, F-IF.7c, N-CN.9 (+))

2. Students will consolidate, generalize, and explain their findings from the polynomial investigation. (A-APR.3, F-IF.7c, N-CN.9 (+))

3. Students will write exact equations for the graphs of polynomial functions given the x‑intercepts and one additional point. (A-APR.3, F-IF.4, F-IF.7c)

4. **Students will solve equations using imaginary and complex numbers.** (N-CN.1, N-CN.7, N-CN.9 (+))

5. Students will be introduced to complex conjugates by solving quadratic equations, learn how to write the equations for quadratic functions given the roots and practice operations with complex numbers. (N-CN.1, N-CN.2, N-CN.7, N-CN.8 (+), N-CN.9 (+))

6. Students will be introduced to the complex plane as a way to visualize complex numbers and complex roots for quadratic functions; they will calculate the absolute value of a complex number and they will start to investigate the number of linear and quadratic factors a polynomial can have. (N-CN.1, N-CN.2, N-CN.7, N-CN.9 (+))

7. Students will use polynomial division to find factors of polynomials. (A-APR.2, A-APR.6, N-CN.9 (+))

8. Students will use the Integral Zero Theorem, polynomial division and the Factor Theorem to find integral roots and to find all roots of polynomials with degree greater than two. (A-SSE.2, A-APR.2, A-APR.3, A-APR.6, F-IF.7c, N-CN.8 (+), N-CN.9 (+))

9. Students will use their knowledge of polynomial functions and graphs to maximize volume of a tank. (A-APR.2, A-APR.3, A-APR.6, F-IF.5, F-IF.7c, N-CN.9 (+))

**Unit 10 – Series** **(approximately 15 days)**

**Description:** In this unit, students will use what they know about arithmetic and geometric sequences and multiple representations to write series and find their sums. Then they will develop the Binomial Theorem, which is useful for simplifying some algebraic manipulations, as well as solving some probability problems.

**Standards**

1. Students will be introduced to arithmetic series and will learn how to distinguish series from sequences. Students will begin to develop strategies to find sums of arithmetic series. (A-SSE.2)

2. Students will generalize a graphical method for finding the sum of an arithmetic series and then apply it. (A-SSE.2)

3. Students will find the sums of series that have unspecified numbers of terms and will learn how known series can be combined to form new series. (A-SSE.2)

4. Students will see an algebraic method for finding the sum of an arithmetic series and they will be introduced to summation notation for arithmetic series. (A-SSE.2)

5. Students will calculate sums of geometric series. (A-SSE.4)

6. Students will find sums of infinite geometric series. (A-SSE.1b)

7. Students will connect the coefficients in the expansion of binomial expressions with the numbers in the rows of the Pascal’s Triangle. (A-APR.4, A-APR.5 (+))

8. Students will explore the origins of the transcendental number, e. (A-SSE.2, F-IF.8b, F-LE.4)