# LESSON 3

# Investigating the Parts of a Parabola

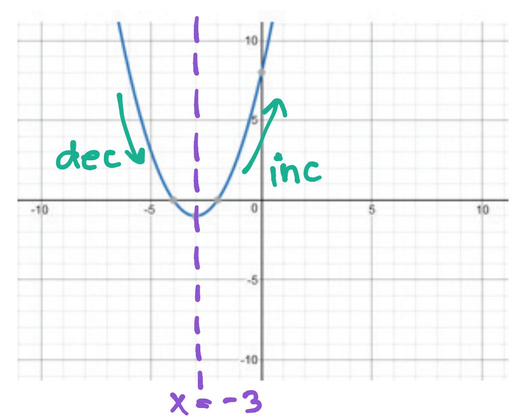
**LEARNING OBJECTIVES**

- Today I am: examining quadratic functions in the real world.
- So that I can: describe a parabola using precise mathematical language.
- I'll know I have it when I can: apply my knowledge to quadratics in vertex form.

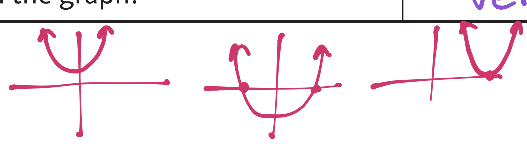
## Opening Exercise

1. Use the graph at the right to fill in the Answer column of the chart below. (You'll fill in the last column in Exercise 9.)

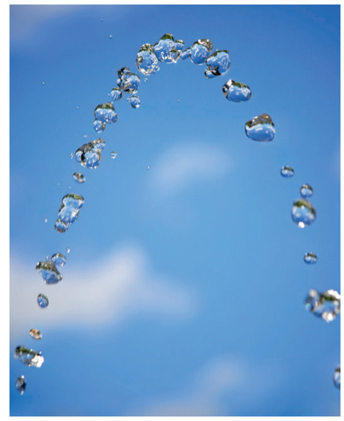
$y = (x + 3)^2 - 1$




| Question | Answer | Bring in the Math! |
|---|---|---|
| A. What is the shape of the graph? | U-shape | parabola |
| B. Does this graph have symmetry? Explain. | yes | axis of symmetry |
| C. What does the function do when $x > -3$? | Goes up | increases |
| D. What does the function do when $x < -3$? | Goes down | decreases |
| E. What are some of the special points on this graph? | the lowest point | vertex |
| F. Where does the graph cross the $y$-axis? y-int | (0,8) | (0,8) |
| G. Where does the graph cross the $x$-axis? x-int (solutions) | (-4,0) (-2,0) | (-4,0) (-2,0) |
| H. What is lowest point on the graph? (roots)(zeros) | vertex | (-3,-1) |



To learn all the math vocabulary associated with parabolas, we'll look at several examples in real life.



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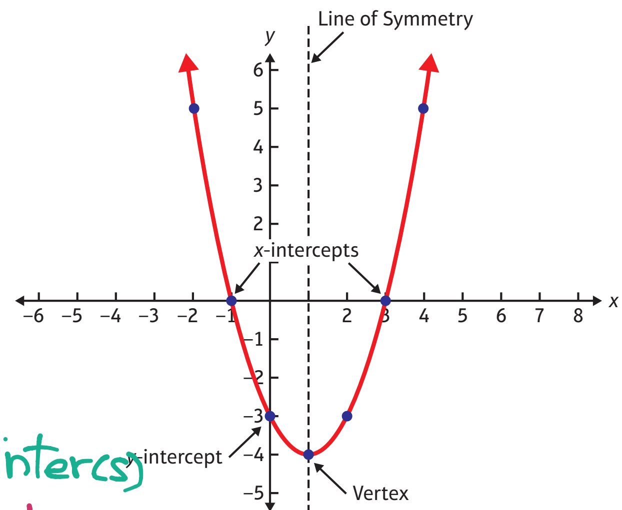
2. Mark the parabola in the water fountain to show where the height is increasing and where it is decreasing.

3. The graph of a quadratic functions forms a U-shape, called a parabola.

4. The graph at the right illustrates the location of the $x$-intercepts and the $y$-intercept.




A. Describe what ***intercepts*** are on a graph.

B. How can we find the intercepts if we have the equation of a parabola? In this case the equation of this parabola can be written in:

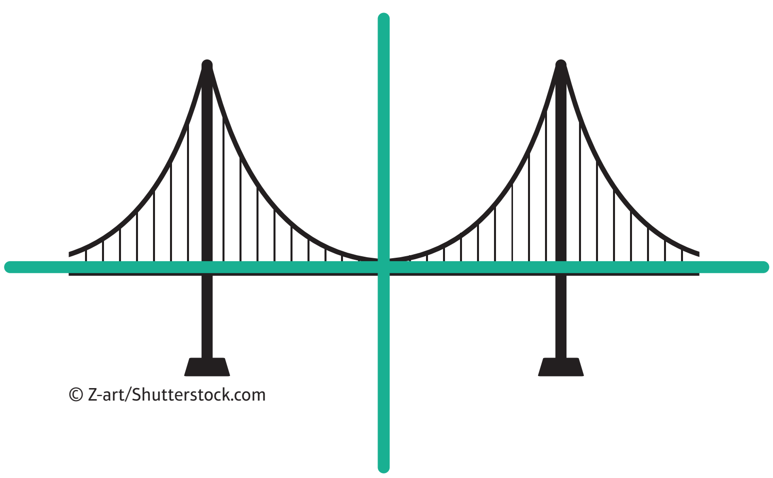
factored form, $y = (x + 1)(x - 3)$ or → x-inter(s)

standard form, $y = x^2 - 2x - 3$ or y-inter (vertex)

vertex form, $y = (x - 1)^2 - 4$. right 1 down 4 $(1, -4)$

$y = x^2$

5. A. Draw an $x$- and $y$-axis on the catenary bridge below. Explain how you chose where the origin would be.



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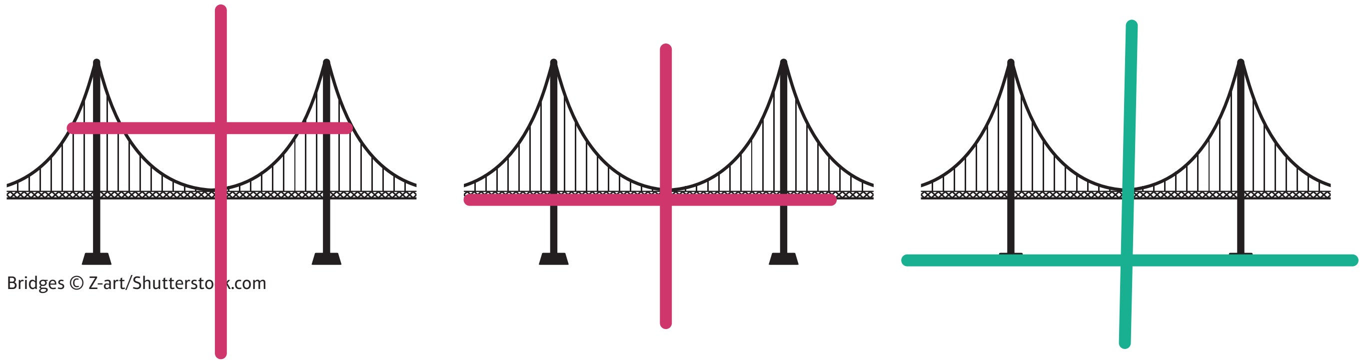
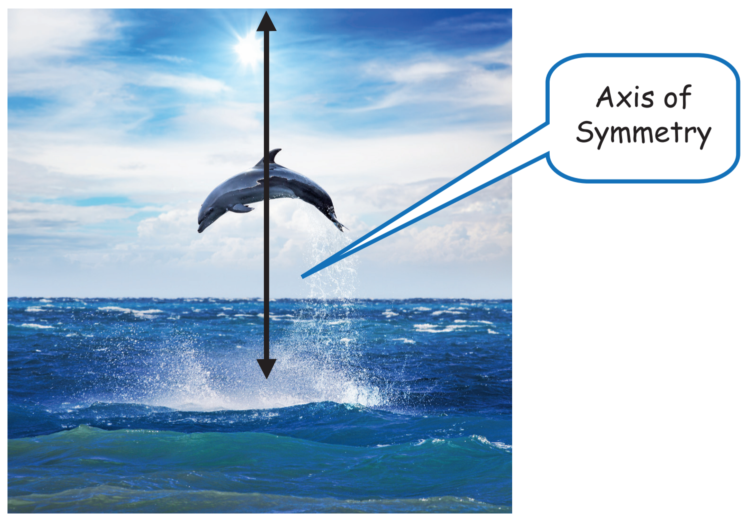
B. Draw the axes so that there are two $x$-intercepts, one $x$-intercept, and no $x$-intercepts.

2 $x$-intercepts 1 $x$-intercept 0 $x$-intercepts



Bridges © Z-art/Shutterstock.com

6. Use the picture at the right to tell what the axis of symmetry does.

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7. The pictures below refer to the vertex of a parabola. What do they mean by vertex?


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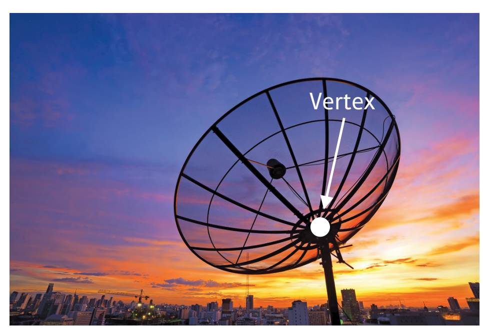


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8. Go back to the Opening Exercise and fill in the correct mathematical vocabulary in the last column of the chart. Then mark and label the vertex, axis of symmetry, *x*-intercepts and *y*-intercept on the graph.

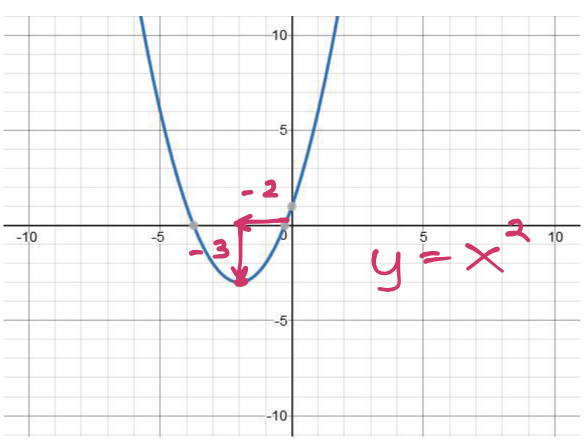
9. Give three examples of parabolas in the real world that are different from the ones shown in this lesson.
   - Rainbow
   - swing? pendulum
   -

In Exercise 4B, you looked at three ways to write the quadratic equation of the parabola. All three forms of the quadratic equation give very specific information about the graph of the parabola. In the next exploration, we'll focus on one of those forms.

**Exploration—Focus on the Vertex**

**For each graph below, identify the vertex of the parabola. Then use the Equation Bank after Exercise 17 to find the equation that matches each graph.**

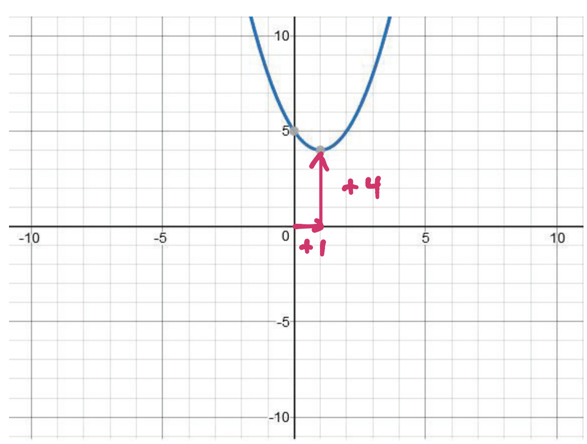
10.




Vertex: $(-2,-3)$

Equation: $y=(x+2)^2-3$

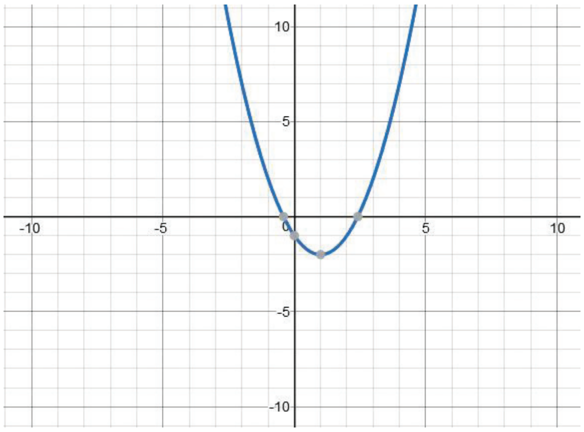
11.




Vertex: $(1,4)$

Equation: $y=(x-1)^2+4$

12.

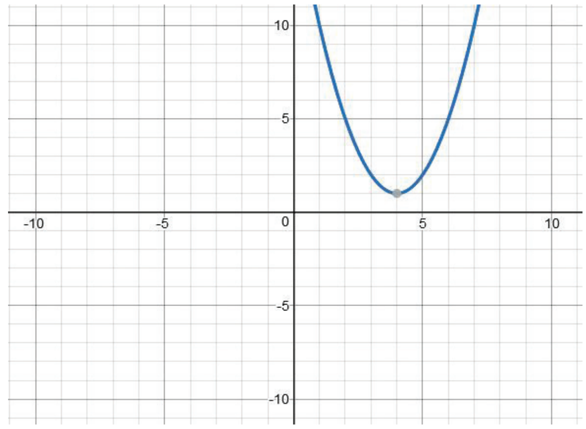


Vertex: $(1,-2)$

Equation: $y=(x-1)^2-2$

vertex form

13.



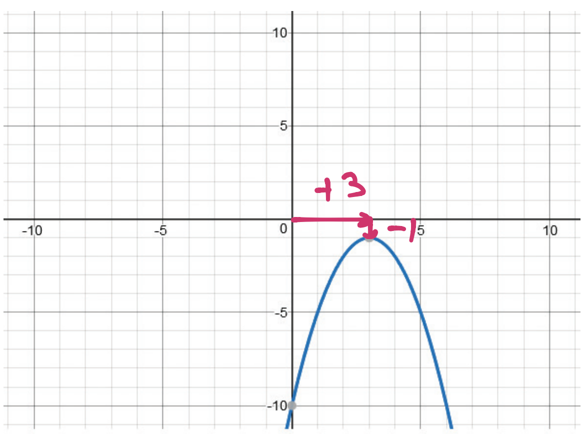
Vertex: $(4,1)$

Equation: $y=(x-4)^2+1$

$y=a(x-h)^2+k$

vertex: $(h,k)$

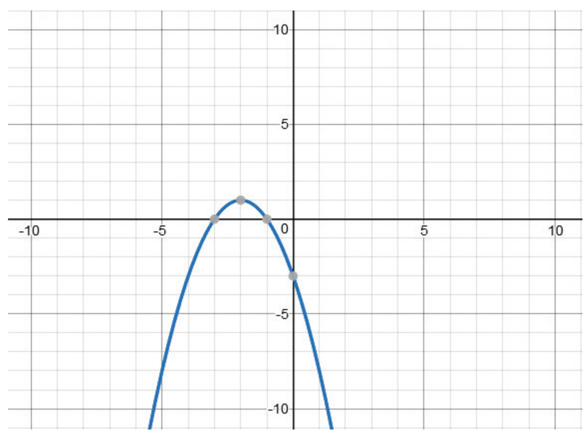
14.




Vertex: $(3,-1)$

Equation: $y=-(x-3)^2-1$

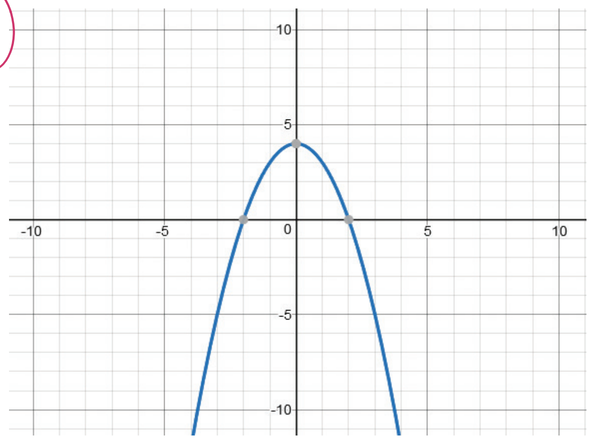
15.



Vertex: $(-2,1)$

Equation: $y=-(x+2)^2+1$

16.

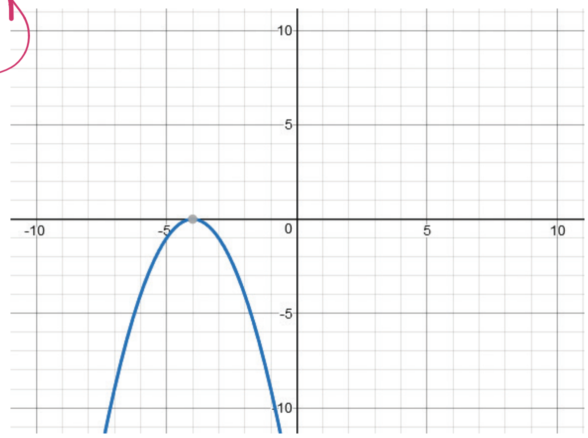


Vertex: $(0,4)$

Equation: $y=-x^2+4$

$y=-x^2+4$

17.



Vertex: $(-4,0)$

Equation: $y=-(x+4)^2$

**Equation Bank**

| | | | |
|---|---|---|---|
| A. $y = (x-1)^2 - 2$ | B. $y = -(x+2)^2 + 1$ | C. $y = (x-1)^2 + 4$ | D. $y = (x-4)^2 + 1$ |
| E. $y = -(x+0)^2 + 4$ | F. $y = (x+2)^2 - 3$ | G. $y = -(x+4)^2 + 0$ | H. $y = -(x-3)^2 - 1$ |

18. What did you notice about the equations for the parabolas in Exercises 14–17?

**Use the equation frame to write an equation of a parabola that has the given vertex.**

19. Vertex: (3, −1) Equation: $y = (x \underline{\ -\ } \underline{\ 3\ })^2 \underline{\ -1\ }$

→ ↓

20. Vertex: (−4, 0) Equation: $y = (x \underline{\ +\ } \underline{\ 4\ })^2 \underline{\qquad}$

21. Vertex: (0, −6) Equation: $y = (x \underline{\qquad} \underline{\qquad})^2 \underline{\ -6\ }$

$y = x^2 - 6$

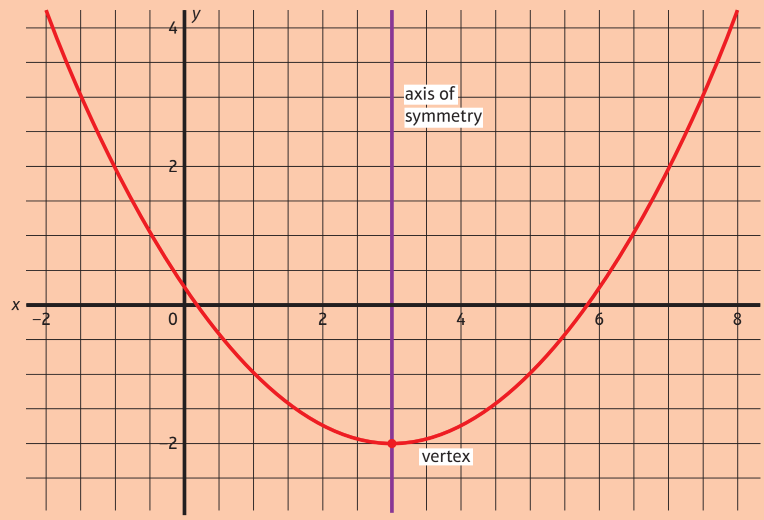
22. Vertex: (2, 4) Equation: $y = (x \underline{\ -\ } \underline{\ 2\ })^2 \underline{\ +4\ }$

23. Vertex: (−5, −7) Equation: $y = (x \underline{\ +\ } \underline{\ 5\ })^2 \underline{\ -7\ }$

# Lesson Summary

AXIS OF SYMMETRY: The axis of symmetry is a vertical line through a parabola so that each side is a mirror image of the other side.

VERTEX: The point where the graph of a quadratic function and its axis of symmetry intersect is called the *vertex*.




END BEHAVIOR OF A GRAPH: Given a quadratic function in the form $f(x) = ax^2 + bx + c$ (or $f(x) = a(x - h)^2 + k$), the quadratic function is said to *open up* if $a > 0$ and *open down* if $a < 0$.

VERTEX FORM: When graphing a quadratic equation in vertex form, $y = a(x - h)^2 + k$, $(h, k)$ are the coordinates of the vertex.

NAME: ______________________ PERIOD: __________ DATE: __________

# Homework Problem Set

Below is an example of a curve found in architecture. The St. Louis Arch can be represented by a graph of a quadratic function.

1. What are the key features this curve has in common with a graph of a quadratic function? Mark each key feature on the picture.



2. How would you describe the overall shape of a graph of a quadratic function?

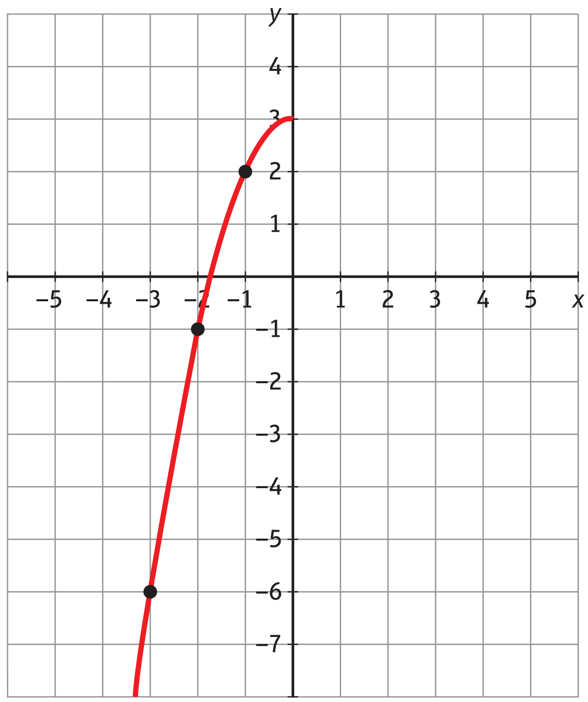
   •

   •

   •

3. Below you see only one side of the graph of a quadratic function.

   A. Complete the graph by plotting three additional points of the quadratic function. Explain how you found these points, and then fill in the table on the right.




| ***x*** | ***f*(*x*)** |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |

   B. What are the coordinates of the *x*-intercepts?

   C. What are the coordinates of the *y*-intercept?

   D. What are the coordinates of the vertex? Is it a minimum or a maximum?

   E. If we knew the equation for this curve, what would the sign of the leading coefficient be?

4. Use your completed graph from Problem 3A to verify that the average rate of change for the interval $-3 \le x \le -2$, or $[-3, -2]$, is 5. Show your steps.

5. Based on your work in Problem 4, what interval would have an average rate of change of $-5$? Explain your thinking.