WAKE COUNTY PUBLIC SCHOOL SYSTEM

High School Programs

Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

Unit Outcomes At the end of this unit, your student should be able to:	**Key Vocabulary** Terms to deepen the student's understanding
✓ ~~Determine whether an expression is a polynomial.~~ ✓ Add and subtract~~ing~~ polynomials. ✓ Multiply up to three linear expressions. ✓ Create quadratic equations in one variable and use them to solve problems. ✓ Solve quadratic equations by inspection (e.g. $x^2 = 49$). ✓ Solve quadratic equations by taking square roots (e.g. $2x^2 + 8 = 170$). ✓ Solve quadratic equations by using the quadratic formula. ✓ Use the discriminant to determine the number of real solutions of a quadratic equation and when a quadratic equation has non-real solutions. ✓ Solve quadratic equations by factoring and be able to justify each step. ✓ Choose an appropriate method to find solutions based on the initial form of the quadratic equation and construct a viable argument to justify that method. ✓ Solve a simple system consisting of a linear equation and a quadratic equation in two variables graphically. ✓ Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically. ✓ ~~Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$.~~ ✓ Find the approximate solutions of the equation $f(x) = g(x)$ using technology to graph the functions, making tables of values, or finding successive approximations. Only linear or quadratic functions should be used for $f(x)$ and $g(x)$. ✓ Represent constraints of systems of linear-quadratic equations and/or inequalities based on a modeling context. ✓ Interpret solutions of linear-quadratic systems as viable or non-viable options in a modeling context. ✓ Given a function verbally, algebraically, in table, or in graph form, determine whether it is a quadratic function.	✓ ~~Polynomial Expression~~ ✓ ~~Degree of a polynomial expression or equation~~ ✓ Quadratic Equation~~s~~ ✓ Quadratic Formula ✓ Factoring ✓ Discriminant ✓ Non-real Solutions ✓ System of Equations ✓ Constraints ✓ Standard form of a quadratic ✓ Factored form of a quadratic ✓ x and y -intercepts ✓ Parabola ✓ Vertex ✓ Extrema ✓ Maximum ✓ Minimum ✓ Axis of symmetry ✓ Domain ✓ Range ✓ Completing the Square ✓ Quadratic Inequality

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Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

✓ Recognize equivalent forms (e.g. standard form $ax^2 + bx + c = 0$, and factored form $y = a(x - r_1)(x - r_2)$ of quadratic functions. ✓ Identify the coefficients and constants of a quadratic function and interpret them in a contextual situation. ✓ Use the process of factoring to find the zeros of a quadratic function. ✓ Find the vertex of a quadratic function algebraically and using technology. ✓ Find the vertex of a quadratic function by completing the square to place the function in vertex form. ✓ Interpret, in context, the key features of the graph and table forms of a quadratic function that models a relationship between two quantities. Key features include: intercepts; intervals where the function is increasing, decreasing, positive or negative; maximum or minimum, and line of symmetry. ✓ Construct a rough graph of a quadratic function using zeros, intercepts, the vertex and symmetry. ✓ Sketch the graph of a quadratic function that was graphed using technology, showing the key features. ✓ Determine the appropriate viewing window and scale using technology to reveal the key features of the graph of a quadratic function. ✓ Relate the domain of a quadratic function to its graph and, when given a context, to the quantitative relationship it describes. ✓ Identify the effect on the graph of a quadratic function $f(x)$ in vertex form when $f(x)$ is replaced with $f(x) + k$, $f(x + k)$ and $k \cdot f(x)$ for specific values of k (both positive and negative). ✓ Experiment with various cases of $f(x)$ when replaced with $f(x) + k$, $f(x + k)$ and $k \cdot f(x)$ and illustrate an explanation of the effects on the graph using technology. ✓ Find the value of k given the graphs of a parent quadratic function and its transformation. ~~✓ Evaluate quadratic functions for inputs in their domains using function notation.~~ ~~✓ Interpret statements that use function notation in terms of a context.~~ ✓ Write a quadratic function that describes a relationship between two quantities.	

WAKE COUNTY PUBLIC SCHOOL SYSTEM

High School Programs

Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

Key Standards Addressed Connections to Common Core/NC Essential Standards	**Where This Unit Fits** Connections to prior and future learning
N-RN.3 Use the properties of rational and irrational numbers to explain why: • the sum or product of two rational numbers is rational; • the sum of a rational number and an irrational number is irrational; • the product of a nonzero rational number and an irrational number is irrational. **N-CN.1** Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + bi$ where a and b are real Numbers **A-SSE.1** Interpret expressions that represent a quantity in terms of its context. a. Identify and interpret parts of a quadratic including terms, factors, coefficients, radicands, and exponents. b. Interpret quadratic made of multiple parts as a combination of single entities to give meaning in terms of a context. **A-SSE.3** Write an equivalent form of a quadratic expression by completing the square, where a is an integer of a quadratic expression, $ax^2 + bx + c$, to reveal the maximum or minimum value of the function the expression defines. **A-APR.1** Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials. ***Note**: At this level, add and subtract any polynomial and extend multiplication to as many as three linear expressions.*	**Coming into this unit, students should have a strong foundation in:** ✓ adding and subtracting polynomials ✓ multiplying binomials ✓ factoring quadratic expressions to find the zeros of the corresponding quadratic function ✓ writing quadratic equations based on a context ✓ interpreting the vertex of a quadratic function in context ✓ interpreting the constants and coefficients of a quadratic function in context ✓ interpreting key features of tables and graphs of quadratic functions, including intercepts and maximum/minimum ✓ graphing quadratic functions showing intercepts and maximum or minimum; by hand in simple cases and using a graphing calculator (or other technology) for more complicated cases ~~**Coming into this unit, students should have a strong foundation in:**~~ ~~**From Math 8**: linear regression models/scatter plots, combining like terms, linear versus nonlinear data, using intersections to solve equations.~~ ~~**From Math 1:**~~ ~~**A-APR.1** Understand that polynomials form a system analogous to the integers; namely, they are closed under the~~

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Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

A-APR.3 Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

Note: At this level, limit to quadratic expressions.

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.

***Note**: At this level, limit to factorable quadratics.*

A-REI.4 Solve quadratic equations in one variable.

b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.

~~***Note**: At this level, limit solving quadratic equations by inspection, taking square roots, quadratic formula, and factoring when lead coefficient is one. Writing complex solutions is not expected; however recognizing when the formula generates non-real solutions is expected.*~~

A-REI.7 Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. For example, find the points of intersection between the line $y = -3x$ and ~~the circle~~ $x^2 + y^2 = 3$.

~~**A-REI.11** Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology~~

~~operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.~~

~~***Note**: At this level, limit to addition and subtraction of quadratics and multiplication of linear expressions; factoring and operations with polynomials have a much smaller focus.*~~

~~**F-LE.3** Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.~~

~~***Note**: At this level, limit to linear, exponential, and quadratic functions; general polynomial functions are not addressed.*~~

~~**A-CED.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.~~

~~***Note**: At this level, focus on quadratic. Limit to situations that involve evaluating exponential functions for integer input.*~~

~~**F-BF.1** Write a function that describes a relationship between two quantities.~~

~~a. Determine an explicit expression, a recursive process (Using NOW-NEXT, not formal notation), or steps for calculation from a context.~~

~~b. Combine standard function types using arithmetic operations. *For example, build a function that models the temperature of a cooling body by*~~

Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

~~to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.~~

~~***Note**: At this level, extend to quadratic functions.*~~

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.*

***Note**: At this level extend to quadratic~~ and inverse variation (the simplest rational) functions and use common logs to solve exponential equations.~~*

A-CED.2 Create and graph equations in two variables to represent quadratic, square root, and inverse variation relationships between quantities.

***Note**: At this level focus only on quadratic.*

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.*

***Note**: Extend to linear-quadratic~~ c, and linear inverse variation (simplest rational)~~ systems of equations.*

~~**F-IF.2** Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.~~
~~*Note: At this level, extend to quadratic, simple power, and inverse variation functions.*~~

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

~~*adding a constant function to a decaying exponential, and relate these functions to the model.*~~

~~***Note**: At this level, limit to addition or subtraction of constant to linear, exponential or quadratic functions or addition of linear functions to linear or quadratic functions.*~~

~~**N-Q.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.~~

~~**A-SSE.1** Interpret expressions that represent a quantity in terms of its context.~~

~~a. Interpret parts of an expression, such as terms, factors, and coefficients.~~

~~b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret $P(1+r)^n$ as the product of P and a factor not depending on P.*~~

~~***Note**: At this level, limit to quadratic expressions.*~~

~~**A-SSE.2** Use the structure of an expression to identify ways to rewrite it. *For example, see $4x^4 - y^4$ as $(x^2)^2 - (y^2)^2$, thus recognizing it as a difference of squares that can be factored as $(x^2 - y^2)(x^2 + y^2)$.*~~

Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

sketch graphs showing key features given a verbal description of the relationship. *Key features include: domain and range, rate of change, symmetries, and end behavior.~~intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.~~* **F-IF-7** Analyze quadratic, square root, and inverse variation functions by generating different representations, by hand in simple cases and using technology for more complicated cases, to show key features, including: domain and range; intercepts; intervals where the function is increasing, decreasing, positive, or negative; rate of change; maximums and minimums; symmetries; and end behavior. ***Note**: Extend to quadratic functions only.* ~~**F-IF.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*~~ ~~***Note**: At this level, extend to quadratic, right triangle trigonometry, and inverse variation functions.*~~ **F-IF.8** Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.	~~**A-SSE.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.~~ ~~a. Factor a quadratic expression to reveal the zeros of the function it defines (factoring tied to a specific purpose, not as a separate unit).~~ ~~***Note**: At this level, the limit is quadratic expressions of the form $ax^2 + bx + c$.*~~ ~~**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.*~~ ~~***Note**: At this level, focus on linear, exponential and quadratic functions; no end behavior or periodicity.*~~ ~~**F-IF.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function $h(n)$ gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.*~~ ~~***Note**: At this level, focus on linear and exponential functions.*~~

WAKE COUNTY PUBLIC SCHOOL SYSTEM

Math 2 II UNIT 2 OVERVIEW: Modeling with Quadratic Functions Parent Guide

1. **F-IF.9** Compare key features of two functions (linear, quadratic, square root, or inverse variation functions) each with a different representations (symbolically, graphically, numerically in tables, or by verbal descriptions). ***Note**: At this level, completing the square is still not expected.* **F-BF.1** Write a function that describes a relationship between two quantities by building quadratic functions with real solution(s) given a graph, a description of a relationship, or ordered pairs (include reading these from a table). 1. Determine an explicit expression, a recursive process, or steps for calculation from a context. ***Note**: Continue to allow informal recursive notation through this level.* 1. Combine standard function types using arithmetic operations. *For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.* 2. **F-BF.3** Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $k\,f(x)$, $f(kx)$, and $f(x + k)$ for specific values of *k* (both positive and negative); find the value of *k* given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them. ***Note**: At this level, extend to quadratic functions and, $k\,f(x)$.*	**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. a. Graph linear and quadratic functions and show intercepts, maxima, and minima. **F-IF.8** Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context. ***Note**: At this level, only factoring expressions of the form $ax^2 + bx + c$, is expected. Completing the square is not addressed at this level.* **F-IF.9** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.* ***Note**: At this level, focus on linear, exponential, and quadratic functions.* **This unit builds to the following future skills and concepts:** ✓ Complex solutions Using completing the square to solve quadratic equations ✓ /Using completing the square to change from standard form to vertex form for a quadratic function ✓ Writing equations using zeros

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WAKE COUNTY PUBLIC SCHOOL SYSTEM

High School Programs

Math 2 II UNIT 2 OVERVIEW: Modeling with Quadratic Functions Parent Guide

	✓ Derivinge the quadratic formula ✓ Higher degree polynomials ✓ Relating degree to zeros and x-intercepts for polynomials.

Additional Resources

Materials to support understanding and enrichment

✓ **Teaching videos made by Wake County teachers**

- Success Series: Polynomials Part 1 – (Video) Basic operations including addition and subtraction polynomials.
- Success Series: Polynomials Part 2 – (Video) Multiplying polynomials.
- Success Series: Quadratic Equations Solutions by Factoring – (Video) Using the factoring to solve quadratic equations.
- Success Series: Quadratic Equations Solutions by Quadratic Formula – (Video) Using the quadratic formula to solve quadratic equations.
- Success Series: Graphing Quadratic Equations – (Video) How to graph a quadratic using the vertex and axis of symmetry.

✓ **Arithmetic Operations with Polynomials**

- Define polynomials – (Video) Outlines properties of polynomials; click on the link and enter the quick code ***LZ2438***.
- Polynomials – (Reference Notes and Tutorial) – Overall explanations and definitions of polynomials.
- Adding Polynomials – (Video) Outlines adding of polynomials; click on the link and enter the quick code ***LZ2694***.
- Subtracting Polynomials – (Video) Explains subtracting polynomials and common errors; click on the link and enter the quick code ***LZ2608***.
- Adding and Subtracting Polynomials – (Reference Notes and Tutorial) Explanations of adding and subtracting polynomials.
- Multiplying Polynomials – (Video) Explains multiplying polynomials; click on the link and enter the quick code ***LZ2619***.
- Multiplying Polynomials – (Reference Notes and Tutorial) Explanations of monomials and polynomials.

✓ **Solving Quadratic Equations**

- Solve Quadratic Equations by Inspection – (Video) Explains solving quadratic equations by inspection; click on the link and enter the quick code ***LZ743***.
- Solve Quadratic Equations by Taking Square Roots – (Video) Explains solving quadratic equations by taking square roots of the equation; click on the link and enter the quick code ***LZ744.***

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Math 2 ~~II~~ UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

- Solve Quadratic Equations by Using the Quadratic Formula – (Video) Explains solving quadratic equations by using the quadratic formula; click on the link and enter the quick code ***LZ748***.
- Nature of Quadratic Solutions – (Video) Explains the solutions of a quadratic using the discriminate; click on the link and enter the quick code ***LZ1288***.
- Quadratic Equations – (Reference Notes and Tutorial) Explains basics of solving quadratic equations, the quadratic formula and discriminates.
- Solving Quadratic Equations by Factoring – (Video) Explains solving quadratic equations by factoring; click on the link and enter the quick code ***LZ745.***
- Factoring Quadratics – (Reference Notes and Tutorial) Overall steps to factoring and solving various quadratic equations.
- Determine the Best Method to Solve a Quadratic Equation – (Video) Explains the best method to solve a quadratic equation by comparing different strategies; click on the link and enter the quick code ***LZ1289***.

✓ **Systems Involving Quadratic Equations**

- Find Solutions for Two Equations – (Video) Explains how to find two solutions for one linear and one quadratic equation by looking at their intersection on a graph; click the link and enter the quick code ***LZ3562***.
- Solutions of a Linear and Quadratic System Graphically – (Video) Explains how to estimate the solutions to linear and quadratic systems by graphing; click on the link and enter the quick code ***LZ3595***.
- Solving Systems of Linear and Quadratic Systems Graphically – (Reference Notes and Tutorial) Outline solving systems of linear and quadratic equations graphically.
- Solutions of a Linear and Quadratic System Algebraically – (Video) Explains how to estimate the solutions to linear and quadratic systems algebraically; click on the link and enter the quick code ***LZ3550***.
- Solving Systems of Linear and Quadratic Systems Algebraically – (Reference Notes and Tutorial) Outline solving systems of linear and quadratic equations algebraically.

✓ **Graphs and Tables of Quadratic Functions**

- Find Axis of Symmetry and Vertex – (Video) Explains how to find the axis of symmetry and vertex of a quadratic function by solving parts of the quadratic formula; click the link and enter the quick code ***LZ2322***.
- Graphing Quadratics on a Graphing Calculator – (Video) Graphs a quadratic function using a graphing calculator; click link and enter the quick code ***LZ2415***.

WAKE COUNTY PUBLIC SCHOOL SYSTEM

High School Programs

Math 2 II UNIT 2 OVERVIEW: ~~Modeling with~~ Quadratic Functions Parent Guide

- Quadratic Transformations – (Video) Shows how to transform a quadratic function $f(x)$ in vertex form when $f(x)$ is replaced with $f(x) + k$, $f(x + k)$ and $k \cdot f(x)$ for specific values of k (both positive and negative).
- Function Transformations – (Reference Notes and Tutorial) Outlines the effects of on the graph of a quadratic function $f(x)$ in vertex form when $f(x)$ is replaced with $f(x) + k$, $f(x + k)$ and $k \cdot f(x)$ for specific values of k (both positive and negative).
- How do you Graph a Quadratic Function? (Video) – Graphing a quadratic function using key features.
- How do you Graph a Quadratic Function? (Reference Notes) Explains graphing a quadratic function using key features.
- Interpreting Function Notation in Context – (Reference Notes) Interprets function notation in the context of a cell phone with explanations.

✓ **Teaching videos made by Wake County teachers**

- Success Series: Polynomials Part 2 – (Video) Multiplying polynomials.
- Success Series: Quadratic Equations Solutions by Factoring – (Video) Using the factoring to solve quadratic equations.
- Success Series: Quadratic Equations Solutions by Quadratic Formula – (Video) Using the quadratic formula to solve quadratic equations.
- Success Series: Graphing Quadratic Equations – (Video) How to graph a quadratic using the vertex and axis of symmetry.

*** Please note**, the unit guides are a work in progress. If you have feedback or suggestions on improvement, please feel free to contact sdupree@wcpss.net.