NAME ________ DATE ______ PERIOD ______

11-1 Study Guide

Student Edition Pages 458–463

Graphing Quadratic Functions

Graphing quadratic functions of the form $y = ax^2 + bx + c$, where $a \neq 0$, can be simplified if you know some common characteristics.

Characteristic	Effect
sign of a: $a > 0$ $a < 0$	graph opens upward graph opens downward
axis of symmetry	vertical line at $x = -\frac{b}{2a}$
vertex	maximum or minimum point of the graph; x-coordinate is $-\frac{b}{2a}$

Example: Use characteristics of quadratic functions to graph $y = x^2 - 2x - 1$.

Step 1 First identify a, b, and c in $y = ax^2 + bx + c$: $a = 1$, $b = -2$, and $c = -1$. Since $a > 0$, the graph opens upwards.

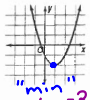
Step 2 Find the axis of symmetry.

$x = -\frac{b}{2a}$ *Equation of the axis of symmetry*

$x = -\frac{-2}{2(1)}$ or 1 *a = 1 and b = −2*

Step 3 Find the vertex. Since the equation of the axis of symmetry is $x = 1$, the x-coordinate of the vertex is 1. Substitute 1 into the equation $y = x^2 - 2x - 1$ to get $y = (1)^2 - 2(1) - 1$ or -2. The vertex is at $(1, -2)$.

Step 4 Construct a table using values for x that will be on both sides of the axis of symmetry. Choose x-values less than 1 and x-values greater than 1. Graph the points.



"min"

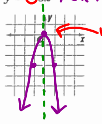
x	−1	0	1	2	3
y	2	−1	−2	−1	2

A of S: $\frac{-b}{2A} = \frac{-(0)}{2(-3)}$

$\frac{0}{-6} = 0$

Graph each quadratic equation. Then give the coordinates of the vertex.

1. $y = -3x^2 + 0x + 0$ (A B C)



max

Vertex: (0, 0)

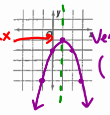
x	y
−2	−12
−1	−3
0	0
1	−3
2	−12

Axis of Symmetry

2. $y = x^2 + 2x$

3. $y = -x^2 + 2x + 2$ (A B C: −1, 2, 2)

A of S: $x = \frac{-b}{2A} = \frac{-2}{2(-1)} = \frac{-2}{-2}$



max

Vertex = +1

(1, −1)

x	y
−1	−5
0	−2
1	−1
2	−2
3	−5

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11-1 Practice

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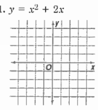
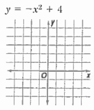
Graphing Quadratic Functions

Graph each quadratic equation by making a table of values.

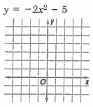
1. $y = x^2 + 2x$



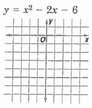
2. $y = -x^2 + 4$



3. $y = -2x^2 - 5$

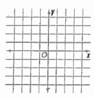


4. $y = x^2 - 2x - 6$

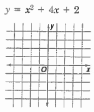


Write the equation of the axis of symmetry and the coordinates of the vertex of the graph of each quadratic function. Then graph the function.

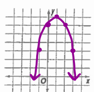
5. $y = x^2 - 1$



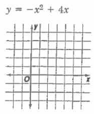
6. $y = x^2 + 4x + 2$



7. $y = -x^2 + 2x + 6$



8. $y = -x^2 + 4x$



A of S: $\frac{-b}{2A} = \frac{-2}{2(-1)} = \frac{-2}{-2} = +1$

Vertex: (+1, +7)

−1	3
0	6
+1	+7
+2	6
+3	3

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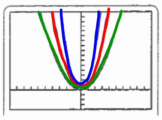
Families of Quadratic Functions

Families of parabolas are parabolas that share the same shape, vertex, or axis of symmetry. Graphing calculators make it easy to study families of graphs. Graph each of the following groups of equations on the same screen to compare and contrast the graphs.

↑coefficient closer to y-axis (narrower)

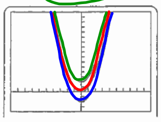
+decimal of fraction (wider)

$y = x^2$, $y = 2x^2$, $y = 0.5x^2$



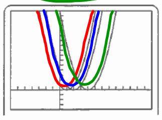
same vertex as $y = x^2$; open upward; different shapes

$y = x^2$, $y = x^2 - 2$, $y = x^2 + 2$



same shape as $y = x^2$; open upward; different vertices

$y = (x - 1)^2$, $y = (x - 2)^2$, $y = (x - 4)^2$



same shape; open upward; shift right

Example: Describe how the graph of $y = (x + 2)^2$ changes from the parent graph of $y = x^2$. Then name the vertex of each graph.

The constant -2 will make the value of the term $(x + 2)^2$ equal to 0. Therefore this graph will shift 2 units to the left. The vertex of $y = x^2$ is at (0, 0), while the vertex of $y = (x + 2)^2$ is at $(-2, 0)$.

Graph each group of equations on the same screen. Compare and contrast the graphs.

1. $y = -x^2$; $y = -4x^2$; $y = -5x^2$
2. $y = (x + 2)^2$; $y = (x + 4)^2$; $y = (x + 6)^2$
3. $y = x^2 - 1$; $y = x^2 - 2$; $y = x^2 - 3$

Describe how each graph changes from the parent graph of $y = x^2$. Then name the vertex of each graph.

4. $y = 4x^2$
graph gets closer to y-axis (gets narrower); same vertex
5. $y = x^2 - 2$
same graph
vertex moves down 2 places
6. $y = -x^2 - 1$
7. $y = (x + 1)^2$
8. $y = (x - 4)^2$
vertex moves 4 places to the right; same graph
9. $y = 0.4x^2$
10. $y = x^2 + 3$
same graph; vertex moves 3 places up
11. $y = (x + 3)^2$
vertex moves 3 places left; same shape
12. $y = -x^2 - 5$

11-2

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Practice

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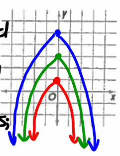
Families of Quadratic Functions

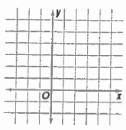
Graph each group of equations on the same axes. Compare and contrast the graphs.

same shape and size; vertex of all 3graphs located on y-axis; all open downward so they have maximum points; different vertices

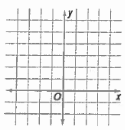
1. $y = -x^2 + 1$; $y = -x^2 + 3$; $y = -x^2 + 5$



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



3. $y = 5.5x^2$; $y = 1.5x^2$; $y = 0.5x^2$



Describe how each graph changes from the parent graph of $y = x^2$. Then name the vertex of each graph.

4. $y = 2x^2$
5. $y = x^2 + 3$
6. $y = -x^2 + 5$
7. $y = -0.2x^2$
8. $y = (x + 1)^2$
vertex moves to the left one space to (-1,0) both open upward; same shape
9. $y = (x - 9)^2$
10. $y = -4x^2 - 1$
11. $y = (x - 6)^2 + 5$
12. $y = -0.5x^2 + 4$
13. $y = 5x^2 + 8$
14. $y = (x - 2)^2 - 3$
15. $y = -(x + 1)^2 + 8$
16. $y = -(x + 3)^2 - 7$
17. $y = -(x - 4)^2 + 5$
18. $y = (x + 6)^2 + 2$

11-3

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Study Guide

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Solving Quadratic Equations by Graphing

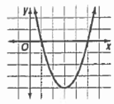
A **quadratic equation** is the equation you get if you set the related quadratic function equal to 0. For example, suppose $h(t) = -16t^2 + 40t + 4$ is the quadratic function representing the height h of a baseball at any time t. A solution to the quadratic equation $0 = -16t^2 + 40t + 4$ represents the time it takes for the ball to hit the ground. The solutions of a quadratic equation are called the roots of the equation. They are also the x-intercepts of the related quadratic function.

Example: Find the roots of $x^2 - 6x + 5 = 0$ by graphing the related quadratic function.

Before making a table of values, find the axis of symmetry.

$x = -\frac{b}{2a} = -\frac{-6}{2(1)}$ or 3 $\quad$ *a = 1 and b = −6*

The equation of the axis of symmetry is $x = 3$. Now make a table using x-values around 3. Graph each point on the coordinate plane.



x	$x^2 - 6x + 5$	$f(x)$
1	$1^2 - 6(1) + 5$	0
2	$2^2 - 6(2) + 5$	−3
3	$3^2 - 6(3) + 5$	−4
4	$4^2 - 6(4) + 5$	−3
5	$5^2 - 6(5) + 5$	0

The x-intercepts of the function are 1 and 5. So the roots are 1 and 5.

Check: Substitute 1 and 5 for x in the equation $x^2 - 6x + 5 = 0$.

$$x^2 - 6x + 5 \stackrel{?}{=} 0 \qquad x^2 - 6x + 5 \stackrel{?}{=} 0$$
$$1^2 - 6(1) + 5 \stackrel{?}{=} 0 \qquad 5^2 - 6(5) + 5 \stackrel{?}{=} 0$$
$$1 - 6 + 5 \stackrel{?}{=} 0 \qquad 25 - 30 + 5 \stackrel{?}{=} 0$$
$$0 = 0 \checkmark \qquad 0 = 0 \checkmark$$

Solve each equation by graphing the related function.

1. $x^2 - 4x + 3 = 0$
2. $x^2 - 2x + 1 = 0$
3. $x^2 + 7x + 6 = 0$
4. $x^2 + 5x - 14 = 0$
see notes
5. $x^2 + 10x + 25 = 0$
6. $x^2 - 8x - 9 = 0$
7. $x^2 + 6x = 0$
8. $x^2 + x + 1 = 0$
see notes
9. $x^2 + 3x + 2 = 0$

A B C

4) $1x^2 + 5x + 14 = 0$

A of S: $\frac{-b}{2A} = \frac{-5}{2(1)} = \frac{-5}{2} = -2\frac{1}{2}$

Vertex: $(-2\frac{1}{2}, -20\frac{1}{4})$

$1x^2 + 5x + -14$

$(\frac{-5}{2})^2 + 5(\frac{-5}{2}) + -14$

$(\frac{-5}{2})(\frac{-5}{2}) + (\frac{5}{1})(\frac{-5}{2}) + -14$

$\frac{25}{4} + \frac{-25 \times 2}{2 \times 2} + \frac{-14 \times 4}{1 \times 4}$

$\frac{25}{4} + \frac{-50}{4} + \frac{-56}{4}$

$106 - 25 = -81$

$Y = \frac{-81}{4} = -20\frac{1}{4}$

$4 \overline{)81}$: -8, 01, -0, 1

x	y
−4	
−3	
$-2\frac{1}{2}$	$-20\frac{1}{4}$ min
−2	
−1	−18
0	−14
roots 2	0
3	10

8) $1x^2 + 1x + 1 = 0$

A of S: $\frac{-b}{2A} = \frac{-(1)}{2(1)} = \frac{-1}{2}$

Vertex: $\left(\frac{-1}{2}, \frac{3}{4}\right)$

$y = 1\left(\frac{-1}{2}\right)^2 + 1\left(\frac{-1}{2}\right) + 1$

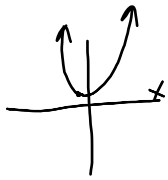
$\left(\frac{-1}{2}\right)\left(\frac{-1}{2}\right) + \frac{-1}{2} + 1$

$+\frac{1}{4} + \frac{-1 \times 2}{2 \times 2} + \frac{1 \times 4}{1 \times 4}$

$+\frac{1}{4} + \frac{-2}{4} + \frac{+4}{4}$

$\frac{+3}{4}$

x	y
-2	3
-1	1
vertex $-\frac{1}{2}$	$\frac{3}{4}$
0	1
1	3

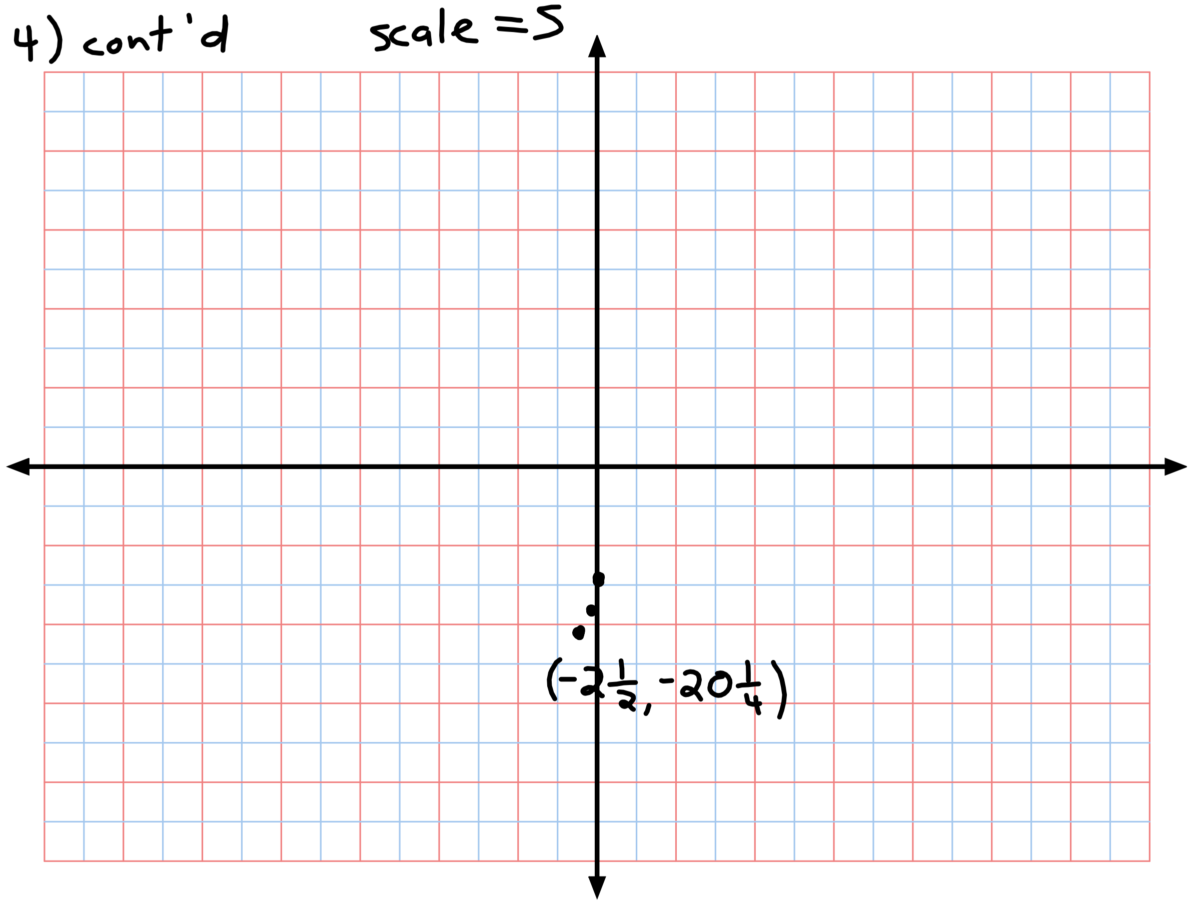


no solution

$\varnothing$

The vertex is above the x-axis and the parabola opens upward. Therefore, the graph does not cross the x-axis so there are no roots.

4) cont'd scale = 5



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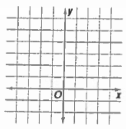
Practice

Student Edition Pages 468–473

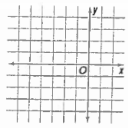
Solving Quadratic Equations by Graphing

Solve each equation by graphing the related function. If exact roots cannot be found, state the consecutive integers between which the roots are located.

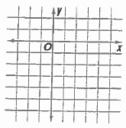
1. $x^2 - 2x + 1 = 0$



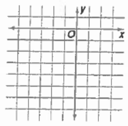
2. $x^2 + 6x + 5 = 0$



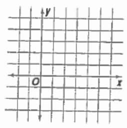
3. $x^2 - 3x - 4 = 0$



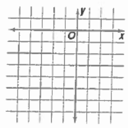
4. $x^2 + 4x - 3 = 0$



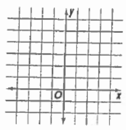
5. $x^2 - 7x + 10 = 0$



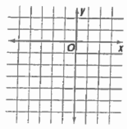
6. $2x^2 - 3x - 6 = 0$



7. $2x^2 - 6x + 3 = 0$



8. $2x^2 + 8x + 2 = 0$



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Study Guide

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Solving Quadratic Equations by Factoring

The roots of a quadratic equation can be found by factoring trinomial expressions. Using the Zero Product Property shown below, set each factor equal to 0, and then solve each equation.

Zero Product Property	For all numbers a and b, if $ab = 0$, then $a = 0$ or $b = 0$, or both a and $b = 0$.

Example: Solve $x^2 + 7x + 6 = 0$ by factoring.

$x^2 + 7x + 6 = 0$

$(x + 6)(x + 1) = 0$ *Factor.*

$x + 6 = 0$ or $x + 1 = 0$ *Zero Product Property*

$x = -6$ or $x = -1$ *Solve each equation.*

The solutions are -6 and -1.

Check: Substitute -6 and -1 for x in the equation $x^2 + 7x + 6 = 0$.

$x^2 + 7x + 6 = 0$	$x^2 + 7x + 6 = 0$
$(-6)^2 + 7(-6) + 6 \stackrel{?}{=} 0$	$(-1)^2 + 7(-1) + 6 \stackrel{?}{=} 0$
$36 - 42 + 6 \stackrel{?}{=} 0$	$1 - 7 + 6 \stackrel{?}{=} 0$
$0 = 0$ ✓	$0 = 0$ ✓

Solve each equation by factoring. Check your solution.

1. $x^2 + 4x + 3 = 0$
$(x + 3)(x + 1) = 0$
see notes

2. $t^2 - 2t + 1 = 0$

3. $x^2 + 5x = 0$
see notes

4. $y^2 + 5y - 6 = 0$
see notes

5. $p^2 + 12p + 36 = 0$

6. $(k + 2)(k - 3) = 0$

7. $4m(m + 3) = 0$
see notes

8. $(g + 2)(g + 7) = 0$

9. $h^2 - h - 2 = 0$

10. $n(n - 3) = 0$

11. $(2g + 2)(g + 4) = 0$
see notes

12. $x^2 - 12x = 0$

13. $s^2 - 4s - 12 = 0$

14. $x^2 + 7x + 10 = 0$

15. $y^2 + 16y + 64 = 0$

1) $(x+3)\cdot(x+1)=0$

$(x+\cancel{3})=0$ or $(x+\cancel{1})=0$

$+\cancel{-3} = +-3$ $\quad$ $+\cancel{-1} = +-1$

$x = -3$ or $x = -1$

$(-3, 0)$ $\quad$ $(-1, 0)$

3) $x^2+5x = 0$

$(x)\cdot(x+5) = 0$

$x = 0$ or $x+\cancel{5} = 0$

$+\cancel{-5} = +-5$

$x = 0$ $\quad$ $x = -5$

$(0,0)$ $\quad$ $(-5, 0)$

4) $y^2 + 5y + {}^{-}6 = 0$

$(y - 1)(y + 6) = 0$

$(y + \cancel{{}^{-}1}) = 0$ or $(y + \cancel{6}) = 0$

$+\cancel{1} = +1$ $\qquad$ $+\cancel{-6} = + -6$

$y = 1$ or $y = -6$

7) $(4m)(m + 3) = 0$

$\dfrac{(\cancel{4}m)}{\cancel{4}} = \dfrac{0}{4}$ or $(m + \cancel{3}) = 0$

$+\cancel{-3} = + -3$

$m = 0$ or $m = -3$

$(0, 0)$ $\qquad$ $(-3, 0)$

11) $(2g+2)\cdot(g+4) = 0$

$(2g+\cancel{2}) = 0$ or $(g+\cancel{4}) = 0$

$+\cancel{-2} = +{-2}$ $\qquad$ $+\cancel{-4} = +{-4}$

$\frac{\cancel{2}g}{\cancel{2}} = \frac{-2}{2}$ $\qquad$ $g = -4$

$g = -1$ or $g = -4$

$(-1,0)$ or $(-4,0)$

11-4

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Practice

Student Edition Pages 474–477

Solving Quadratic Equations by Factoring

Solve each equation. Check your solution.

1. $s(s+3)=0$
2. $4a(a-6)=0$
3. $3m(m+5)=0$
4. $6t(t-2)=0$
5. $(y+4)(y-5)=0$
6. $(p-2)(p+3)=0$
7. $(x+5)(x-6)=0$
8. $(3r+2)(r-1)=0$
9. $(2n-2)(n+1)=0$
10. $(x-3)(3x+6)=0$
11. $(y+4)(2y-8)=0$
12. $(4c+3)(c-7)=0$
see notes
13. $x^2+3x-10=0$
14. $x^2-6x+8=0$
15. $x^2+11x+30=0$
16. $x^2+4x=21$
17. $x^2-5x=36$
18. $x^2-5x=0$
19. $2a^2=6a$
see notes
20. $2x^2-10x+8=0$
see notes
21. $3x^2-7x-6=0$
22. $5x^2-x=4$
23. $3x^2+13x=-4$
see notes
24. $4x^2+7x=2$

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12) $(4c+3)\cdot(c+^{-}7) = 0$

$(4c+3)=0$ $\quad$ $(c+^{-}7)=0$

$+^{-}3 \quad +^{-}3$ $\quad$ $+7 \quad +7$

$\frac{4c}{4}=\frac{^{-}3}{4}$ $\quad$ $c=7$

$4\overline{)3.0}$ = .75, -28, 20, -20, 0

$(^{-}0.75, 0)$

$(7, 0)$

19) $2A^2 = \cancel{6A}$

$+{-6A} \quad = +\cancel{^{-}6A}$

$2A^2 + {-6A} = 0$

$(2A)(A \; +^{-}3) = 0$

$\frac{\cancel{2}A}{\cancel{2}} = \frac{0}{2}$ or $A + \cancel{^{-}3} = 0$

$+\cancel{+3} = ++3$

$A = 0$ or $A = +3$

$(0, 0)$ $\quad$ $(3, 0)$

20) $2x^2 + -10x + 8 = 0$

$(2x - 8)(x - 1) = 0$

$(x + -1 = 0$
$+1 \quad +1$
$x = 1$

$2x - 8 = 0$
$+8 \quad +8$
$\frac{2x}{2} \quad \frac{+8}{2}$

$(4, 0) \quad (1, 0)$

23) $3x^2 + 13x = \cancel{-4}$
$++4 = +\cancel{+4}$

$3x^2 + 13x + 4 = 0$

$(3x + 1)(x + 4) = 0$

$3x\cancel{+1} = 0$ or $x\cancel{+4} = 0$
$+\cancel{-1} = +{-1} \qquad +\cancel{-4} = +{-4}$

$\frac{\cancel{3}x}{\cancel{3}} = \frac{-1}{3} \qquad x = -4$

$(-4, 0)$

$x = -\frac{1}{3}$

$(-\frac{1}{3}, 0)$

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Solving Quadratic Equations by Completing the Square

Quadratic equations can be solved by completing the square. You complete the square for a quadratic expression of the form $x^2 + bx$, according to the steps shown below.

Completing the Square for a Quadratic $x^2 + bx$	Step 1 Take $\frac{1}{2}$ of b and square it. Step 2 Add the result to $x^2 + bx$. The perfect square is $x^2 + bx + \left(\frac{b}{2}\right)^2$.	Example: For $x^2 + 6x$, $b = 6$. $\frac{1}{2} \times 6 = 3$ $3^2 = 9$ The perfect square is $x^2 + 6x + 9$.

Once you determine $\left(\frac{b}{2}\right)^2$, you must add this number to each side of the equation. Finally, you find the square root of each side to solve the resulting equation.

Example: Solve $x^2 + 8x - 9 = 0$ by completing the square.

$x^2 + 8x - 9 = 0$

$x^2 + 8x = 9$ *Add 9 to each side.*

$x^2 + 8x + \left(\frac{8}{2}\right)^2 = 9 + \left(\frac{8}{2}\right)^2$ *Add the square of $\frac{1}{2}b$ to each side.*

$x^2 + 8x + 16 = 25$

$\sqrt{(x + 4)^2} = \sqrt{25}$ *Factor $x^2 + 8x + 16$.*

$x + 4 = \pm\sqrt{25}$ *Take the square root of each side.*

$x = \pm 5 - 4$ *Subtract 4 from each side.*

$x = 5 - 4$ or $x = -5 - 4$

$x = 1$ or $x = -9$ The solutions are 1 and -9.

Solve each equation by completing the square.

1. $x^2 + 6x + 9 = 0$
2. $m^2 - 7m - 8 = 0$
3. $y^2 + 4y = 6$ see notes
4. $y^2 + 14y = 0$
5. $t^2 - 12t - 7 = 0$
6. $z^2 - 8z - 9 = 0$
7. $n^2 + 5n = 0$
8. $x^2 + 4x = 1$
9. $k^2 + k - 2 = 0$ see notes

3) $y^2 + 4y = 6$

$\left(\frac{4}{2}\right)^2$

$y^2 + 4y + 4 = 6 + +4$

$\sqrt{(y+2)^2} = \sqrt{10}$

$y + \cancel{2} = \pm\sqrt{10}$

$+\cancel{-2} = +-2$

$y = -2 \pm \sqrt{10}$

$y = -2 + \sqrt{10}$ or $y = -2 - \sqrt{10}$

9) $k^2 + k + \cancel{{}^-2} = 0$

$\quad + {}^+2 = + {}^+2$

$(\frac{1}{2})^2 \to \frac{1}{2}\cdot\frac{1}{2}$

$k^2 + 1k + \frac{1}{4} = {}^+2 + \frac{1}{4}$

$k^2 + k + \frac{1}{4} = 2\frac{1}{4}$

$\sqrt{(k + \frac{1}{2})^2} = \sqrt{2\frac{1}{4}}$

$k + \frac{1}{2} = \pm\sqrt{2\frac{1}{4}}$

$\sqrt{\frac{9}{4}} = \frac{\sqrt{9}}{\sqrt{4}} = \frac{3}{2}$

$k + \cancel{\frac{1}{2}} = \pm \frac{3}{2}$

$\quad + \cancel{{}^-\frac{1}{2}} = + {}^-\frac{1}{2}$

$k = -\frac{1}{2} \pm \frac{3}{2}$

$k = \frac{-1}{2} + \frac{3}{2}$ or $k = -\frac{1}{2} - \frac{3}{2}$

$k = \frac{2}{2} = 1$ or $k = \frac{-4}{2} = -2$

$(1, 0)$ $(-2, 0)$

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Practice

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Solving Quadratic Equations by Completing the Square

Find the value of c that makes each trinomial a perfect square.

1. $x^2 + 12x + c$	2. $b^2 - 4b + c$	3. $g^2 - 16g + c$
4. $n^2 + 6n + c$	5. $q^2 + 20q + c$	6. $s^2 - 8s + c$
7. $a^2 + 10a + c$	8. $m^2 - 26m + c$	9. $r^2 + 5r + c$
10. $y^2 + y + c$	11. $p^2 - 7p + c$	12. $z^2 + 11z + c$

Solve each equation by completing the square.

13. $x^2 + 10x - 11 = 0$	14. $p^2 - 8p + 12 = 0$ see notes	15. $r^2 - 2r - 15 = 0$
16. $c^2 - 4c - 12 = 0$	17. $t^2 - 4t = 0$	18. $x^2 + 6x - 7 = 0$
19. $n^2 + 6n = 16$	20. $w^2 - 14w + 24 = 0$	21. $m^2 - 2m - 5 = 0$
22. $f^2 + 10f + 15 = 0$	23. $s^2 - 6s - 4 = 0$	24. $h^2 - 4h = 2$
25. $y^2 - 12y + 7 = 0$ see notes	26. $k^2 - 8k + 13 = 0$	27. $d^2 + 8d + 9 = 0$

14) $p^2 - 8p + 12 = 0$

$(p-6)(p-2) = 0$

$p - \cancel{6} = 0$ or $p - 2 = 0$

$+\cancel{+6} = +6 \qquad +2 = +2$

$p = +6$ or $p = +2$

$(6,0) \qquad (2,0)$

$\left(\frac{-8}{2}\right)^2$

$p^2 - 8p + 16 = -12 + 16$

$\sqrt{(p-4)^2} = \sqrt{+4}$

$p - \cancel{4} = \pm 2$

$+\cancel{4} = +4$

$p = 4 \pm 2$

$p = 4 + 2$ or $p = 4 - 2$

$p = +6$ or $p = 2$

$(6,0) \quad (2,0)$

25) $y^2 - 12y + \cancel{7} = 0$

$+\cancel{-7} = +-7$

$\left(\frac{-12}{2}\right)^2$

$y^2 + -12y + 36 = -7 + +36$

$(y-6)^2 = +29$

$\sqrt{(y-6)^2} = \sqrt{+29}$

$y - \cancel{6} = \pm\sqrt{29}$

$+\cancel{+6} = ++6$

$y = +6 \pm \sqrt{29}$

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The Quadratic Formula

A general formula for solving *any* quadratic equation is the **Quadratic Formula.** Begin with a quadratic equation in the general form $ax^2 + bx + c = 0$, where $a \neq 0$. Identify the values of a, b, and c. Then substitute the values into the Quadratic Formula. If the value of $b^2 - 4ac$ is negative, the equation has no real solutions.

The Quadratic Formula	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, $a \neq 0$

Example: Use the Quadratic Formula to solve $2x^2 + 3x - 8 = 0$.

$2x^2 + 3x - 8 = 0$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ *$a = 2$; $b = 3$; $c = -8$*

$x = \frac{-3 \pm \sqrt{3^2 - 4(2)(-8)}}{2(2)}$ *Substitute the values of a, b, and c into the Quadratic Formula.*

$x = \frac{-3 \pm \sqrt{73}}{4}$

The solutions are $\frac{-3 + \sqrt{73}}{4}$ and $\frac{-3 - \sqrt{73}}{4}$.

Use the Quadratic Formula to solve each equation.

1. $x^2 + 4x + 4 = 0$ see notes
2. $n^2 - 8n - 9 = 0$
3. $x^2 + 5x = 8$ see notes
4. $m^2 + 18m = 0$
5. $t^2 - 8t + 7 = 0$
6. $k^2 - 10k + 25 = 0$
7. $n^2 - 9n = 0$
8. $2a^2 + a = -6$ see notes
9. $m^2 + m - 6 = 0$
10. $n^2 - 6n + 9 = 0$
11. $2y^2 + y = 5$
12. $-x^2 + 9x - 7 = 0$

1) $1x^2 + 4x + 4 = 0$

$(x+2)\cdot(x+2) = 0$

$x + 2 = 0$

$x = -2$

A = 1
B = 4
C = 4

$$x = \frac{-b \pm \sqrt{b^2 - 4AC}}{2A}$$

$$x = \frac{-(4) \pm \sqrt{(4)^2 - 4(1)(4)}}{2(1)}$$

P
E
M
D
A
S

$$x = \frac{-4 \pm \sqrt{16 - 16}}{2}$$

$$x = \frac{-4 \pm \sqrt{0}}{2} = \frac{-4 \pm 0}{2} = \frac{-4}{2} = -2$$

$(-2, 0)$

3) $x^2 + 5x = \cancel{8}$

$+{-8} = +\cancel{-8}$

$1x^2 + 5x + -8 = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4AC}}{2A}$$

$$x = \frac{-(5) \pm \sqrt{(5)^2 + {-4}(1)(-8)}}{2(1)}$$

$$x = \frac{-5 \pm \sqrt{25 + {+32}}}{2}$$

$$x = \frac{-5 \pm \sqrt{57}}{2}$$

$$x = \frac{-5 + \sqrt{57}}{2} \quad \text{or} \quad x = \frac{-5 - \sqrt{57}}{2}$$

8) $2A^2 + A = -\cancel{6}$

$+{+6} = +\cancel{+6}$

$\overset{A}{2A^2} + \overset{B}{1A} + \overset{C}{6} = 0$

A = 2
B = 1
C = 6

$$x = \frac{-b \pm \sqrt{b^2 - 4AC}}{2A}$$

$$x = \frac{-(1) \pm \sqrt{(1)^2 - 4 \cdot (2)(6)}}{2 \cdot (2)}$$

P
E
M
D
A
S

$$x = \frac{-(1) \pm \sqrt{+1 + {-(48)}}}{4}$$

$$x = \frac{-1 \pm \sqrt{-47}}{4}$$ → No real solutions

12) $-x^2+9x-7=0$

$$\frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$\frac{-9 \pm \sqrt{81-4(-1)(-7)}}{2(-1)}$$

$$\begin{array}{r} 81 \\ -28 \\ \hline 53 \end{array}$$

$$\frac{-9 \pm \sqrt{81-28}}{-2}$$

$$\frac{-9 \pm \sqrt{53}}{-2}$$

$$\frac{-9+\sqrt{53}}{-2} \qquad \frac{-9-\sqrt{53}}{-2}$$

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The Quadratic Formula

Use the Quadratic Formula to solve each equation.

1. $y^2 - 49 = 0$
2. $x^2 + 7x + 6 = 0$
3. $k^2 - 7k + 12 = 0$
4. $n^2 + 5n - 14 = 0$
5. $b^2 - 5b - 6 = 0$
6. $z^2 + 8z + 12 = 0$
7. $-q^2 + 5q - 4 = 0$
8. $a^2 - 9a + 22 = 0$
9. $c^2 - 4c = -3$
10. $x^2 + 9x = -14$
11. $h^2 - 2h = 8$
12. $m^2 + m = -4$
13. $-z^2 - 8z - 15 = 0$
14. $r^2 + 6r = -5$
15. $-h^2 + 6h = -7$
16. $g^2 + 12x + 20 = 0$
17. $w^2 + 10w = -9$
18. $2y^2 + 6y + 4 = 0$
19. $-2m^2 + 4m + 6 = 0$
20. $2x^2 + 8x = 10$
21. $2b^2 - 3b = -1$
22. $2p^2 + 6p + 8 = 0$
23. $3k^2 + 6k = 9$
24. $-3x^2 - 4x + 4 = 0$

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Exponential Functions

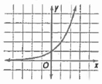
An **exponential function** is a function of the form $y = a^x$, where $a > 0$ and $a \neq 1$. If a is a value greater than one, then the function represents *exponential growth*. This can be very rapid growth, as in the case of $y = 2^x$, or less rapid growth as in the case of $y = 1.05^x$. To graph exponential functions, first make a table of ordered pairs.

x	2^x	y
−1	2^{-1}	0.5
0	2^0	1
1	2^1	2
2	2^2	4
3	2^3	8

x	1.05^x	y
−1	1.05^{-1}	0.95
0	1.05^0	1
1	1.05^1	1.05
2	1.05^2	1.1
3	1.05^3	1.16

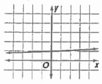
x	2^{2x}	y
−1	2^{-2}	0.25
0	2^0	1
1	2^2	4
2	2^4	16
3	2^6	64

$y = 2^x$



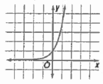
y-intercept = 1

$y = 1.05^x$



y-intercept = 1

$y = 2^{2x}$



y-intercept = 1

$\frac{3^{-1}}{1} = \frac{1}{3^1} = \frac{1}{3}$

$(-2, 2\frac{1}{16})$

$4^{-1} = \frac{1}{4^1} = \frac{1}{4}$

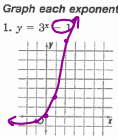
$4^{-2} = \frac{1}{4^2} = \frac{1}{16}$

$\frac{2^{-1}}{1} = \frac{1}{2^1} = \frac{1}{2}$

Graph each exponential function.

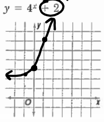
1. $y = 3^x - 1$

x	y
−1	$-\frac{2}{3}$
0	0
1	2
2	8
3	26



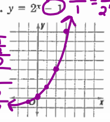
2. $y = 4^x + 2$

x	y
−1	$2\frac{1}{4}$
0	3
1	6
2	18
3	66



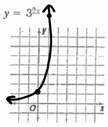
3. $y = 2^x - 1$

x	y
−1	$-\frac{1}{2}$
0	0
1	1
2	3
3	7

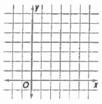


4. $y = 3^{2x}$

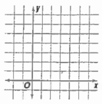
x	y
−2	$\frac{1}{81}$
−1	$\frac{1}{9}$
0	1
1	9
2	81



5. $y = 4^{2x}$



6. $y = 1.08^x$



$3^{2(2)} = 3^4 = 81$

$3^{2(1)} = 3^2 = 9$

$3^{2(0)} = 1$

$3^{2(-1)} = 3^{-2} = \frac{1}{3^2} = \frac{1}{9}$

$3^{2(-2)} = 3^{-4} = \frac{1}{3^4} = \frac{1}{81}$

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Practice

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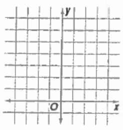
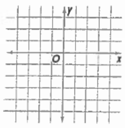
Exponential Functions

Graph each exponential function. Then state the y-intercept.

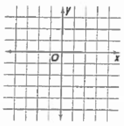
1. $y = 2^x + 3$



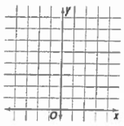
2. $y = 2^x - 2$



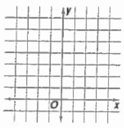
3. $y = 3^x - 4$



4. $y = 2^x + 4$

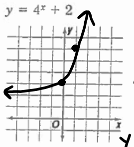


5. $y = 3^x + 1$



6. $y = 4^x + 2$

x	y
−2	$2\frac{1}{16}$
−1	$2\frac{1}{4}$
0	3
1	6
2	18

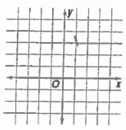


$4^{-1} = \frac{1}{4^1} = \frac{1}{4}$

$4^{-2} = \frac{1}{4^2} = \frac{1}{16}$

y-int: (0, 3)

7. $y = 3^x - 2$



8. $y = 2^x - 1$