Complete the exercise.

1. Does (4, 3) satisfy the equation $y = 3x^2 - x + 7$?

2. Does (0, −1) satisfy the equation $y = -2x^2 + \frac{1}{2} - 1$?

3. Does (5, 0) satisfy the equation $y = 4x^2 - 2x + 4$?

4. Does (−1, −9) satisfy the equation $y = -2x^2 + 3x - 4$?

Warm Up

- Substitute the x and y values in and see if the equation is true

Solve the inequality. Graph the solution.

1. $4y \geq -12$
2. $36 > 6t$
3. $\frac{a}{2} > 9.3$
4. $-18 \geq \frac{9}{2}t$

Cumulative Warm Up

- Review solving Inequalities
- Solving
- Graphing

Essential Question

How can you find the vertex of the graph of $f(x) = ax^2 + bx + c$?

Essential Question

What you will learn:

- Graph Quadratic functions of the form $f(x) = ax^2 + bx + c$
- Find maximum and minimum values of the quadratic

Work with a partner.

a. Sketch the graphs of $y = 2x^2 - 8x$ and $y = 2x^2 - 8x + 6$.

b. What do you notice about the x-coordinate of the vertex of each graph?

c. Use the graph of $y = 2x^2 - 8x$ to find its x-intercepts. Verify your answer by solving $0 = 2x^2 - 8x$.

d. Compare the value of the x-coordinate of the vertex with the values of the x-intercepts.

Exploration 1

· practice

Work with a partner.

a. Solve $0 = ax^2 + bx$ for x by factoring.

b. What are the x-intercepts of the graph of $y = ax^2 + bx$?

c. Copy and complete the table to verify your answer.

x	$y = ax^2 + bx$
0	
$-\frac{b}{a}$	

Exploration 2

· practice

Work with a partner. Complete the following logical argument.

The x-intercepts of the graph of $y = ax^2 + bx$ are 0 and $-\frac{b}{a}$.

The vertex of the graph of $y = ax^2 + bx$ occurs when $x =$ ____.

The vertices of the graphs of $y = ax^2 + bx$ and $y = ax^2 + bx + c$ have the same x-coordinate.

The vertex of the graph of $y = ax^2 + bx + c$ occurs when $x =$ ____.

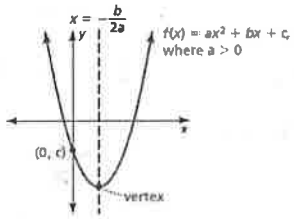
Exploration 3

· practice

Core Concept

Graphing $f(x) = ax^2 + bx + c$

- The graph opens up when $a > 0$, and the graph opens down when $a < 0$.
- The y-intercept is c.
- The x-coordinate of the vertex is $-\frac{b}{2a}$.
- The axis of symmetry is $x = -\frac{b}{2a}$.



Core Concept

- standard form
- axis of symmetry
- y-intercept

- look at a term
  - positive = ∪
  - negative = ∩

Find (a) the axis of symmetry and (b) the vertex of the graph of $f(x) = 2x^2 + 8x - 1$.

$a = 2 \quad b = 8 \quad c = -1$

$x = \frac{-b}{2a}$

$\frac{-8}{2(2)} = \frac{-8}{4} = -2$

$f(-2) = 2(-2)^2 + 8(-2) - 1$

$2(4) - 16 - 1$

$8 - 16 - 1$

$-8 - 1$

-9

Example 1

- find axis of symmetry
- solve for x
- plug value into quadratic to find y
- (x, y) = vertex

axis of symmetry $x = -2$

vertex $(-2, -9)$

Find (a) the axis of symmetry and (b) the vertex of the graph of the function.

1. $f(x) = 3x^2 - 2x$

2. $g(x) = x^2 + 6x + 5$

3. $h(x) = -\frac{1}{2}x^2 + 7x - 4$

Monitoring Progress 1-3

* Student practice

Graph $f(x) = 3x^2 - 6x + 5$. Describe the domain and range.

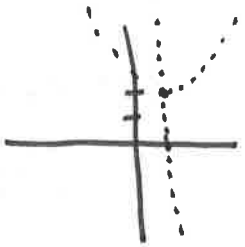
$x = \frac{-(-6)}{2(3)} = \frac{6}{6} = 1$ vertex (1,2)

$f(1) = 3(1)^2 - 6(1) + 5$

$3 - 6 + 5$

$-3 + 5$

2



d = all real #'s

r = $y \geq 2$

Example 2

- find axis of symmetry
- find vertex
- is a + or −
- which direction does it open
- domain all x-values
- range all y-values

Graph the function. Describe the domain and range.

4. $h(x) = 2x^2 + 4x + 1$

5. $k(x) = x^2 - 8x + 7$

6. $p(x) = -5x^2 - 10x - 2$

Monitoring Progress 4-6

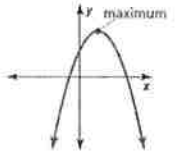
* Student practice

Core Concept

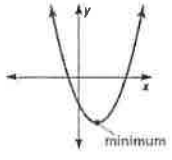
Maximum and Minimum Values

The y-coordinate of the vertex of the graph of $f(x) = ax^2 + bx + c$ is the **maximum value** of the function when $a < 0$ or the **minimum value** of the function when $a > 0$.

$f(x) = ax^2 + bx + c, a < 0$



$f(x) = ax^2 + bx + c, a > 0$



Core Concept

- open up vs open down

$a > 0$ ∪ +

$a < 0$ ∩ −

Tell whether the function $f(x) = -4x^2 - 24x - 19$ has a minimum value or a maximum value. Then find the value.

max value

$$x = \frac{-(-24)}{2(-4)} = \frac{24}{-8} = -3$$

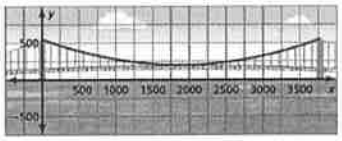
$$f(-3) = -4(-3)^2 - 24(-3) - 19$$
$$= -4(9) + 72 - 19$$
$$= 17$$

Example 3

- $a < 0$ (neg) opens down → maximum
- axis of symmetry $x = -3$
- vertex $(-3, 17)$

The suspension cables between the two towers of the Mackinac Bridge in Michigan form a parabola that can be modeled by

$y = 0.000098x^2 - 0.37x + 552$, where x and y are measured in feet. What is the height of the cable above the water at its lowest point?



$$x = \frac{(-.37)}{2(.000098)} \approx 1888$$

$$y = .000098(1888)^2 - .37(1888) + 552$$
$$y = 203$$

Cable is about 203 ft. above the water at the lowest point.

Example 4

Tell whether the function has a minimum value or a maximum value. Then find the value.

7. $g(x) = 8x^2 - 8x + 6$

8. $h(x) = -\frac{1}{4}x^2 + 3x + 1$

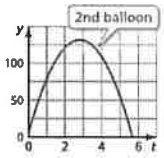
9. The cables between the two towers of the Tacoma Narrows Bridge in Washington form a parabola that can be modeled by

$y = 0.00016x^2 - 0.46x + 507$, where x and y are measured in feet. What is the height of the cable above the water at its lowest point?

Monitoring Progress 7-9

* Student practice

A group of friends is launching water balloons. The function $f(t) = -16t^2 + 80t + 5$ represents the height (in feet) of the first water balloon t seconds after it is launched. The height of the second water balloon t seconds after it is launched is shown in the graph. Which water balloon went higher?



Example 5

10. Which balloon is in the air longer? Explain your reasoning.

11. Which balloon reaches its maximum height faster? Explain your reasoning.

Monitoring Progress 10-11

Write an equation of a quadratic function that opens up, has a negative y-intercept, and is wider than the graph of $y = x^2$.

Closure