Orange Public Schools

Office of Curriculum & Instruction

2019-2020 Mathematics Curriculum Guide

Advanced Topics in Algebra I

Unit 3: Functions, Quadratic Functions

January 31, 2019 –April 9, 2020

Board Approved: 1.14.2020

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Contents

Curriculum Map

A STORY OF UNITS (Yearlong Pacing Guide)				
Marking Period	MP 1 (9/9/19 – 11/13/19)	MP 2 (11/14/19- 1/30/20)	MP 3 (1/31/20-4/9/20)	MP 4 (4/10-20-6/22/20)
Unit Topic	Linear Equations and Inequalities	Systems of Linear Equations/Inequalities & Functions	Quadratic Functions & Equations	Solve Quadratic Equations
Description	Create linear equations & inequalities to model situations given and solve related problems	Create systems of equations/inequalities to model real-life situations and solve problems; Identify types of functions with tables and graphs	Identify quadratic functions; find key features for the graphs. Solve quadratic equations by using tables, and graphing and solving algebraically	Interpret, write, and solve quadratic equations

Unit Overview

Unit 3: Linear equations & Inequalities
Essential Questions
➢ How can you determine if something is a mathematical function? ➢ How can we use mathematical models to describe physical relationships? ➢ How are quadratic functions represented in real life situations?

- What are the different forms of a quadratic function?
- What are key characteristics of a quadratic function?
- How do you write and graph a quadratic function?

Enduring Understandings

- A mathematical function is a relation between a set of inputs (values of the domain) and outputs (values of the range) in which one element of the domain is assigned to exactly one element of the range.
- A linear relationship is one where the dependent quantity is changing at a constant rate per unit of the independent quantity
- The graph of a quadratic function is a parabola. Parabolas are symmetric and contain a vertex.
- A quadratic function can be written in standard form, factored form, or vertex form.
- The second differences of values from a quadratic relationship are constant.
- The parent function of a quadratic is f(x) = x2, and from there you can have a translation, a dilation, or a reflection

Overview

Unit Summary:
In this unit, students expand their understanding of functions, building on what they learned in previous math course. Students develop their capacity to represent, interpret, and use functions to make sense of quantities in situations and to solve problems. They are introduced to new tools for communicating about functions: function notation, domain and range, average rates of change, and mathematical terms for describing key features of graphs. The also focus to study quadratic functions systematically. They look at patterns which grow quadratically and contrast them with linear. Then they examine other quadratic relationships via tables, graphs, and equations, gaining appreciation for some of the special features of quadratic functions and the situations they represent.

New Jersey Student Learning Standards (NJSLS)

1) F.IF.1: Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If is a function and is an element of its domain, then () denotes the output of corresponding to the input .
2) 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.
3) F.IF.3: Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. *For example, the Fibonacci sequence is defined recursively by f(0) = f(1) = 1, f(n+1) = f(n) + f(n-1) for n ≥ 1*
4) 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.**
5) F-IF-4: For a function that models a relationship between two quantities, and sketch graphs showing key features given a verbal description of the relationship.
6) 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
7) F-IF-8: Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.
8) F-IF-9: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).
9) F-BF-1: Write a function that describes a relationship between two quantities.*
10) A-SSE-1: Interpret expressions that represent a quantity in terms of its context.*
11) A-SSE-2: Use the structure of an expression to identify ways to rewrite it.
12) F-LE-1: Distinguish between situations that can be modeled with linear functions and with exponential functions.
13) HSF-BF.B.3: Identify the effect on the graph of replacing f(x) by f(x)+k ,kf(x) ,f(kx) , and f(x+k) for specific values of (both positive and negative); find the value of 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.

M : Major Content S: Supporting Content A : Additional Content

Mathematical Practice Standards:
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning

Student Learning Material

Illustrative math Algebra I **https://curriculum.illustrativemathematics.org/HS/teachers/index.html**

These materials were created by Illustrative Mathematics. They were piloted and revised in the 2018–2019 school year.

Units contain between 10 and 25 lesson plans. Each unit has a diagnostic assessment for the beginning of the unit (Check Your Readiness) and an end-of-unit assessment. Longer units also have a mid-unit assessment. In addition to lesson and assessments, modeling prompts are provided to be used throughout the year.

The time estimates in these materials refer to instructional time. Each lesson plan is designed to fit within a class period that is at least 45 minutes long. Some lessons contain optional activities that provide additional scaffolding or practice for teachers to use at their discretion.

There are two ways students can interact with these materials. Students can work solely with printed workbooks or pdfs. Alternatively, if all students have access to an appropriate device, students can look at the task statements on that device and write their responses in a notebook or the print companion for the digital materials. It is recommended that if students are to access the materials this way, they keep the notebook carefully organized so that they can go back to their work later.

Teachers can access the teacher materials either in print or in a browser. A classroom with a digital projector is recommended.

Many activities are written in a card sort, matching, or info gap format that requires teachers to provide students with a set of cards or slips of paper that have been photocopied and cut up ahead of time. Teachers might stock up on two sizes of resealable plastic bags: sandwich size and gallon size. For a given activity, one set of cards can go in each small bag, and then the small bags for one class can be placed in a large bag. If these are labeled and stored in an organized manner, it can facilitate preparing ahead of time and re-using card sets between classes. Additionally, if possible, it is often helpful to print the slips for different parts of an activity on different color paper. This helps facilitate quickly sorting the cards between classes.

Modifications

Special Education/ 504:

English Language Learners:

-Adhere to all modifications and health concerns stated in each IEP.

-Give students a MENU options, allowing students to pick assignments from different levels based on difficulty.

-Accommodate Instructional Strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), handouts, definition list with visuals, extended time

-Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write

-Provide breaks between tasks, use positive reinforcement, use proximity

-Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum by using manipulatives

-Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 17-18)

- Use manipulatives to promote conceptual understanding and enhance vocabulary usage

- Provide graphic representations, gestures, drawings, equations, realia, and pictures during all segments of instruction

- During ALEKS lessons, click on “Español” to hear specific words in Spanish

- Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information

- Use sentence frames and questioning strategies so that students will explain their thinking/ process of how to solve word problems

- Utilize program translations (if available) for L1/ L2 students

- Reword questions in simpler language

- Make use of the ELL Mathematical Language Routines (click here for additional information)

-Scaffolding instruction for ELL Learners

-Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 16-17)

Gifted and Talented:

Students at Risk for Failure:

- Elevated contextual complexity

- Inquiry based or open ended assignments and projects

- More time to study concepts with greater depth

- Promote the synthesis of concepts and making real world connections

- Provide students with enrichment practice that are imbedded in the curriculum such as:

  - Application / Conceptual Development
  - Are you ready for more?

- Common Core Approach to Differentiate Instruction: Students with Disabilities (pg. 20)

- Provide opportunities for math competitions

- Alternative instruction pathways available

- Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum

- Modify Instructional Strategies, reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), inclusion of more visuals and manipulatives, Field Trips, Google Expeditions, Peer Support, one on one instruction

- Assure constant parental/ guardian contact throughout

the year with successes/ challenges

- Provide academic contracts to students and guardians

- Create an interactive notebook with samples, key vocabulary words, student goals/ objectives.

- Always plan to address students at risk in your learning tasks, instructions, and directions. Try to anticipate where the needs will be and then address them prior to lessons.

-Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 19)

21st Century Life and Career Skills:

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

https://www.state.nj.us/education/cccs/2014/career/9.pdf

- **CRP1**. Act as a responsible and contributing citizen and employee.
- **CRP2**. Apply appropriate academic and technical skills.
- **CRP3**. Attend to personal health and financial well-being.
- **CRP4**. Communicate clearly and effectively and with reason.
- **CRP5**. Consider the environmental, social and economic impacts of decisions.
- **CRP6**. Demonstrate creativity and innovation.
- **CRP7**. Employ valid and reliable research strategies.
- **CRP8**. Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9**. Model integrity, ethical leadership and effective management.
- **CRP10**. Plan education and career paths aligned to personal goals.
- **CRP11**. Use technology to enhance productivity.
- **CRP12**. Work productively in teams while using cultural global competence.

Students are given an opportunity to communicate with peers effectively, clearly, and with the use of technical language. They are encouraged to reason through experiences that promote critical thinking and emphasize the importance of perseverance. Students are exposed to various mediums of technology, such as digital learning, calculators, and educational websites.

Technology Standards:

All students will be prepared to meet the challenge of a dynamic global society in which they participate, contribute, achieve, and flourish through universal access to people, information, and ideas.

https://www.state.nj.us/education/cccs/2014/tech/

8.1 Educational Technology:	**8.2 Technology Education, Engineering, Design,**

All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge. A. **Technology Operations and Concepts:** Students demonstrate a sound understanding of technology concepts, systems and operations. B. **Creativity and Innovation:** Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology. C. **Communication and Collaboration:** Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. D. **Digital Citizenship:** Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. E. **Research and Information Fluency:** Students apply digital tools to gather, evaluate, and use of information. F. **Critical thinking, problem solving, and decision making:** Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.	**and Computational Thinking - Programming:** All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment. A. **The Nature of Technology: Creativity and Innovation-** Technology systems impact every aspect of the world in which we live. B. **Technology and Society:** Knowledge and understanding of human, cultural, and societal values are fundamental when designing technological systems and products in the global society. C. **Design:** The design process is a systematic approach to solving problems. D. **Abilities in a Technological World:** The designed world in a product of a design process that provides the means to convert resources into products and systems. E. **Computational Thinking: Programming-** Computational thinking builds and enhances problem solving, allowing students to move beyond using knowledge to creating knowledge.

Interdisciplinary Connections:	
English Language Arts:	
NJSLS ELA.LITERACY.RI-9-10.4	Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of a newspaper).
NJSLS ELA-LITERACY.SL.9-10.4	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
NJSLS .ELA-LITERACY.W.9-10.2.A	Introduce a topic; organize complex ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

Pacing Guide

Overview			
Lesson	Topic	NJSLS	Suggesting Pacing
1	Function Notation	HAS-IF.A.1	1 day
2	Interpreting & Using Function Notation	HAS-IF.A.2	1 day
3	Using Function Notation to Describe Rules (Part I)	HAS-BF.A.1	1 day
4	Using Function Notation to Describe Rules (Part 2)	HAS-REI.A.1	1 day
5	Features of Graphs	HAS-IF.A.2	1 day
6	Using Graphs to Find Average Rate of Change	HAS-IF.B.6	1 day
7	Domain and Range (Part 1)	HAS.IF.B.5	1 day
8	Domain and Range (Part 2)	HAS.IF.B.4	1 day
9	A Different Kind of Change	HAS-LE.A	1 day
10	How Does it Change	HAS-SSE.A.1; HAS-SSE.B.3	1 day
11	Building Quadratic Functions from Geometric Patterns	HAS-BF.A.1	2 days
12	Equivalent Quadratic Expressions	HAS-SSE.B.3	2 days
13	Standard Form and Factored Form	HAS-SSE.B.3	2 days
14	Graphs of Functions in Standard and Factored Forms	HAS-SSE.B.3	2 days
15	Graphing from the factored Form	HAS-SSE.A	1 day
16	Graphing the Standard Form (Part 1)	HAS-LE.A.2	2 days
17	Graphing the Standard Form (Part 2)	HAS-SSE.B.3	2 days
18	Graphs That Represent Situations	HAS-IF.A.2	2 days
19	Vertex Form	HAS-IF.C.8	2 days
20	Graphing from the Vertex Form	HAS-IF.C	2 days
21	Changing the Vertex	HAS-IF.C	2 days

Summary:

31 days on new content (21 lessons/topics)
2 task days
1 review day
1 test day
2-4 flex day (Re-teaching, Post-assessment Intervention…etc)
1 Benchmark day

38-40 days in Unit 3

Calendar

Please complete the pacing calendar based on the suggested pacing.

February 2019						
Sun	Mon	Tue	Wed	Thu	Fri	Sat

March 2019						
Sun	Mon	Tue	Wed	Thu	Fri	Sat

April 2020						
Sun	Mon	Tue	Wed	Thu	Fri	Sat

Assessment Framework

Assessment	CCSS	Estimated Time	Format	Graded
Unit Diagnostic Assessment		1 Period	Individual	No
Check point 1 *(Formative Assessment)*		1 Period	Individual	Yes
Check point 2 *(Formative Assessment)*		1 Period	Individual	Yes
Performance Task *(Authentic Assessment)*		1 Period	Individual,	Yes
Extended Constructed Responded (ECR)		1 Period	Individual	Yes
Benchmark Assessment *(Summative Assessment)*		1 Block	Individual	Yes
Exit tickets *(Formative Assessment)*	Varies by lesson	5-10 minutes (Daily)	Individual	Varies

MP 3 Benchmark Assessment Window: 3/23/2020 – 4/3/2020

Lesson Analysis

<table>
<tr><th colspan="2">Lesson 1: Function Notation</th></tr>
<tr><td>Objectives</td><td>(Teacher Facing)
Interpret statements that use function notation and explain (orally and in writing) their meaning in terms of a situation.
Understand that function notation is a succinct way to name a function and specify its input and output.
Use function notation to express functions with specific inputs and outputs.
(Student Facing)
I can use function notation to express functions that have specific inputs and outputs.
I understand what function notation is and why it exists.
When given a statement written in function notation, I can explain what it means in terms of a situation.
Focused Mathematical Practices
MP 2: Reason abstractly and quantitatively.
MP 6: Attend Precision
Vocabulary
Function Notation</td></tr>
<tr><td>Lesson narrative:</td><td>This lesson introduces students to function notation. Students encounter situations in which referencing certain functions and their input-output pairs gets complicated, wordy, or unclear. This motivates a way to talk about functions that is more concise and precise.

Students learn that function notation is a succinct way to name a function and to specify its input and output. They interpret function notation in terms of the quantities in a situation and use function notation to represent simple statements about a function. The work in this lesson prompts students to reason quantitatively and abstractly (MP2) and communicate precisely (MP6).</td></tr>
<tr><td>NJSLS</td><td>HSF-IF.A.1
Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If is a function and is an element of its domain, then f(x) denotes the output of f corresponding to the input x . The graph of f is the graph of the equation y = f(x) .</td></tr>
<tr><td>Learning Material</td><td>Illustrative Math Algebra I Unit 4 Lesson 2
Student Learning Material
https://curriculum.illustrativemathematics.org/HS/students/1/4/2/index.html</td></tr>
</table>

Lesson 2: Interpreting & Using Function Notation	
Objectives	Teacher's Facing: • Describe connections between statements that use function notation and a graph of the function. • Practice interpreting statements that use function notation and explaining (orally and in writing) their meaning in terms of a situation. • Sketch a graph of a function given statements in function notation. Student Facing: • I can describe the connections between a statement in function notation and the graph of the function. • I can use function notation to efficiently represent a relationship between two quantities in a situation. • I can use statements in function notation to sketch a graph of a function. Focused Mathematical Practices • MP 2: Reason abstractly and quantitatively. • MP 6: Attend Precision
Lesson narrative:	In this lesson, students continue to develop their ability to interpret statements in function notation in terms of a situation, including reasoning about inequalities such as $f(a) > f(b)$. They now have to pay closer attention to the units in which the quantities are measured to effectively interpret symbolic statements. Along the way, students practice reasoning quantitatively and abstractly (MP2) and attending to precision (MP6). Students also begin to connect statements in function notation to graphs of functions. They see each input-output pair of a function as a point with coordinates $(x, f(x))$ when x is the input, and use information in function notation to sketch a possible graph of a function. Students' work with graphs is expected to be informal here. In a later lesson, students will focus on identifying features of graphs more formally.
NJSLS	HSF-IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. HSF-IF.B.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.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 3 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/3/index.html

Lesson 3: Using Function Notation to Describe Rules (Part 1)

Objectives	Teacher's Facing: • Create tables and graphs to represent a function given statements in function notation. • Interpret rules of functions that are expressed using function notation. • Use function notation to write equations that represent rules of functions. Student Facing: • I can make sense of rules of functions when they are written in function notation, and create tables and graphs to represent the functions. • I can write equations that represent the rules of functions. Focused Mathematical Practices • MP 2: Reason abstractly and quantitatively. • MP 7: Look for and make use of structure Vocabulary:
Lesson narrative:	In earlier lessons, students interpreted and wrote statements in function notation to represent specific input-output pairs of a function (such as p(2.5) = 18) or relationships between specific pairs (such as W(10) =W(12)). In this lesson, students learn that function notation can also be used to describe the rule of a function or how a function behaves generally, at any value of input. For instance, they see that if the output of a function f can be found by multiplying the input by 3 and then subtracting 10 from the result, we can write f(x) = 3x -10to represent this rule. We can also use this rule (either the verbal description or the equation) to find the output for any input. In some cases, the rule can also be used to find the input when we know the output. Students continue to decontextualize given situations into symbolic representations and to contextualize the latter in order to solve problems (MP2). To connect different representations of functions defined by rules, they look for and make use of structure (MP7).
NJSLS:	HSF-BF.A.1.a Determine an explicit expression, a recursive process, or steps for calculation from a context. HSF-IF.A.1 Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and is an element of its domain, then f(x) denotes the output of f corresponding to the input x . The graph of f is the graph of the equation y = f(x) . HSF-IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. HSF-IF.B.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. HSF-IF.C Analyze functions using different representations.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 4 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/4/index.html

Lesson 4: Using Function Notation to Describe Rules (Part 2)

Objectives	Teacher's Facing: • Evaluate functions and solve equations given in function notation, either by graphing or by reasoning algebraically. • Understand linear function as a function whose output changes at a constant rate and whose graph is a line. • Use technology to graph and evaluate functions given in function notation. Student Facing: • I can use technology to graph a function given in function notation, and use the graph to find the values of the function. • I know different ways to find the value of a function and to solve equations written in function notation. • I know what makes a function a linear function. Focused Mathematical Practice: • MP 2: Reason abstractly and quantitatively.
Lesson narrative:	In an earlier lesson, students learned that some functions can be defined with a rule and the rule can be expressed using function notation. In this lesson, students use rules of functions to find the output when the input is given (or to evaluate functions) and to find the input when the output is known (or to solve equations that define functions). They also interpret rules of functions in terms of a situation. Along the way, they practice reasoning quantitatively and abstractly (MP2). The term linear function is introduced here. In middle school, students learned a relationship between two quantities is linear if one quantity changes at a constant rate relative to the other. Students see that a linear function can be understood in similar terms: a function is linear if the output changes by a constant rate relative to its input. This lesson includes an optional activity that is designed to enable students to use technology to graph and evaluate functions expressed in function notation. This skill can help to develop students' understanding of functions and ability to solve problems in this unit and in future units.
NJSLS	HSF-IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. HSA-REI.A.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. HSF-IF.B.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.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 5 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/5/index.html

Lesson 5: Features of Graphs

Objectives	Teacher's Facing: • Analyze connections between statements that use function notation and features of graphs and describe (orally and in writing) these connections. • Interpret key features of a graph—the intercepts, maximums, minimums, and the intervals when the function is increasing or decreasing—in terms of a situation. • Understand and be able to use the terms "horizontal intercept," "vertical intercept," "maximum," and "minimum" when talking about graphs of functions. Student Facing: • I can identify important features of graphs of functions and explain what they mean in the situations represented. • I understand and can use the terms "horizontal intercept," "vertical intercept," "maximum," and "minimum" when talking about functions and their graphs. Focused Mathematical Practice: • •MP 2: Reason abstractly and quantitatively. Vocabulary: • Vertical Intercept
Lesson narrative:	Prior to this point, students have described characteristics of graphs, made sense of points on the graphs, and interpreted them in terms of a situation. In this lesson, students develop this work more formally, while continuing to use the idea of function as the focusing lens. Students use mathematical terms such as intercept, maximum, and minimum in their graphical analyses, and relate features of graphs to features of the functions represented. For instance, they look at an interval in which a graph shows a positive slope and interpret that to mean an interval where the function's values are increasing. Students also use statements in function notation, such as h(0) and h(t)=0 , to talk about key features of a graph. By now, students are familiar with the idea of intercepts. Note that in these materials, the terms horizontal intercept and vertical intercept are used to refer to intercepts more generally, especially when a function is defined using variables other than x and y. If needed, clarify these terms for students who may be accustomed only to using x-intercept and -intercept. As students look for connections across representations of functions and relate them to quantities in situations, they practice making sense of problems (MP1) and reasoning quantitatively and abstractly (MP2). Using mathematical terms and notation to describe features of graphs and features of functions calls for attention to precision (MP6).
NJSLS:	HSF-IF.B.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.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 6 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/6/index.html

Lesson 6: Using Graphs to Find Average Rate of Change

Objectives	Teacher's Facing: • Given a graph of a function, estimate or calculate the average rate of change over a specified interval. • Recognize that the slope of a line joining two points on a graph of a function is the average rate of change. • Understand that the average rate of change describes how fast the output of a function changes for every unit of change in the input. Student Facing: • I understand the meaning of the term "average rate of change." • When given a graph of a function, I can estimate or calculate the average rate of change between two points. Focused Mathematical Practices: • MP 6: Attend to Precision Vocabulary: • Average rate of change
Lesson narrative:	Previously, students have characterized how functions are changing qualitatively, by describing them as increasing, staying constant, or decreasing in value. In earlier units and prior to this course, students have also computed and compared the slopes of line graphs and interpreted them in terms of rates of change. In this lesson, students learn to characterize changes in functions quantitatively, by using average rates of change. Students learn that average rate of change can be used to measure how fast a function changes over a given interval. This can be done when we know the input-output pairs that mark the interval of interest, or by estimating them from a graph. Attention to units is important in computing or estimating average rates of change, because units give meaning to how much the output quantity changes relative to the input. In thinking carefully about appropriate units to use, students practice attending to precision (MP6). Students also engage in aspects of mathematical modeling (MP4) when they use a data set or a graph to compute average rates of change and then use it to analyze a situation or make predictions.
NJSLS	HSF-IF.B.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.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 17 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/7/index.html

Lesson 7: Domain and Range (Part 1)

Objectives	Teacher's Facing: • Given a description of a function that represents a situation, determine reasonable domain and range. • Understand that the domain of a function is the set of all possible inputs and the range is the set of all possible outputs. Student Facing: • I know what is meant by the "domain" and "range" of a function. • When given a description of a function in a situation, I can determine reasonable domain and range for the function. Focused Mathematical Practices: • MP 2: Reason abstractly and quantitatively. Vocabulary: • Domain, Range
Lesson narrative:	In this lesson and the next one, students focus their attention on possible input and output values, framing them as the domain and range of a function. In this lesson, they identify the domain and range of functions and describe them using words, lists of numbers, or inequalities (if appropriate). In the next lesson, students will relate the domain and range of a function with features of its graph. Students' analyses of inputs and outputs continue to be grounded in context, allowing many chances to reason quantitatively and abstractly (MP2). In an optional activity, there is an opportunity to study the domain of a function without a context. The insights students gain here will help them later in the unit and throughout the course, as they make sense of other kinds of functions—piecewise-defined, exponential, and quadratic. These understandings will also expand students' capacity to model with mathematics.
NJSLS:	HSF-IF.B Interpret functions that arise in applications in terms of the context. HSF-IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function gives the number of person-hours it takes to assemble engines in a factory, then the positive integers would be an appropriate domain for the function.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 10 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/10/index.html

Lesson 8: Domain and Range (Part 2)

Objectives	Teacher's Facing: • Given a description of a function that represents a situation, determine reasonable domain and range. • Practice interpreting key features of graphs in terms of the quantities represented. Student Facing: • When given a description of a function in a situation, I can determine reasonable domain and range for the function. Focused Mathematical Practice: • MP 6: Attend Precision • MP 7: Look for and make use of structure
Lesson narrative:	Students learn to look for graphical features that would help them identify restrictions to the input or output. For example, they recognize that maximums and minimums, intercepts, and gaps on the graph can be quite informative. They also see that discrete points or breaks in a graph suggest that not all values can be in the domain or range, and that a graph may only partially represent a function. The work here offers opportunities to look for and make use of structure (MP7). As they examine graphs against situations and vice versa, students practice making sense of quantities (MP1) and reasoning concretely and abstractly (MP2). When describing domain and range, students also practice attending to precision by minding relevant details in the graphs and descriptions of functions (MP6)
NJSLS	HSF-IF.B.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. HSF-IF.B.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 engines in a factory, then the positive integers would be an appropriate domain for the function.
Learning Material	Illustrative Math Algebra I Unit 4 Lesson 11 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/4/11/index.html

Lesson 9: A Different Kind of Change

Objectives	Teacher's Facing: • Describe (orally and in writing) a relationship that increases then decreases when represented by a graph. • Given an interesting context, create drawings, tables, and graphs that represent a quadratic relationship.. Student Facing: • I can create drawings, tables, and graphs that represent the area of a garden. • I can recognize a situation represented by a graph that increases then decreases. Focused Mathematical Practice: • MP2: Reason abstractly and quantitatively.
Lesson narrative:	In this lesson, students encounter a situation where a quantity increases then decreases. They don't yet have a name for this new pattern of change, but they recognize that it is neither linear nor exponential, and that the graph is unlike the graph of an exponential function. Students make sense of this new kind of relationship in a geometric context and describe it in concrete and qualitative ways (MP2). Though some students may choose to represent the relationships with calculations or with expressions, these are not required or emphasized in the lesson. Students will have many opportunities to reason symbolically about quadratic patterns in upcoming lessons.
NJSLS:	HSF-BF.A.1.a Determine an explicit expression, a recursive process, or steps for calculation from a context
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 1 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/1/index.html

Lesson 10: How Does it Change?	
Objectives	Teacher's Facing: • Comprehend that a "quadratic relationship" can be expressed with a squared term. • Describe (orally and in writing) a pattern of change associated with a quadratic relationship. • Determine and explain (orally and in writing) whether a visual pattern represents a linear, exponential, or quadratic relationship. Student Facing: • I can describe how a pattern is growing. • I can tell whether a pattern is growing linearly, exponentially, or quadratically. • I know an expression with a squared term is called quadratic. Focused Mathematical Standards: • MP 8: Look for and make use of structure Vocabulary: • Quadratic expression
Lesson narrative:	In this lesson, students contrast visual patterns that show quadratic relationships with those that show linear and exponential relationships. To analyze the patterns, students generate tables of values, write expressions, and create graphs. They also encounter the term quadratic expression and learn that a quadratic relationship can be written using an expression with a squared term. Discerning and extending different patterns of change prompts students to look for and make use of structure (MP7). Generating tables of values and generalizing the relationships prompts students to express regularity in repeated reasoning (MP8).
NJSLS:	HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. HSF-BF.A.1.a Determine an explicit expression, a recursive process, or steps for calculation from a context.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 2 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/2/index.html

Lesson 11: Building Quadratic Functions from Geometric Patterns	
Objectives	Teacher's Facing: • Comprehend that the same quadratic function can be expressed symbolically in different ways. • Interpret (using words and other representations) the quadratic relationships in growing patterns as functions, where each input gives a particular output. • Write expressions that define quadratic functions. Student Facing: • I can recognize quadratic functions written in different ways. • I can use information from a pattern of shapes to write a quadratic function. • I know that, in a pattern of shapes, the step number is the input and the number of squares is the output. Focused Mathematical Practice: • MP 1: Make sense of problems and persevere in solving them. Vocabulary: • Quadratic function
Lesson narrative:	In an earlier lesson, students reasoned about visual patterns using different representations and wrote expressions to describe the patterns. In this lesson, they continue to work with patterns but begin to see these relationships as quadratic functions and write equations to define them. Students recognize that different expressions can be used to describe the same function. Previously they learned that an expression like n^2+2n is a quadratic expression. Here they see that $n(n+2)$ defines the same function as n^2+2n, so $n(n+2)$ is also a quadratic expression. The work here is a preview to a more formal exploration of equivalent expressions later.
NJSLS:	HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. HSF-BF.A.1.a Determine an explicit expression, a recursive process, or steps for calculation from a context. HSF-IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 3 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/3/index.html

Lesson 12: Equivalent Quadratic Expressions	
Objectives	Teacher's Facing: • Use area diagrams to reason about the product of two sums and to write equivalent expressions. • Use the distributive property to write equivalent quadratic expressions. Student Facing: • I can rewrite quadratic expressions in different forms by using an area diagram or the distributive property. Focused Mathematical Practice: • MP 2: Reason abstractly and quantatively Vocabulary: • Standard form, Factored form
Lesson narrative:	This lesson transitions students from reasoning concretely and contextually about quadratic functions to reasoning about their representations in ways that are more abstract and formal (MP2). In earlier grades, students reasoned about multiplication by thinking of the product as the area of a rectangle where the two factors being multiplied are the side lengths of the rectangle. In this lesson, students use this familiar reasoning to expand expressions such as (x+4)(x+7) , where x+4 and x+7 are side lengths of a rectangle with each side length is decomposed into and a number. They use the structure in the diagrams to help them write equivalent expressions in expanded form, for example, x2+11x+28 (MP7). Students recognize that finding the sum of the partial areas in the rectangle is the same as applying the distributive property to multiply out the terms in each factor.
NJSLS:	HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. HSA-SSE.A.2 Use the structure of an expression to identify ways to rewrite it. HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 8 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/8/index.html

Lesson 13: Standard Form and Factored Form	
Objectives	Teacher's Facing: • Comprehend the terms "standard form" and "factored form" (in written and spoken language). • Use rectangular diagrams to reason about the product of two differences or of a sum and difference and to write equivalent expressions. • Use the distributive property to write quadratic expressions given in factored form in standard form. Student Facing: • .I can rewrite quadratic expressions given in factored form in standard form using either the distributive property or a diagram. • I know the difference between "factored form" and "standard form." Focused Mathematical Practice: • MP 6: Attend to precision Vocabulary: • Standard form, Factored form
Lesson narrative:	In this lesson, they see that the same generalization can be applied when the factored expression that contains a sum and a difference (when or is negative) or two differences (when both and are negative). Although they have encountered an algebraic approach, students still benefit from drawing diagrams to expand unfamiliar factored expressions. Area diagrams are intuitive for visualizing the product of two sums, but they are less intuitive for visualizing the product of two differences (for example, $(x – 5)^2$) or of a sum and a difference (for example, (x + 3)(x -4)). Subtraction can be represented by removing parts of a rectangle and finding the area of the remaining region, but this strategy can get complicated when both factors are differences. At this point, students transition from thinking about rectangular diagrams concretely, in terms of area, to thinking about them more abstractly, as a way to organize the terms in each factor. (Students made similar transitions from area diagrams to abstract diagrams in middle school, for example, when they learned to distribute the multiplication of a number or a variable—positive and negative—over addition and subtraction.) Students also learn to use the terms standard form and factored form. When classifying quadratic expressions by their form, students refine their language and thinking about quadratic expressions (MP6). In an upcoming lesson, students will graph quadratic expressions of these forms and study how features of the graphs relate to the parts of the expressions.
NJSLS:	HSA-SSE.A.2 Use the structure of an expression to identify ways to rewrite it HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 9 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/9/index.html

Lesson 14: Graphs of Functions in Standard and Factored Forms	
Objectives	Teacher's Facing: • Coordinate (orally and in writing) a quadratic expression given in factored form and the intercepts of its graph. • Interpret (orally and in writing) the meaning of -intercepts and -intercepts on a graph of a quadratic function that represents a context. Student Facing: • I can explain the meaning of the intercepts on a graph of a quadratic function in terms of the situation it represents. • I know how the numbers in the factored form of a quadratic expression relate to the intercepts of its graph. Focused Mathematical Practice: • MP 7: Look for and make use of structure Vocabulary: •
Lesson narrative:	This lesson serves two goals. The first is to relate the work in the past couple of lessons on quadratic expressions back to the quadratic functions that represent situations. Now students have additional insights that enable them to show (algebraically) that two different expressions can define the same function. The second goal is to prompt students to notice connections between different forms of quadratic expressions and features of the graphs that represent the expressions. Students are asked to identify the x- and y-intercepts of graphs representing expressions in standard and factored form. They observe that some numbers in the expressions are related to the intercepts and hypothesize about the patterns they observe (MP7). This work sets the foundation for upcoming lessons, in which students look more closely at how the parameters of quadratic expressions are related to their graphs.
NJSLS:	HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 10 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/10/index.html

Lesson 15: Graphing from the Factored Form

Objectives	Teacher's Facing: • Create graphs of quadratic functions that are in factored form. • Given a quadratic function in factored form, explain how to determine the vertex and -intercept of its graph. Student Facing: • I can graph a quadratic function given in factored form. • I know how to find the vertex and -intercept of the graph of a quadratic function in factored form without graphing it first. Focused Mathematical Practice: • MP 7: Look for and make use of structure Vocabulary: •
Lesson narrative:	In an earlier lesson, students noticed a connection between the numbers in a quadratic expression in factored form (for example, the "2" and "8" in (x+2)(x -8) and the -intercepts of the graph. In this lesson, they explore that connection further. Prior to this point, students have not looked closely at how the addition and subtraction symbols in the factors affect the -intercepts. They also have not considered how or why the connection works, or whether it is a reliable way to determine the -intercepts. In this lesson, they verify their observations by evaluating the expressions at certain values and seeing if they produce an output of 0. Students also explore what the factored form can tell us about the vertex and the -intercept of a graph representing a quadratic function.
NJSLS:	HSA-SSE.A Interpret the structure of expressions. HSF-IF.C.7.a Graph linear and quadratic functions and show intercepts, maxima, and minima.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 11 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/11/index.html

Lesson 16: Graphing from the Standard Form (Part 1)

Objectives	Teacher's Facing: • Comprehend (orally and in writing) how the a and c in $y=ax^2+bx+c$ are visible on the graph. • Coordinate (orally and in writing) different representations of quadratic functions (expressions, tables, and graphs). • Use technology to explore how the parameters of quadratic expressions in standard form are visible on the graph. Student Facing: • I can explain how the a and c in $y=ax^2+bx+c$ affect the graph of the equation. • I understand how graphs, tables, and equations that represent the same quadratic function are related. Focused Mathematical Practice: • MP 8: Look for and express regularity in repeated reasoning Vocabulary: •
Lesson narrative:	Students just explored the connections between quadratic functions expressed in factored form and their graphs. In this lesson, they experiment with the graphs of quadratic functions expressed in standard form and reason about how the parameters of the expressions—specifically the coefficient of the squared term and the constant term—relate to features of the graphs. Students use technology to change these values and produce the graphs. They study the effects and generalize their observations (MP8). Then, students practice identifying equivalent quadratic expressions in standard and factored form and their corresponding graph. To do so, they look for and make use of structure (MP7). The work here strengthens students' understanding of the ties across various representations of quadratic functions.
NJSLS:	HSF-BF.B.3 Identify the effect on the graph of replacing f(x) by f(x)+k ,kf(x) ,f(kx , and f(x+k) for specific values of (both positive and negative); find the value of 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. HSF-IF.C Analyze functions using different representations. HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. HSF-LE.A.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).
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 12 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/12/index.html

Lesson 17: Graphing from the Standard Form (Part 2)

Objectives	Teacher's Facing: • Describe (orally and in writing) how the in y = ax2 + bx + c affects the graph. • Write quadratic expressions in standard and factored forms that match given graphs. Student Facing: • I can explain how the in $y = ax^2 + bx + c$ affects the graph of the equation. • I can match equations given in standard and factored form with their graph. Focused Mathematical Practice: • MP 7: Look for and make use of structure Vocabulary: •
Lesson narrative:	This lesson is optional because it goes beyond the depth of understanding required to address the standards. In this lesson, students continue to examine the ties between quadratic expressions in standard form and the graphs that represent them. The focus this time is on the coefficient of the linear term, the b in $ax^2+bx + c$, and how changes to it affect the graph. Students are not expected to know how to modify given expressions to transform the graphs in certain ways, but they will notice that adding a linear term to the squared term translates the graph in both horizontal and vertical directions. This understanding will help students to conclude that writing an expression such as x^2+bx in factored form can help us reason about the graph. Students also practice writing expressions that produce particular graphs. To do so, students make use of the structure in quadratic expressions (MP7) and what they learned about the connections between expressions and graphs.
NJSLS:	HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. HSF-BF.B.3 Identify the effect on the graph of replacing f(x) by f(x)+k ,kf(x) ,f(kx , and f(x+k) for specific values of (both positive and negative); find the value of 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. HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 13 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/13/index.html

Lesson 18: Graphs That Represent Situation

Objectives	Teacher's Facing: • Interpret (orally and in writing) the graph and equation representing a function in terms of the context. Student Facing: • I can explain how a quadratic equation and its graph relate to a situation. Focused Mathematical Practice: • MP 2: Reason abstractly and quantitatively Vocabulary: •
Lesson narrative:	By now students have seen how the parameters of a quadratic expression in standard form and in factored form relate to the graph representing the function. In the past few lessons, students worked with decontextualized quadratic functions. In this lesson, they transfer what they learned about the graphs to make sense of quadratic functions that model concrete contexts. Students interpret equations and graphs of quadratic functions in terms of the situations they represent. They use their analyses to solve problems and to compare quadratic functions given in different representations. Along the way, they practice reasoning quantitatively and abstractly (MP2).
NJSLS:	HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. HSF-IF.A.2 Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context. HSF-IF.B.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. HSF-IF.C.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.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 14 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/14/index.html

Lesson 19: Vertex Form

Objectives	Teacher's Facing: • Comprehend quadratic expressions in "vertex form" by seeing the form as a constant plus a coefficient times a squared term. • Coordinate (using words and other representations) the parameters of a quadratic expression in vertex form and the graph that represents it. Student Facing: • I can recognize the "vertex form" of a quadratic equation. • I can relate the numbers in the vertex form of a quadratic equation to its graph. Focused Mathematical Practice: • MP 6: Attend the precision Vocabulary: • Vertex Form
Lesson narrative:	In earlier lessons, students have determined the -coordinate of the vertex of a graph by determining the value exactly between the two -intercepts. They have seen that the vertex of a graph that represents a quadratic function tells us the maximum or minimum value of the function. Because of this, we are often interested in identifying the vertex of a graph. In this lesson, students are introduced to quadratic expressions in vertex form and learn that this form allows us to easily see where the vertex of a graph is. Students use technology to experiment with the parameters of expressions in vertex form, examine how they are visible on the graphs, and articulate their observations, all of which require attending to precision (MP6). They also consider how the connections between expressions and graphs here are like or unlike other connections they studied in earlier lessons.
NJSLS:	HSF-BF.B.3 Identify the effect on the graph of replacing f(x) by f(x)+k ,kf(x) ,f(kx , and f(x+k) for specific values of (both positive and negative); find the value of 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. HSF-IF.C Analyze functions using different representations. HSF-IF.C.7.a Graph linear and quadratic functions and show intercepts, maxima, and minima.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 15 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/15/index.html

Lesson 20: Graphing from the Vertex Form

Objectives	Teacher's Facing: • Create a graph of a quadratic function written in vertex form, showing a maximum or minimum and the y-intercept. • Use an equation in vertex form to identify the maximum or minimum of a quadratic function Student Facing: • I can graph a quadratic function given in vertex form, showing a maximum or minimum and the y-intercept. • I know how to find a maximum or a minimum of a quadratic function given in vertex form without first graphing it. Focused Mathematical Practice: • MP 7: Look for and make use of structure Vocabulary: • Vertex Form
Lesson narrative:	In an earlier lesson, students saw that a quadratic expression in vertex form can reveal the location of the vertex of the graph of the function defined by the expression. It can also suggest the direction of the opening of the graph (that is, whether the parabola opens up or down). Here, students think about how the structure of the form helps to explain these connections and helps to show whether the vertex of a graph represents the minimum or the maximum value of the function (MP7). They informally use the symmetry of the graph to locate two additional points on the graph to help them make a sketch. Students begin to see that we can anticipate what happens on the graph on either side of the vertex by reasoning about the parts of an expression in vertex form. The squared expression $a(x-h)^2$ is 0 when x = h . For all other values of $(x – h)^2$, the value of is positive because squaring any number gives a positive number. This suggests that, if the coefficient is positive, the expression $a(x-h)^2$ will be positive (or greater than the value at the vertex, so the vertex is the minimum). If a is negative, $a(x-h)^2$ will be negative (or less than the value at the vertex, which means the vertex is the maximum). Students are not assessed on this line of reasoning, but are prompted to apply their new insights to sketch the graphs of quadratic functions and to match a set of quadratic functions to the graphs that represent them.
NJSLS:	HSF-IF.C Analyze functions using different representations. HSF-IF.C.7.a Graph linear and quadratic functions and show intercepts, maxima, and minima.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 16 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/16/index.html

Lesson 21: Changing the Vertex

Objectives	Teacher's Facing: • Create a quadratic function by changing the vertex of an existing function given its equation, graph, and a description. • Describe informally (orally and in writing) the effect on the graph of a quadratic function when performing simple algebraic transformations. Student Facing: • I can describe how changing a number in the vertex form of a quadratic function affects its graph. Focused Mathematical Practice: • MP 7: Look for and make use of structure Vocabulary: • Vertex Form
Lesson narrative:	Previously, students were given quadratic expressions in vertex form and asked to visualize the location of the vertex and the direction of the opening of the graph representing each expression. In this lesson, they reason the other way around and think about what expressions would produce graphs with particular vertices. Students look more closely at how changing the h and the k in a quadratic expression of the form $a(x-h)^2 + k$ translates the graph, and recall that the coefficient affects the direction of the opening of a parabola. Students continue to reason abstractly with expressions and graphs, but in one of the activities they also reconnect abstract expressions and quantities to a context. They continue to consolidate the ideas, structure, and generalizations from the past few lessons and apply them in new ways (MP7).
NJSLS:	HSF-IF.C Analyze functions using different representations. HSF-IF.C.7.a Graph linear and quadratic functions and show intercepts, maxima, and minima. HSF-BF.B.3 Identify the effect on the graph of replacing f(x) by f(x)+k ,kf(x) ,f(kx , and f(x+k) for specific values of (both positive and negative); find the value of 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.
Learning Material	Illustrative Math Algebra I Unit 6 Lesson 17 Student Learning Material https://curriculum.illustrativemathematics.org/HS/students/1/6/17/index.html

5 Practices for Orchestrating Productive Mathematics Discussions	
Practice	Description/ Questions
1. Anticipating	What strategies are students likely to use to approach or solve a challenging high-level mathematical task? How do you respond to the work that students are likely to produce? Which strategies from student work will be most useful in addressing the mathematical goals?
2. Monitoring	Paying attention to what and how students are thinking during the lesson. Students working in pairs or groups Listening to and making note of what students are discussing and the strategies they are using Asking students questions that will help them stay on track or help them think more deeply about the task. (Promote productive struggle)
3. Selecting	This is the process of deciding the ***what*** and the ***who*** to focus on during the discussion.
4. Sequencing	What order will the solutions be shared with the class?
5. Connecting	Asking the questions that will make the mathematics explicit and understandable. Focus must be on mathematical meaning and relationships; making links between mathematical ideas and representations.

Ideal Math Block

The following outline is the department approved ideal math block for grades 9-12.

1) Do Now (7-10 min)
    a. Serves as review from last class' or of prerequisite material
    b. Provides multiple entry points so that it is accessible by all students and quickly scaffolds up

2) Starter/Launch (5-10 min)
    a. Designed to introduce the lesson
    b. Uses concrete or pictorial examples
    c. Attempts to bridge the gap between grade level deficits and rigorous, on grade level content
    d. Provides multiple entry points so that it is accessible by all students and quickly scaffolds up

3) Mini-Lesson /Task(15-20 min)
    a. Design varies based on content
    b. May include an investigative approach, direct instruction approach, whole class discussion led approach, etc.
    c. Includes CFU's
    d. Anticipates misconceptions and addresses common mistakes

4) Guided Practice (25-30 min)
    a. Design varies based on content
    b. May include partner work, group work/project, experiments, investigations, game based activities, etc.

5) Independent Practice (7-10 min)
    a. Provides students an opportunity to work/think independently

6) Closure (5-10 min)
    a. Connects lesson/activities to big ideas
    b. Allows students to reflect and summarize what they have learned
    c. May occur after the activity or independent practice depending on the content and objective

7) DOL (5 min)
    a. Exit ticket

Authentic Assessment

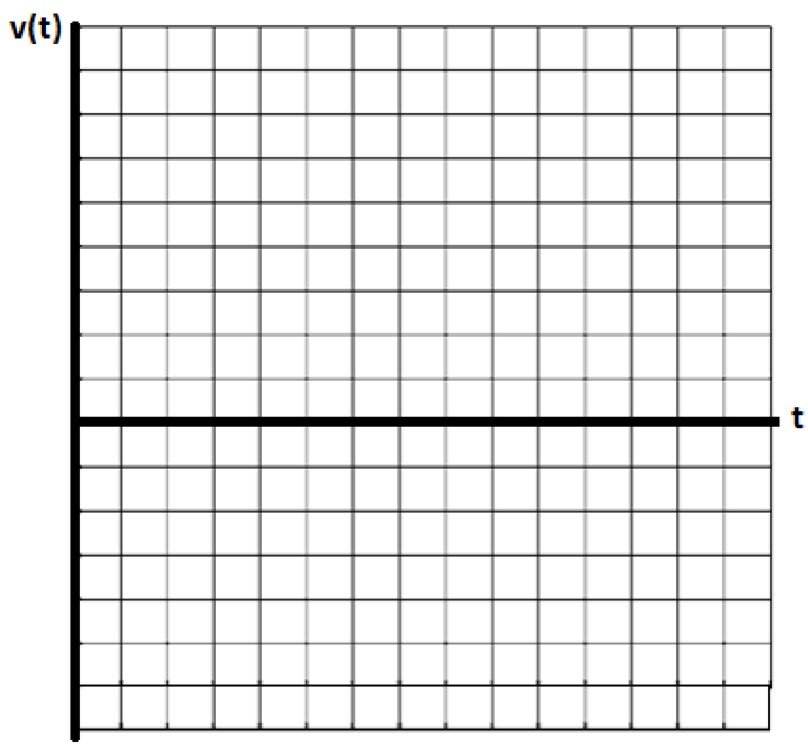
Rate of Change Task (Calculator is allowed)

NAME: ____________________

Andrew invested money in a stock portfolio. The total value of his investment, V(t), in hundreds of dollars, fluctuates over time. The table below shows the value of his investment every 2 months, t, over an 18-month time period.

t (months)	V(t) (hundreds of dollars)
2	325
4	385
6	405
8	385
10	325
12	225
14	85
16	-95
18	-315

Part A: Create a graph that represents the value of Andrew's investment over time by plotted all of the values from the table on a coordinate plane. Provide axis labels and scales.



PartB: What type of function is V(t)? (linear or quadratic?)

____

Explain how you know.

Part C: Find a two month interval where Andrew's money is increasing. Justify your answer by finding the rate of change.

Part D: Find a two month interval where Andrew's money is decreasing. Justify your answer by finding the rate of change.

Part E: Determine the two month interval that Andrew sees the largest change in his investment over the 18 month time period. Show your work to support your response.

Algebra II Modeling & Reasoning (Unit 3: Average Rate of change) Rubric

Name: ____ Date: ______________

CCSS: F.IF.6, F.IF.7 SMP:MP1, MP2, MP4 Types:________ Teacher: _____________

Task Description	• Create a graph • Explain how to determine the types of function • Computing average rate of change • Interpreting average rate of change				
Command Level **Description**	***Level 5:*** ***Distinguished Command*** Perform the task items accuately or with minor computation errors.	***Level 4:*** ***Strong Command*** Perform the task items with some non-conceptual errors	***Level 3:*** ***Moderate Command*** Perform the task items with minor conceptual errors and some computation errors.	***Level 2:*** ***Partial Command*** Perform the task items with some errors on both math concept and computation.	***Level 1:*** ***No Command*** Perform the task items with serious errors on both math concept and computation.
Score range	8 ~10 pts	7 points	5 ~ 6 pts	2 ~4 pts	0 ~ 1 pt
Task Scores & **PLD Assigned**					
Teacher Comment					

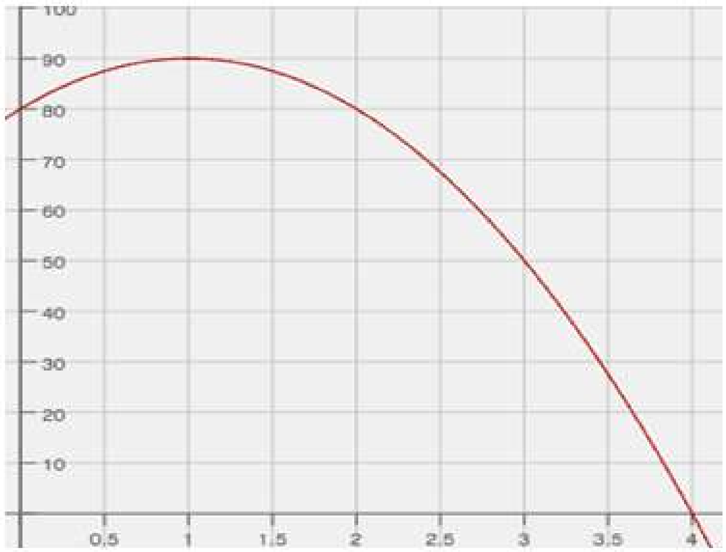
Algebra I unit 2 Task: Whose baseball is higher? Name: _______

Brian and Peter each throw a baseball into the air. The height of Brian's baseball is given by

$h(t) = -10t^2 + 40t + 50$

Where h is in feet and t is in seconds. The height of Peter's baseball is given by the graph below:

Height (feet)



Time (sec)

Part A:

i) When will Peter's baseball reach the highest height? What is the height?

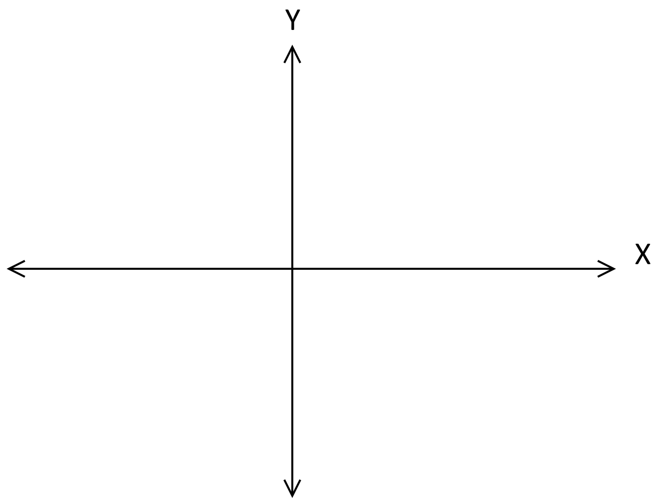
ii) When will Peter's baseball hit the ground? Use mathematical evidence to explain your answer.

Part B:

i) Brian claims that his baseball went higher than Peter's. Is he right? Use mathematical evidence to explain your answer.

ii) How long is each baseball airborne? Show your work

iii) Sketch a graph to represent the height of Brain's baseball by using the function $h(t) = -10t^2 + 40t + 50$. Label the key features (intercepts, maximum/minimum).



iv) What does the y-intercept mean in terms of the context of the problem?

Part C: Peter says that he is going to use a mathematical function P(x).

- What function Peter could have created? Identify the variables for the function.

- Use the function to determine the height of the ball to the nearest hundredths when time is 2.5 seconds. Show your work.

Algebra 1 Modeling Task (Unit 3: Whose baseball is higher?) Rubric

Name: ____________________ Date: ______________ Teacher: ______________

CCSS: A.CED.2, F.IF.4, 7, 9 SMP:MP1, 4, 5, 6, &7

Task Description	• Build functions that model mathematical and contextual situation. • Analyze different presentations to create a function algebraically. • Interpreting mathematical results in the context of the situation • Write a complete, clear and correct expression, equation or function to describe a situation • Clearly constructs and communicates the reasoning to precision when making mathematical statement/conclusion.				
Command Level Description	***Level 5: (100%) Distinguished Command*** Perform the task items accurately or with minor computation errors.	***Level 4: (89%) Strong Command*** Perform the task items with some non-conceptual errors	***Level 3: (79%) Moderate Command*** Perform the task items with minor conceptual errors and some computation errors.	***Level 2: (69%) Partial Command*** Perform the task items with some errors on both math concept and computation.	***Level 1: (59%)*** Perform the task items with serious errors on both math concept and computation.
Score range	15 ~ 17 pts	11 ~ 14 pts	7 ~10 pts	3 ~6 pts	0 ~ 2 pts
Task Scores & PLD Assigned					
Teacher Feedback					

Extended Constructed Response (ECR)

Multiple Representations

System of Equations	
Pictorial	
Abstract	

PARCC Sample Assessment Items/ Unit Assessment Question Bank

Unit Assessment/PARCC aligned Tasks		
#	Dropbox location and filename	Task Type
1	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.1**	I (1 pt)
2	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.2**	I (1 pt)
3	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.3**	I (1 pt)
4	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.4**	I (1 pt)
5	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.5**	I (2 pts)
6	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.6**	I (2 pts)
7	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.7**	I (2 pts)
8	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.8**	I (4 pts)
9	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.9**	II (3 pts)
10	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.10**	II (4 pts)
11	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.11**	III (3 pts)
12	Orange 9-12 Math > Algebra 1 > Unit 2 > Additional Resources > **Task 2.12**	III (6 pts)