Big Idea/ Topic

- Analyze and solve quadratic functions.
- Use quadratic models to interpret and solve problems.

Standard(s) Alignment

**MGSE9-12.A.CED.1** Create equations and inequalities in one variable and use them to solve problems. Include equations arising from quadratic functions.

**MGSE9-12.F.IF.7a** Graph linear and quadratic functions and show intercepts, maxima, and minima (as determined by the function or by context).

**MGSE9-12.A.SSE.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Diagnostic Assessment

**Phet Area Builder Explore**

Direct students to the link above. Have them select “explore” and toggle to two area builders at once by clicking the button on the bottom right. Ask students to create various figures with a perimeter of 12. Have them try to maximize and minimize the area. Pose the question, “What other areas are possible using a perimeter of 12?”.
Instructional Design

Desmos Activity: **Build a Bigger Field !!!**

**Engage**

1. Take a guess.
   - Which of these three rectangles has the largest perimeter?

   **Teacher Moves**
   - Emphasize the range of student responses on this screen. It’s okay—even desirable—to lack consensus at this stage. The activity will build toward consensus later on.
   - Show the histogram view in the dashboard and discuss the ideas behind students’ choices.

2. Fun Fact
   - They all have the SAME perimeter.
   - What is the perimeter (in meters) of each rectangle?

   **Teacher Moves**
   - This is a great place to check student progress. Offer individual support where needed, or lead a whole-class discussion if enough students are struggling with the concept of perimeter.
   - Sample Answer: 50

- **Synchronous**: Complete during a classroom discussion while pausing the activity to highlight student responses.
- **Asynchronous**: Introduce the problem to students in a virtual platform; this can be done via e-document or video. Allow students to share responses within the Desmos platform and provide feedback via the teacher dashboard. Additionally, students could use an audio/video to share. Provide feedback to individual student responses and highlight multiple strategies used by students.
- **Unplugged/ Offline**: Provide the opening image for students to engage in the task. Have students share ideas via email/text/phone. Provide feedback to students and share other students’ ideas before engaging in the remaining sections.
Explore

3 Before We Build...So...

Given: Perimeter of 56m and length of 16m

Semiperimeter = \( \frac{1}{2} \) the perimeter, or \((l + w)\).

Area of rectangle = length * width

Teacher Moves

Answer may vary on this screen, but this is a great place to check student progress.

In order to calculate the width of their rectangles, students will need to understand that the perimeter is the sum of two widths and two lengths.

Offer individual support where needed, or lead a brief whole-class discussion if enough students are struggling.

4 Build a Field

You're building a field with exactly 50 meters of fencing.

Click and drag the corner of the fence to change the field. Build UNIQUE fields that use exactly 50 meters of fencing.

Continue to the next screen when you are finished.

Teacher Moves

Answers may vary on this screen and the next two.

5 Calculate the Area of...

These are the three fields you created.

You said that Field C would have the greatest area.

Calculate the width and area of each field to see if you were right.

Teacher Moves

Answer may vary on this screen, but this is a great place to check student progress.

In order to calculate the width of their rectangles, students will need to understand that the perimeter is the sum of two widths and two lengths.

Offer individual support where needed, or lead a brief whole-class discussion if enough students are struggling.

- **Synchronous**: Complete Desmos activity during synchronous learning, either face to face, virtual, or blended.
- **Asynchronous**: Using the teacher dashboard, unrestrict screens three through five. Give students time to complete the screens and provide feedback. Ensure that enough time is provided for students to participate and respond to your feedback and edit responses.
- **Unplugged/Offline**: Using graph paper and printed materials, students can create the fields and calculate their dimensions. Students can provide feedback using email/text/phone.

### Apply

**6 Graph the Data**

This graph shows all the fields our class created today. Your points are in orange. Your classmates' are in blue. What function family BEST describes the data?

**Teacher Moves**

Use responses mode in the teacher dashboard to identify students who may need additional support. Ask students to consider whether there are any points the class has graphed that they think do NOT satisfy the constraints.

Sample Answer: The points appear to form a parabola, so this is a quadratic graph.

**Sample Responses**

Students with incorrect calculations on the previous slide will be directed to make corrections. It is important for the aggregate data to be accurate.

You may want to consider completing slides 4 and 5 as a student so that the first student to complete their field calculations have aggregate data to work with.

**7 Graph the Data**

You said a quadratic function best describes the data.

Drag the green point so that it represents where on the graph we'll find the largest field.

Explain how you knew where to place the green point.

**Teacher Moves**

Use responses mode in the teacher dashboard to identify students who may need additional support.

Sample Answer: The place on the graph where we'll find the biggest field is at the vertex of the parabola.
Use variable expressions to write the width and area of a field with a perimeter of 50 meters, and a length of \( x \) meters.

The title will "light up" when you are correct.

**Teacher Moves**

Encourage students to extend their arithmetic reasoning from early rows in the table. Invite them to perform similar operations to find the width and area of this new rectangle.

Sample Answer: The width is \( 25 - x \) and the area is \( x(25 - x) \).

Dashboard Note: ✓ indicates a width of \( 25 - x \) and an area of \( x(25 - x) \) or equivalent for field D.

Here’s the graph of your function.

(1) What does it say about the dimensions of the field with the most area (the length and width)?

(2) What is the area of that field?

**Teacher Moves**

Highlight several student responses for the class. Start with informal math language and reasoning, then move to more formal responses.

Sample Answer: The maximum of the parabola occurs at \( (12.5, 156.25) \), which means the field with the greatest area has length 12.5 meters (and width 12.5 meters – hey!) and area 156.25 \( m^2 \).

**Teacher Moves**

Students can receive feedback when they hit the button.

**Sample Responses**

A square with side lengths of 20 maximizes area.

- **Synchronous**: Complete Desmos activity during synchronous learning, either face-to-face, virtual, or blended.
- **Asynchronous**: Using the teacher dashboard, unrestrict screens six through ten. Give students time to complete the screens and provide feedback. Ensure that enough time is provided for students to participate and respond to your feedback and edit responses as needed.
● **Unplugged/ Offline:** Provide students with access to graph paper and allow students to engage in the questions presented on screens six to ten. Ask students to complete the questions and have them submit responses via email/text/phone. Provide feedback, share these responses with other students, and share other students’ responses with them.

**Reflect**

### 11 Extension #1: A Rec...

Let's say you don't have 80 meters of fencing. You have NO idea how much fencing you have. So you call it $m$ meters of fencing.

Write instructions for how to find the dimensions of the biggest field, given $m$ meters of fencing.

Use the sketch tool if it helps to illustrate your thinking.

**Teacher Moves**

This screen asks students to generalize their ideas beyond the one particular example. This is a crucial step worth spending time on with the large group. In the dashboard, look for different approaches—especially at different levels of formality. Have these students share their thinking and ask your class to look for connections among these approaches.

Sample Answer: I’d find the vertex of the parabola using the function $A(x) = x\left(\frac{m}{2} - x\right)$ where $m$ is the available perimeter. From there I know the parabola opens downward and the maximum is found at $\frac{m}{4}$ meters.
Synchronous: Students will discover that squares maximize a rectangular field’s area. Upon making that discovery, they will attempt to apply that to writing an expression to maximize a field with an unknown perimeter. Students will share their expressions and compare and contrast them with their classmates’ expressions.

Asynchronous: Virtual Think-Pair-Share. Students will discover that squares maximize a rectangular field’s area. Upon making that discovery, they will attempt to apply that to writing an expression to maximize a field with an unknown perimeter. Students will share their expressions and compare and contrast them with their classmates’ expressions within the activity.

Unplugged/Offline: Students will discover that squares maximize a rectangular field’s area. Upon making that discovery, they will attempt to apply that to writing an expression to maximize a field with an unknown perimeter. Students will share their expressions via email/phone/text.
### Evidence of Student Success

**Formative Assessment Questions:**

- How can you create a mathematical model to explain a real-life problem?
- Describe the mathematics of the model you created. (What do the vertex and x-intercepts mean in the context of the problem?)
- Can you use your model to make accurate predictions?
- What would make your class’ model more accurate?
- What are the minimum points in context of building a field?
- Are different expressions possible to maximize the area of a field?

### Student Learning Supports

**Establish mathematics goals to focus learning.**
- Make instructions and expectations clear for the activities.
- Make explicit connections between current and prior lessons or units.

**Facilitate meaningful mathematical discourse.**
- Explicitly model and teach good “discussion board” etiquette.

**Pose purposeful questions.**
- Predetermine when you will call on the student or use the pause feature within the activities.
- Break class into small discussion groups to work collaboratively and then have groups report back to the whole group.

**Support productive struggle in learning mathematics.**
- Offer outlines and other scaffolding tools and share tips that might help students learn.
- Provide feedback using the feedback feature within activities and offer corrective opportunities.
- Consider the pacing of the lesson.

**Elicit and use evidence of student thinking.**
- Anticipate any misconceptions or questions students might have about the task, materials or technology. Proactively address them with readily available and accessible resources like those from [Math is Fun](Math is Fun).
Engaging Families

● Students and families can delve further into key characteristics of quadratics using this interactive.

● Video on how to graph quadratics, watch and discuss.

● Number Talk: Look at this diagram and discuss your takeaways. Note that the perimeters are the same for each rectangle.

● Families can explore the optimization application as well as other quadratic applications on Mathbits self-checking practice problems.