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Lesson 1: Transformers: Shifty y's

Develop Understanding

Learning Focus

Find patterns in the equations and graphs of quadratic functions.

What happens to the graph of $f(x) = x^2$ *when the equation is changed by adding, subtracting, or multiplying by a constant?*

Open Up the Math

Launch, Explore, Discuss

Optima Prime is designing a robot quilt for her new grandson. She plans for the robot to have a square face. The amount of fabric that she needs for the face will depend on the area of the face, so Optima decides to model the area of the robot's face mathematically. She knows that the area A of a square with side length x units (which can be inches or centimeters) is modeled by the function $A(x) = x^2$ square units.

1. What is the domain of the function $A(x)$ in this context?

2. Match each statement about the area to the function that models it.

A. ______

The length of each side is increased by 5 units.

B. ______

The length of each side is multiplied by 5 units.

C. ______

The area of a square is increased by 5 square units.

D. ______

The area of a square is multiplied by 5.

1. $A = 5x^2$
2. $A = (x + 5)^2$
3. $A = (5x)^2$
4. $A = x^2 + 5$

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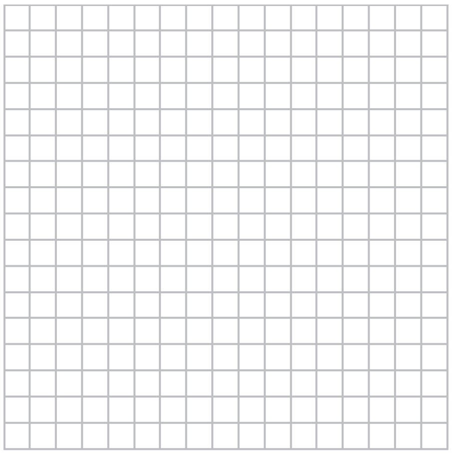
3. Optima started thinking about the graph of $y = x^2$ (in the domain of all real numbers). Make a table that contains both negative and positive values of x, and graph the function. What features do you notice?



Optima began wondering about how changes to the equation of the function, like adding 5 or multiplying by 5, affect the graph. She decided to make predictions about the effects and then check them out.

4. Make your own predictions of how the graphs of each of the following equations will be the same or different from the graph of $y = x^2$.

	Similarities to the graph of $y = x^2$	**Differences from the graph of** $y = x^2$
$y = 5x^2$		
$y = (x + 5)^2$		
$y = (5x)^2$		
$y = x^2 + 5$		

5. Optima decided to test her ideas using technology. She thinks that it is always a good idea to start simple, so she decides to go with $y = x^2 + 5$. She graphs it along with $y = x^2$ in the same window. Test it yourself, and describe what you find.

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6. Knowing that things make a lot more sense with more representations, Optima tries a few more examples, like $y = x^2 + 2$ and $y = x^2 - 3$, looking at both a table and a graph for each. What conclusion would you draw about the effect of adding or subtracting a number to $y = x^2$? Carefully record the tables and graphs of these examples, and explain why your conclusion would be true for any value of k, given $y = x^2 + k$.

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7. After her amazing success with addition in the last problem, Optima decided to look at what happens with addition and subtraction inside the parentheses, or as she says it, "Adding to the x before it gets squared." Using your technology, decide the effect of h in the equations $y=(x+h)^2$ and $y=(x-h)^2$. (Choose some specific numbers for h.) Record a few examples (in both tables and graphs) and explain why this effect on the graph occurs.

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8. Optima thought that problem 7 was very tricky and had hoped that multiplication was going to be more straightforward. She decides to start simple and multiply by -1, so she begins with $y = -x^2$. Predict what the effect is on the graph, and then test it. Why does it have this effect?

9. Optima is encouraged because she was able to figure out the last problem. She decides to end her investigation for the day by determining the effect of a multiplier, a, in the equation $y = ax^2$. Using both positive and negative numbers, fractions, and integers, create at least two tables and matching graphs to determine the effect of a multiplier.

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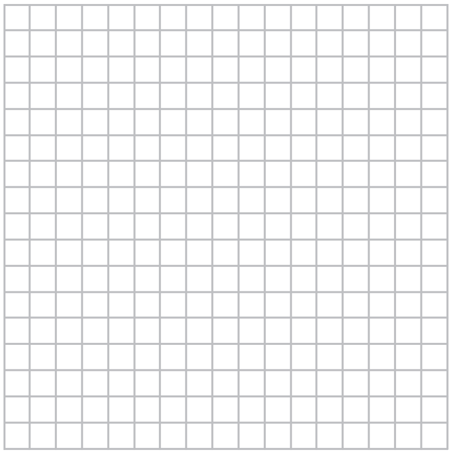

Ready for More?

Use technology to explore the behavior of the line $y = x$. If the point $(0, 0)$ is used as an anchor point, much like $(0, 0)$ is used on the graph of the parabola, will the transformations discovered for the parabola work for a line? Why or why not?

Takeaways

Equation	Transformation of $y = x^2$
$y = x^2 + k$	
$y = (x - h)^2$	
$y = (x + h)^2$	
$y = -x^2$	

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$y = ax^2$	

Adding Notation, Vocabulary, and Conventions

Vertex:

Line of Symmetry:

Vocabulary

- angle
- **horizontal shift**
- **line of symmetry**
- parabola
- **reflection**
- symmetry
- **transformations on a function (non-rigid)**
- **transformations on a function (rigid)**
- **vertex**
- **vertical shift**
- **vertical stretch**

Bold terms are new in this lesson.

Lesson Summary

In this lesson, we explored transformations of the function $y = x^2$. We found vertical and horizontal shifts, reflections, and vertical stretches of the parabola. We justified why changes to the equation transform the graph, using tables and our understanding of functions.

Retrieval

Draw a line of symmetry for the graph, state whether the graph has a maximum point or a minimum point, and provide the coordinates for that point.

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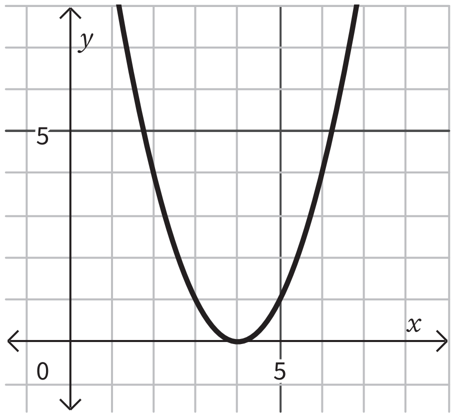
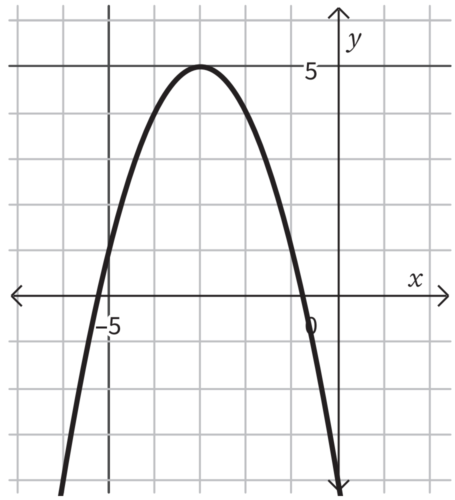
1.

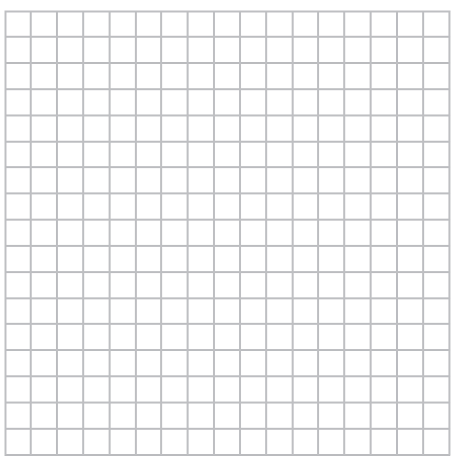


2.



Graph the linear equations, and explain your strategy.

3. $f\left(x\right)=-4\left(x+3\right)+7$



4. $3x-4y=24$