Math 2 **Lesson Title:** Modeling with Quadratics: Connections to Linear Models

Unit 4: Quadratic Functions: Modeling (Lesson 2 of 2) **Time Frame:** 5 days

Essential Question(s):

- What do the key features of the graph of a quadratic function represent in a modeling situation?
- How do you create an appropriate function to model data or situations given within context?

Targeted Content Standard(s):

- 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.*

- 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.

- F.IF.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

Student Friendly Learning Targets

I can…

- Interpret key features of the graph of a quadratic function.
- Relate domain of a quadratic function to its graph.
- Represent real life situations using graphs, tables, and equations.
- Show that the rate of change of a quadratic function can be modeled using a linear function.

Targeted Mathematical Practice(s):

- ☐ 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 an express regularity in repeated reasoning

Supporting Content Standard(s): *(optional)*

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

a) Determine an explicit expression, a recursive process, 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 adding a constant function to a decaying exponential, and relate these functions to the model.*

Explanation of Rigor: *(Fill in those that are appropriate.)*

Conceptual:	**Procedural:**	**Application:**
		Using quadratic functions to model situations and interpreting key features of a graph in context.

Vocabulary:

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Quadratic	Periodicity
Parabola	End behavior
Standard form	Symmetries
Vertex form	
Intervals	
Relative maximums	
Relative minimums	

Purpose of Lesson:

The purpose of this lesson is to connect students' prior learning of quadratic functions to real-life situations and applications.

Evidence of Learning (Assessment):

Pre-Assessment: *Unit 4 Pre-Assessment*

Formative Assessment(s): *Quadratic Gallery Walk, Box Problem*

Summative Assessment:

Self-Assessment: *Exit Ticket*

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Segment 1

Approximate Time Frame:

45-50 minutes

Lesson Format:

- ☐ Whole Group
- ☐ Small Group
- ☒ Independent

- ☐ Modeled
- ☐ Guided
- ☒ Collaborative
- ☒ Assessment

Resources:

Pre-Assessment

Focus:

Students will show that they know the relationship between two quantities using a linear model, domain, and rate of a change of linear function

Modalities Represented:

- ☐ Concrete/Manipulative
- ☒ Picture/Graph
- ☒ Table/Chart
- ☐ Symbolic
- ☐ Oral/Written Language
- ☒ Real-Life Situation

Math Practice Look For(s):

MP#2: Reason abstractly and quantitatively. Students will use given information to determine what form of a quadratic to use for modeling. *For example, a set of data that appears to have a minimum value might lead a student to choose vertex form over standard form of a quadratic. Students will solve problems and interpret solutions considering scale, units, data displays, and levels of accuracy.*

MP#4: Model with mathematics. Students will use graphs, tables, and equations to model quadratic equations.

MP#6: Attend to precision. Students will use appropriate scales and levels of precision in their models and predictions, as determined by the precision in the data.

Differentiation for Remediation:

Differentiation for English Language Learners:

Differentiation for Enrichment: Teachers can expose students to higher degree polynomial

Potential Pitfall(s):

Students may not remember the term linear and how we use linear functions which will make it difficult to make connections to quadratic functions.

Independent Practice (Homework):

Steps:

1. Hand out the *Pre-Assessment* to have the students work through each problem independently.

Teacher Notes/Reflections:

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2. After they are finished with the pre-assessment: a. Go through the answers to each question with the students, while they fill out a skeleton self-assessment b. Once they have finished the self-assessment, break students up into groups for them to discuss what they did well and what they need more help with c. If students all missed the same question, take this time to provide some direct instruction on that specific concept.	**Teacher Notes/Reflections:**

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Segment 2

Approximate Time Frame:

90-100 minutes

Lesson Format:

☒ Whole Group
☒ Small Group
☒ Independent

☒ Modeled
☐ Guided
☒ Collaborative
☐ Assessment

Resources:

Box Problem

Scissors (If teacher/students prefer not to tear paper)

Focus:

Students will be comparing the average rate of change of linear and quadratic functions.

Modalities Represented:

☒ Concrete/Manipulative
☒ Picture/Graph
☒ Table/Chart
☐ Symbolic
☒ Oral/Written Language
☐ Real-Life Situation

Math Practice Look For(s):

MP#4: Model with mathematics. Students will use graphs, tables, and equations to model quadratic equations.

MP#6: Attend to precision. Students will use appropriate scales and levels of precision in their models and predictions, as determined by the precision in the data.

Differentiation for Remediation: Provide solid blocks for students to complete the activity instead of paper.

Differentiation for English Language Learners:

Differentiation for Enrichment:

Potential Pitfall(s):

Students may have difficulty thinking three-dimensionally even with the manipulatives. In this case, solid blocks can be used in place of paper.

Independent Practice (Homework):

Steps:

1. Pass out activity and explain the beginning steps to the students.

The students should work individually on the steps of the activity that require them to form the boxes and find the information for those boxes.

2. Once they have completed the task, have students form a "Think-Pair-Share" team.
    a. Individually students will think about questions 7-11 and write down their answer.
    b. Students will turn to their partner to share

Teacher Notes/Reflections:

Essential Question(s):

- What do the key features of the graph of a quadratic function represent in a modeling situation?
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each other's thoughts on their answers. *This should be one at a time, and to increase collaboration, you might want to tell them that they need a different partner for each sharing of a problem.*	
3. Once they have completed all the problems and collaborated with one another, facilitate a whole group discussion about the differences and similarities in each column and what is being modeled by the activity. a. The goal is to help students arrive at the fact that some of the columns are linear and some are quadratic. *Exit ticket can be used here.*	**Teacher Notes/Reflections:**

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Segment 3

Approximate Time Frame: 40-50 minutes	**Lesson Format:** ☐ Whole Group ☒ Small Group ☐ Independent ☐ Modeled ☐ Guided ☒ Collaborative ☐ Assessment	**Resources:** Quadratic Gallery Walk
Focus: Students will be comparing quadratic functions that model unique real life situations.		**Modalities Represented:** ☐ Concrete/Manipulative ☐ Picture/Graph ☐ Table/Chart ☒ Symbolic ☒ Oral/Written Language ☒ Real-Life Situation

Math Practice Look For(s):

MP#2: Reason abstractly and quantitatively. Students will use given information to determine what form of a quadratic to use for modeling. For example, a set of data that appears to have a minimum value might lead a student to choose vertex form over standard form of a quadratic. Students will solve problems and interpret solutions considering scale, units, data displays, and levels of accuracy.

MP#4: Model with mathematics. Students will use graphs, tables, and equations to model quadratic equations.

MP#6: Attend to precision. Students will use appropriate scales and levels of precision in their models and predictions, as determined by the precision in the data.

Differentiation for Remediation: Review quadratics qualifications

Differentiation for English Language Learners: Discuss important vocabulary associated with quadratic equations and functions

Differentiation for Enrichment: use the situations that students came up with during the deer hunting activity for the gallery walk.

Potential Pitfall(s):

Students may need review on using function notation.

Independent Practice (Homework):

Steps:

1. Quadratic Gallery Walk
    a. Put students in groups of 2-4 and have each one of the Gallery pages posted around your classroom.
    b. Have the groups of students start at one of the pages and answer the questions.
    c. As they complete pages, they will move to another page until they have completed the walk.

Teacher Notes/Reflections:

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2. As students are completing the gallery walk, an observational checklist has been included to complete. *Students can each be observed at one station to assess competency and ability. The teacher does not have to observe every student at every station.*	**Teacher Notes/Reflections:**
3. Once the students have completed the gallery walk, facilitate a whole group discussion about the activity. Be sure to address commonly missed questions and revisit any concepts that students did not demonstrate mastery.	

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Segment 4

Approximate Time Frame:

80-90 minutes

Lesson Format:

☐ Whole Group
☒ Small Group
☒ Independent

☐ Modeled
☐ Guided
☒ Collaborative
☐ Assessment

Resources:

Box Problem

19 x 19 gridded cardstock (1 per student)

Scissors may be needed

Focus:

Students will be looking at perimeter, surface area, and volume to see how different the rate of change compares between the three.

Modalities Represented:

☒ Concrete/Manipulative
☐ Picture/Graph
☒ Table/Chart
☒ Symbolic
☒ Oral/Written Language
☐ Real-Life Situation

Math Practice Look For(s):

MP#2: Reason abstractly and quantitatively. Students will use given information to determine what form of a quadratic to use for modeling. *For example, a set of data that appears to have a minimum value might lead a student to choose vertex form over standard form of a quadratic.* Students will solve problems and interpret solutions considering scale, units, data displays, and levels of accuracy.

MP#4: Model with mathematics. Students will use graphs, tables, and equations to model quadratic equations.

MP#6: Attend to precision. Students will use appropriate scales and levels of precision in their models and predictions, as determined by the precision in the data.

Differentiation for Remediation: May need to cover how to find perimeter, surface area, or volume of a box.

Differentiation for English Language Learners: Discuss important vocabulary associated with perimeter, area, and volume.

Differentiation for Enrichment: If you feel as though students fully understand the 3 dimension you could ask how the rate of change would differ if it had 4 dimension.

Potential Pitfall(s):

Students may need volume, perimeter, and surface area.

Students may not have experience with regressions on the calculator and might need additional instruction prior to this activity (or during step 4)

Independent Practice (Homework):

Steps:

1. Teacher Tip: In order to structure this activity to fit your group of students, the teacher should work through the activity ahead of time. This will allow for the individual teacher to make decisions about how

Teacher Notes/Reflections:

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much (or little) scaffolding to provide during the actual activity *Print table separately from the activity instructions*	
2. Start by having students individually follow steps 1-5 by tearing, counting, and calculating the information for the table.	**Teacher Notes/ Reflections:**
3. Put students into groups for parts 6-8 and have them work together to answer the questions posed	
4. Then, as a whole class discuss 9-11 and work together with students to complete each task.	