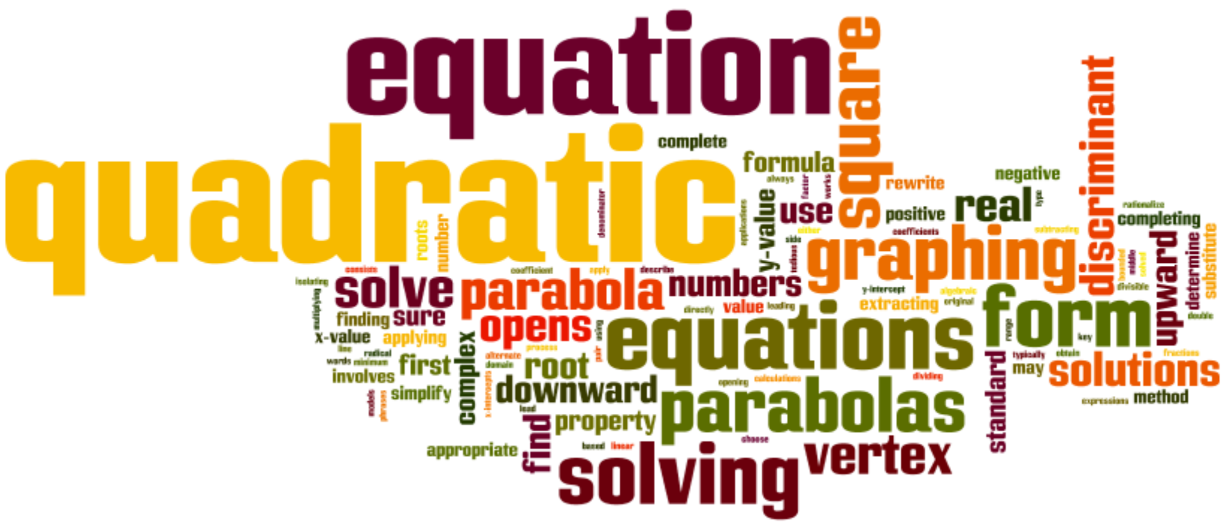
Applied 30S

Unit 1 – Quadratic Functions



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Learning checklist – Quadratics

Learning increases when you have a goal to work towards. Use this checklist as guide to track how well you are grasping the material. In the center column, rate your understand of the topic from 1-5 with 1 being the lowest and 5 being the highest. Be sure to write down any questions you have about the topic in the last column so that you know what you have yet to learn.

Outcome	Understanding	Questions
Demonstrate an understanding of the characteristics of quadratic functions, including - vertex - intercepts - domain and range - axis of symmetry		
Determine, with technology, the intercepts of the graph of a quadratic function or the roots of the corresponding quadratic equation.		
Explain the relationships among the roots of an equation, the zeros of the corresponding function, and the x -intercepts of the graph of the function.		
Explain, using examples, why the graph of a quadratic function may have zero, one, or two x intercepts.		
Express a quadratic equation in factored form, using the zeros of a corresponding function or the x -intercepts of its graph.		
Determine, with technology, the coordinates of the vertex of the graph of a quadratic function.		
Determine the equation of the axis of symmetry of the graph of a quadratic function, given the x -intercepts of the graph.		
Determine the coordinates of the vertex of the graph of a quadratic function, given the equation of the function and the axis of symmetry, and determine whether the y -coordinate of the vertex is a maximum or a minimum.		
Determine the domain and range of a quadratic function.		
Sketch the graph of a quadratic function.		
Solve, with technology, a contextual problem involving data that is best represented by graphs of quadratic functions, and explain the reasoning.		
Solve a contextual problem that involves the characteristics of a quadratic function.		

Factoring Polynomial Expressions - Review

Monomial by Monomial:

$(4x)(7x^2) =$ ______________________________

$(-6m^2n^3)(-7mn^2) =$ ______________________________

Monomial by Binomial: Distributive Property

$3x(x - 2) =$ ______________________________

$5y^2(x^2 - y) =$ ______________________________

Monomial by Trinomial:

$abc(3a + 4b - 2c) =$ ______________________________

$(2y^2 + 3y - 1)(4y) =$ ______________________________

Binomial by Binomial (F. O. I. L.):

$(2x - y)(3x + y) =$ ______________________________

$=$ ______________________________

$(x + 6)(x + 8) =$ ______________________________

$=$ ______________________________

$(x - 2y)(x + 2y) =$ ______________________________

$=$ ______________________________

$-3(x - 3y)(2x + 5y) =$ ______________________________

$=$ ______________________________

$=$ ______________________________

Binomial Squared: (F. O. I. L.)

$(x + y)^2 =$ ______________________________

$=$ ______________________________

$(x + 5)^2 =$ ______________________________

$=$ ______________________________

$(2x - y)^2 =$ ______________________________

$=$ ______________________________

$-4(3x + y)^2 =$ ______________________________

$=$ ______________________________

$=$ ______________________________

Prerequisite Skills: Simplify the following

a) $7x^2 - 3x + x^2 - x$

b) $(4x - 3)(x + 7)$

b) $(2x - 5)^2$

d) $(x - 1)^2 - (2x + 3)(x - 4)$

e) $3(2x - 7) - 4(x - 1)$

f) $5x(3x - 2)$

g) $(4x - 3)(2x + 5)$

h) $(5x - 4)^2$

Pre-Calculus 20S
Name:____________________

Binomial Products

1. $(a + 3)(a + 2) =$ ____

____

2. $(x - 1)(x - 2) =$ ____

____

3. $(2 + k)(3 + k) =$ ____

____

4. $(c - 5)(c - 3) =$ ____

____

5. $(y - 4)(y + 6) =$ ____

____

6. $(y + 5)(t - 1) =$ ____

____

7. $(3 - b)(4 + b) =$ ____

____

8. $(6v + 3)(v + 2) =$ ____

____

9. $(5 + 3x)(2 + x) =$ ____

10. $(y - 5)(2y - 2) =$ ______

11. $(m + 3)(3m - 2) =$ ______

12. $(2a + 3)(3a + 2) =$ ______

13. $(4 + 3p)(3 - 4p) =$ ______

14. $2(a + 3)(a + 2) =$ ______

15. $-3(y - 7)(y + 5) =$ ______

16. $(a - 3)(a + 3) =$ ______

17. $(5a + 3)(5a - 3) =$ ______

18. $(a^2 - 6)(a^2 + 6) =$ ______

19. $(a + 4)(a + 4) =$ ______

20. $(x - 3)^2 =$ ______________________________

21. $(2c + 5)^2 =$ ______________________________

22. $(4a - 3b)^2 =$ ______________________________

23. $(y + 3)(y^2 - 7y + 5) =$ ______________________________

24. $(a^2 - 3a + 11)(a - 3) =$ ______________________________

25. $(2x - 3)(2x^2 - 3xy + y^2) =$ ______________________________

Exercise 1: Factoring Review (Common and Simple Trinomial)

Factoring is the reverse process of ____________________. The better you are at multiplying, the better you will be at factoring.

Multiplication →

$5x(x - 2y) = 5x^2 - 10xy$

$(x - 3)(x + 5) = x^2 + 2x - 15$

Factoring →

$9x^2 - 15x = 3x(3x - 5)$

$x^2 + 8x + 15 = (x + 3)(x + 5)$

Common Factoring:

- When factoring, always begin by looking for any numbers or variables that is (are) common to (appears in) every term. It could be a number, a variable or both.
- Place this common factor in front of the parentheses, with the remaining polynomial inside the parentheses.
- Once this is done, the same number of terms as in the original question should be inside the brackets.

Examples: $8x - 32y$ = __________(____________) $b - b^2r^3c$ = __________(______ ______)

Common factor Remaining factor Common factor Remaining factor

$3x^3 - 6x^2y + 9xy^2$ = _________(__________________)

Common factor Remaining factor

- Factoring can always be quickly and easily checked by ______________ the ________________ together to see if the result is the same as the original polynomial.

Trinomial Factoring:

- When factoring a trinomial, you need to ask yourself: "*Where did it come from*?" Trinomials are most commonly the result of multiplying two binomials using ____________.

- For now, we will consider only trinomials where the lead coefficient in front of the "x^2" is one. If it is not 1, try to make it one by factoring out a common value amongst all terms.

Example: $x^2 + 5x + 6$

Difference
Outside
Inside
(__________)(____________)

① Once you have factored out any common terms/variables, the first terms of each binomial will simply be the square root of the first term of the trinomial.

② To determine the last terms of each binomial, we need to first identify the factors of the last term of the trinomial. In this case, the factors of 6 are: _____________ ; and _________

③ Next, determine which pair of factors either adds up to or subtracts to get the ______ term. (In this case: _____). These factors become the last terms of the binomial

④ Therefore, $x^2 + 5x + 6$ factors to (________)(________)

Check your factoring by multiplying using FOIL!

- There are <u>4</u> *types* of simple trinomials:

1. $x^2 + 8x + 12$ Sign in the __________ is ____ in both parentheses. $\Rightarrow$ $(x + 2)(x + 6)$
2. $x^2 - 8x + 16$ Sign in the __________ is __________ in both parentheses. $\Rightarrow$ $(x - 4)(x - 4)$
3. $x^2 - 5x - 24$ One middle sign is________, one is_______________. $\Rightarrow$ $(x + 3)(x - 8)$
4. $x^2 + 3x - 54$ One middle sign is__________, one is______________. $\Rightarrow$ $(x + 9)(x - 6)$

<u>Examples:</u> Factor the following trinomials:

1. $x^2 + 9x + 18$

① **Common** terms? Y/N The first term: _________

② **Factors** of _____:

③ Which of these pairs add/subtract to: ______

④ $\Rightarrow$ (_________)(__________)

<u>More Examples:</u>

2. $x^2 - 2x - 15 =$___________________________________ ④ $\Rightarrow$ (_________)(__________)

3. $x^2 - 6x + 5 =$___________________________________ ④ $\Rightarrow$ (_________)(__________)

4. $a^2 - 3a + 2 =$___________________________________ ④ $\Rightarrow$ (_________)(__________)

5. $a^2 + 10a + 24 =$_________________________________ ④ $\Rightarrow$ (_________)(__________)

6. $x^2 - 4x - 60 =$___________________________________ ④ $\Rightarrow$ (_________)(__________)

7. $x^2 + 8x =$_______________________________________ ④ $\Rightarrow$ (______)(_______)

8. $b^2 + b - 12 =$ ____________________________________ ④ $\Rightarrow$ (_________)(___________)

9. $2x^2 + 8x + 6 =$ ____________________________________

= ____________________________________ ④ $\Rightarrow$ __(________)(___________)

10. $xy^2 + xy - 13y =$ ____________________________________

= ____________________________________ ④ $\Rightarrow$ (___)(___________)

11. $x^2 - 6x + 9 =$ ____________________________________ ④ $\Rightarrow$ (______)(_____) = (________)

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Factoring Using F.O.I.L.

1. $x^2 + 10x + 24 =$ ____________________

2. $p^2 + 8p + 16 =$ ____________________

3. $c^2 - 17x + 72 =$ ____________________

4. $a^2 – 7a + 6 =$ ____________________

5. $x^2 - 14x + 49 =$ ____________________

6. $d^2 – 4d - 45 =$ ____________________

7. $m^2 – 15m + 50 =$ ____________________

8. $k^4 + 11k^2 + 30 =$ ____________________

9. $x^2 + 5x + 5 =$ ____________________

10. $a^2 – 5a + 4 =$ ____________________

11. $y^2 + 12y + 35 =$ ____________________

12. $z^2 – 12z + 35 =$ ____________________

13. $v^2 + 2v - 35 =$ ____________________

14. $d^2 – 2v - 35 =$ ____________________

15. $2x^2 + 12x + 10 =$ ____________________

16. $4y + 10 =$ ____________________

17. $6m^2 + 9m =$ ____________________

18. $4t^3 – 6t^2 =$ ____________________

19. $3p^3q^2r^2 – 4p^2q^2r =$ ____________________

20. $5a^2 + 10ab – 15b^2 =$ ____________________

<u>Exercise 1</u>: **Factoring $ax^2 + bx + c$**

- Recall: Factoring is the inverse of multiplication.

Example: Factor **$15x^2 + 48x + 36$**

Product-Sum-Factor **(PSF) Method**	
	① ALWAYS begin factoring by checking for common factors_______________ within each term.
	② From the remaining trinomial, calculate the product of the first and last coefficients.
	③ List all of the factors of this product. (List them as pairs)
	④ ④ From these *pairs* of factors, identify which pair, when <u>*added*</u> together, result in the middle term of the trinomial.
	⑤ Re-write the trinomial with the original first and last terms. In between these two terms, insert two new terms using the pair of factors from step ④. When inserting these two new terms, think about which two should go together. That is, which two coefficients have a common factor?
	⑥ Now factor the first two and the last two terms. (Notice how a common factor emerges.)
	⑦ Now factor again.
	⑧ **Check** your answer by expanding (multiplying using FOIL)

① Any common terms?

② Product of 1st & last coefficients?

③ Product factors (pairs)?

④ Which pair = Sum of middle term?

In summary, to factor a trinomial of the form **$ax^2 + bx + c$**, look for **two integers** with a **sum of b** and a **product of ac**.

Examples: Factor the following fully, *if possible*:

1. $3x^2 + 17x + 10 =$

2. $3y^2 - 10y + 8 =$

3. $8a^2 + 18a - 5 =$

4. $2c^2 + 2c - 3 =$

5. $5x^2 - 20xy + 20y^2 =$

6. $6b^4 + 7b^2 - 10 =$

7. $2d^3 + 7d^2 - 30d =$

8. $12 + 18e + 8e^2 =$

9. $9f^2 - 15f - 4 =$

10. $10g^2 - 3gh - h^2 =$

11. $6k^2 + 14km - 12m^2 =$

12. $24x^2z + 38xyz - 36zy^2 =$

Exercise 1: **Factoring Difference of Squares (& *Perfect* Squares)**

Example:

$x^2 - 16y^2$

A) Difference of Squares: $ax^2 - by^2$

- A difference of squares has 3 main features:
  1. The first term is a *perfect square*.
  2. The second term is a *perfect* square.
  3. They are separated by a *minus* sign.

- The middle term is missing because it is **0**.

Eg. $x^2 - 0xy - 16y^2$

- Factoring a perfect square *binomial* results in 2 almost identical factors, that differ only in the middle negative and positive signs. **Note: You can't factor if both middle terms are "+".**
- **To factor a difference of squares:**
  ① Remember to always begin factoring by looking for a **common** factor.
  ② The first term of the factors comes from the square root of the first term.
  ③ The second term of the factors comes from the square root of the second term.
  ④ Place a negative sign in one parentheses and a positive in the other.
  ⑤ **Check** the result by using FOIL.

Example from above: $x^2 - 16y^2 =$ (__________)(__________)

Examples:

1. $x^2 - 9 =$ (____________)(____________)

2. $225b^2 - a^2 =$ (_______________)(______________)

3. $49 + x^2 =$ (___________)(____________)

4. $-y^2 + 36 =$ (__________)(____________)

5. $3x^3 - 48x =$

$=$

6. $x^4 - 16 =$

Example:
$x^2 - 8xy + 16y^2$

B) **Perfect Square *Trinomials*: $ax^2 \pm bxy + cy^2$**

- A *perfect* square trinomial has *4* main features:
  1. The first term is a *perfect square*.
  2. The third term is a *perfect square*.
  3. The *sign* of the *3rd* term is always *positive*.
  4. The *middle* term is always *twice* the sum/difference of the outside/inside product of the binomials.

- Factoring a perfect square *trinomial* results in two **identical binomials**.

- **To factor a perfect square trinomial:**

① Remember to ALWAYS begin factoring by looking for a **common factor**.
② The first terms of the factors come from taking the square root of the first term of the trinomial.
③ The 2nd terms of the factors comes from taking the square roots of the 3rd term of the trinomial.
④ The middle signs of the factors will always be either positive or negative, depending on the sign of the middle term of the trinomial.
Remember: The last term of the trinomial is +. (+ × + = + or − × − = +)
⑤ **Check** the result by using FOIL.

Example: Factor: $x^2 - 8xy + 16y^2$ = (___________)(___________) =

Check:

Examples: Factor the following trinomials (1-5) fully, if possible.

1. $49 + 14x + x^2$ = (_____________)(____________)

2. $5b^3 - 40b^2 + 80b$ = _______(_______________________)

= _____(___________)(___________)

3. $4p^2 + 20pq + 25q^2$ =

4. $16y^2 + 24y - 9$ =

5. $121x^2 - 22x + 1$ =

6. The *volume* of a *rectangular* prism is represented by $2x^3 - 24x^2 + 72x$. What are possible *dimensions* of the prism?=_____(______________________)

= ____

Practice - Factoring ($ax^2 + bx + c$ and perfect squares)

Name: ____

Factor the following polynomials completely.

1. $5a^2 + 15a - 20$

2. $2b^2 + 2b - 112$

3. $9c^2 + 54c + 45$

4. $3d^2 + 15d - 108$

5. $7e^2 - 84e - 196$

6. $g^2 + 5gh + 6h^2$

7. $x^2y^2 + 5xy + 6$

8. $5km^2 - 40km + 35k$

9. $f^4 + 9f^2 + 14$

10. $2n^4 + 16n^2 + 30$

11. $6x^3y - 7x^2y^2 - 3xy^3$

12. $4s^2 - 21st - 18t^2$

13. $p^2 - 64$

14. $9r^2 - 81$

15. $16 - 49u^2$

16. $25v^2 - 169w^2$

17. $1 - 16x^4$

18. $y^4 - 16$

19. $63a^2b - 28b$

20. $81x^2 - (3x + y)^2$

21. $(5m - 2)^2 - (3m - 4)^2$

22. $(3y + 8z)^2 - (3y - 8z)^2$

1.1 Properties of Graphs of Quadratic Functions

A quadratic function can be written in the form

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

where a, b, and c are real numbers.

Vocabulary of Quadratic Functions:

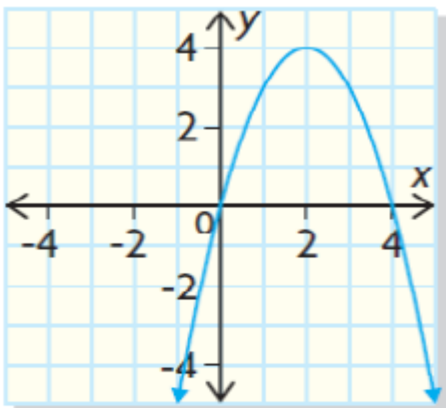
Definition: **Quadratic Function**	Diagram/Example:
Definition: **Quadratic Equation**	Diagram/Example:
Definition: **Parabola**	Diagram/Example:
Definition: **Vertex**	Diagram/Example:
Definition: **Axis of Symmetry**	Diagram/Example:

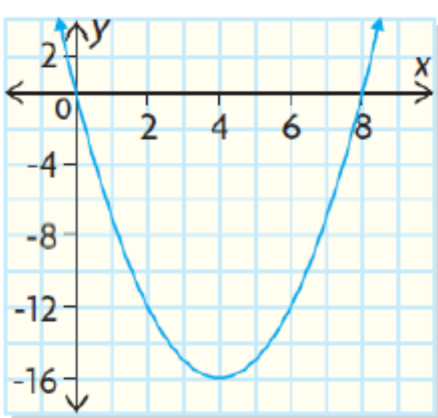
Definition: **Maximum Value of a Quadratic**	Diagram/Example:
Definition: **Minimum Value of a Quadratic**	Diagram/Example:
Definition: **Domain**	Diagram/Example:
Definition: **Range**	Diagram/Example:
Definition: ***x*-intercept or zeros**	Diagram/Example:
Definition: ***y*-intercept**	Diagram/Example:

Example 1: Identify Characteristics of Graphs of Quadratic Functions

For each of the following graphs:

a. Determine the equation for the axis of symmetry and draw it on the graph.
b. Determine the coordinates of the vertex of the parabola.
c. State the domain and range of the function.
d. Determine whether each parabola has a maximum or minimum value, and determine this value.
e. Identify the x-intercept(s) and y-intercept





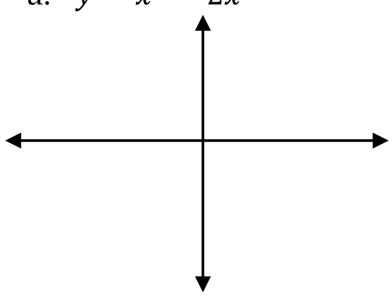
1.2 X-intercepts, Zeros, and Roots

To find the x-intercepts of a quadratic function using a calculator, follow these steps:

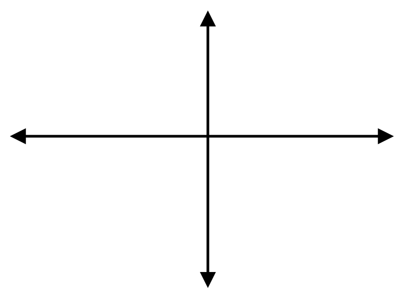
- Graph the function in Y_1=.
- Press GRAPH.
- Make sure you can see both x-intercepts on the screen – if not, change your window!
- Press 2nd Calc Zero.
    - Move your cursor to the left of the x-intercept you want to find and press enter.
    - Move your cursor to the right of the x-intercept you want to find and press enter.
    - Press enter again.

Example 1
Find the x-intercepts of the following quadratic functions. Sketch a graph of each function. LABEL each x-intercept.

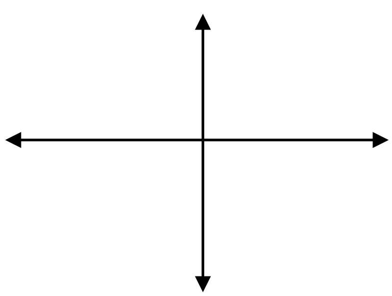
a. $y = x^2 - 2x$



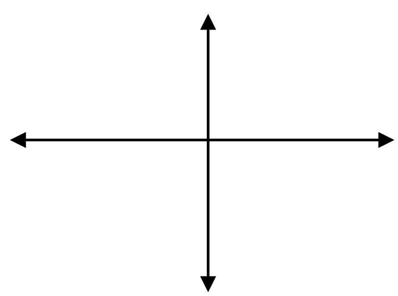
c. $y = -2x^2 + 3x + 4$



b. $y = x^2 + 2x - 3$



d. $y = x^2 + 4$

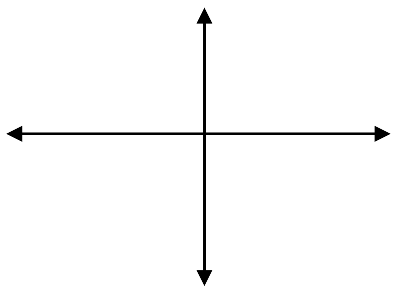


You can also solve quadratic equations by graphing the corresponding quadratic function.

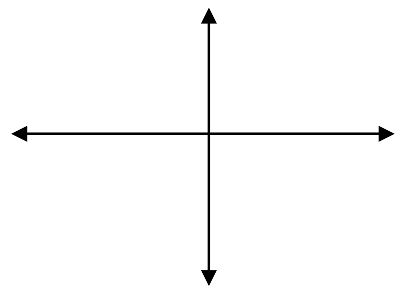
- The roots of a quadratic equation are the x-intercepts of the graph of the corresponding quadratic function. They are also the zeros of the corresponding quadratic function.

Example 2: Solving Quadratic Equations in Standard form
Solve each equation by graphing the corresponding function and determining the zeros.

a. $2x^2 - 5x - 3 = 0$



b. $-4x^2 + 9x = 0$



Standard form of a quadratic equation: ________________________

What happens if a quadratic equation is not in standard form?

Example 3: Rearranging Quadratic Equations Rearrange the following quadratic equations into standard form.

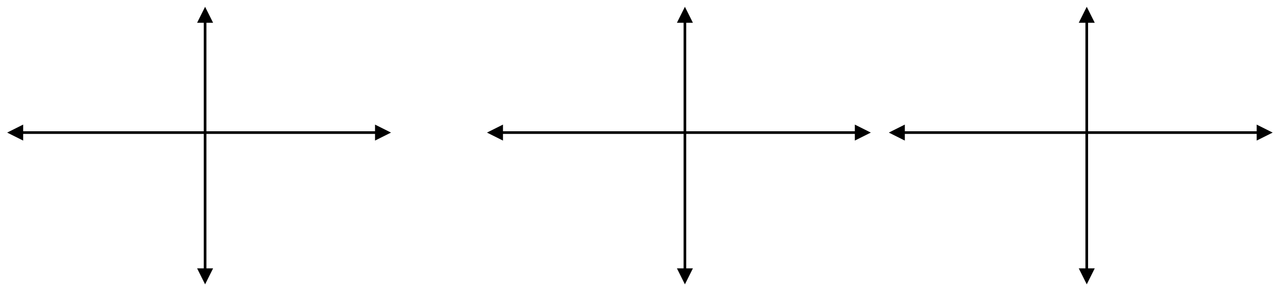
a. $x(7 - 2x) = x^2 + 1$

b. $4x(x + 3) = 3(4x + 3)$

Example 4: Solving a quadratic equation in non-standard form
Determine the roots of this quadratic equation.

$3x^2 - 6x + 5 = 2x(4 - x)$

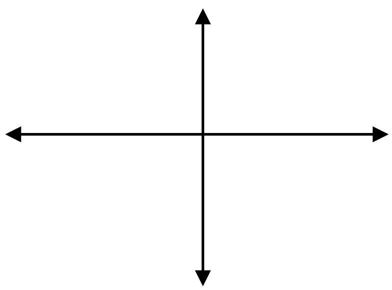
For any quadratic equation, there can be zero, one, or two real roots. This is because a parabola can intersect the x-axis in zero, one, or two places.



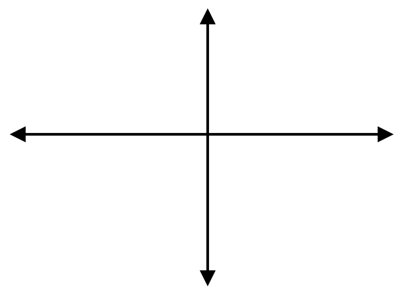
1.3 Factored Form of a Quadratic Function

Investigate:
Graph the following functions and determine the x-intercepts. What do you notice?

a. $y = (x + 2)(x - 3)$



b. $y = (x - 2)(x - 2)$



When a quadratic function is written in factored form each factor can be used to determine a zero of the function by setting each factor equal to zero and solving.

- If a parabola has one or two x-intercepts, the equation of the parabola can be written in factored form using the x-intercept(s) and the coordinates of one other point on the parabola.
- Quadratic functions without any zeros cannot be written in factored form.
- If a quadratic function has only one x-intercept, the factored form can be written as follows: ________________________________

Example 1: Factoring Review
Greatest Common Factor:

$-4x^2 + 12x$

Difference of Squares:

$x^2 - 49$

Trinomial, a = 1

$x^2 + 8x + 16$

Trinomial, $a \neq 1$

$6x^2 + 13x + 6$

Example 2:
Determine the x-intercepts of the following functions.

a. $y = (x - 3)(x + 7)$

b. $y = x^2 - 49$

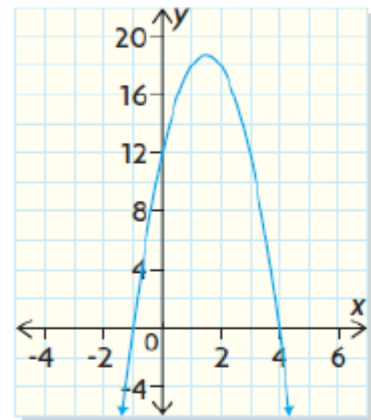
c. $y = x^2 - 14 + 45$

Example 3:

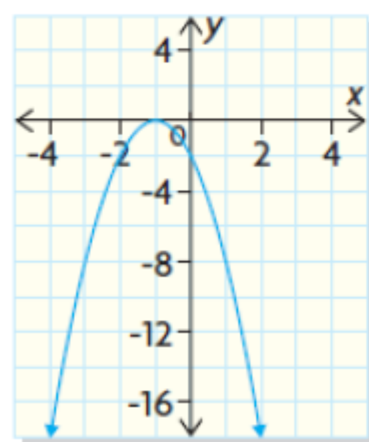
The x-intercepts of a function are 4 and -7. What is the equation of the function if the parabola is of standard width?

Example 4: Determine the equation of a quadratic function, given its graph

a. Determine the function that defines this parabola.
   i. Write the function in factored form.
   ii. Write the function in standard form.



b. Determine the function that defines this parabola.
   i. Write the function in factored form.
   ii. Write the function in standard form.



1.4 The Vertex

You can determine the coordinates of the vertex of a quadratic function by following these steps on your calculator:

- Graph the function in Y_1=.
- Press GRAPH.
- Change the window so you can see the vertex (if needed).
- Determine if the vertex is a maximum or a minimum.
- Press 2nd CALC and then either MAXIMUM or MINIMUM depending upon what your graph looks like.
- Move your cursor to the left of the vertex and press enter.
- Move your cursor to the right of the vertex and press enter.
- Press enter again. Your coordinates of the vertex will be displayed.

Example 1:
Determine the coordinates of the following quadratic functions using your calculator. State whether each vertex is a maximum or a minimum.

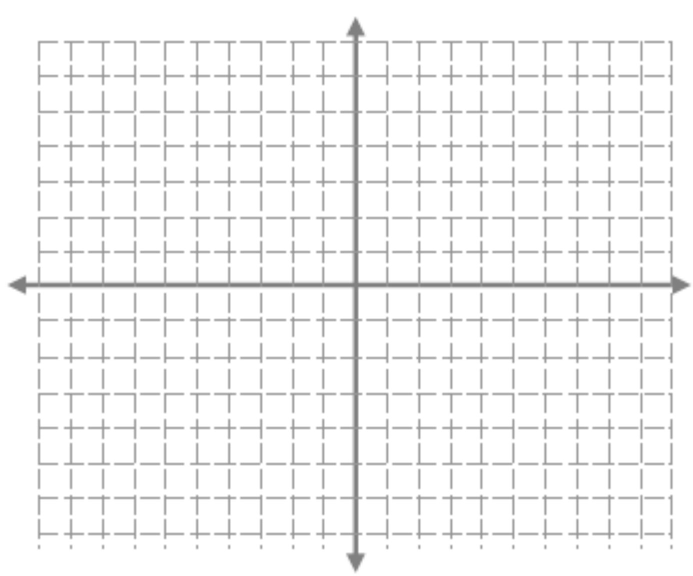
a. $y = 3x^2 - 2x + 5$

b. $y = x^2 - 4$

c. $y = -2x^2 + 7x - 3$

Example 2: Locating the Vertex Using Technology
A skier's coach determines the quadratic function that relates the skier's height above the ground, y, measured in metres, to the time, x, in seconds that the skier was in the air: $y = -4.9x^2 + 15x + 1$.

Graph the function. Then determine the skier's maximum height, to the nearest tenth of a metre, and state the range of the function for this context.



Axis of Symmetry Review!

The axis of symmetry is located in the middle of the parabola. What else is located in the middle of the parabola?

If you know the location of the axis of symmetry, you will be able to determine the location of the vertex.

Example 3:
A quadratic function $y = -3x^2 + 4x - 9$ has an axis of symmetry at $x = 1$.

a. Determine the coordinates of the vertex.

b. Determine if the vertex is a maximum or a minimum.

Given the location of the two x-intercepts, you are also able to determine both the location of the axis of symmetry. This is because parabolas are
________________________.

Example 4
Quadratic functions have the following x-intercepts. Determine the location of each axis of symmetry.

a. $x = 3$ and $x = -7$

b. $x = -2$ and $x = -8$

c. $x = 4$ and $x = 8$

1.5 Sketching Graphs of Quadratic Functions

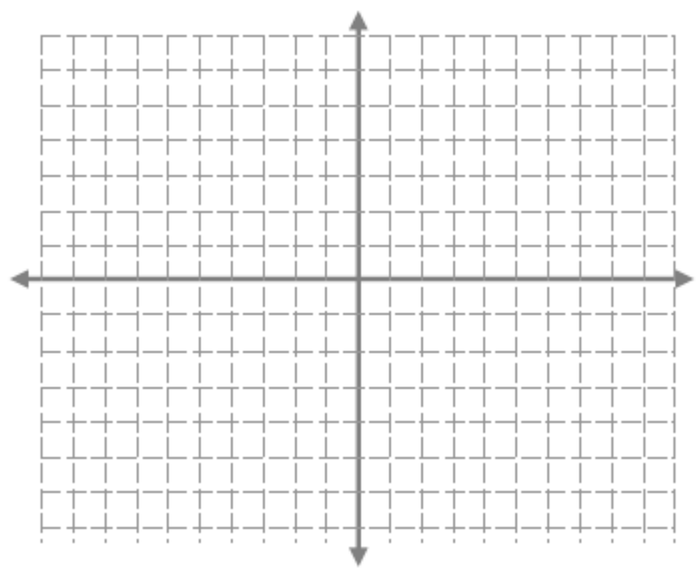
A properly labeled sketch of a quadratic function has the following characteristics:

- Labeled vertex
- Labeled x-intercept(s)
- Labeled y-intercept

Example 1: Graphing a Quadratic Function Using a Table of Values

Sketch the graph of the function $y = x^2 + 2x - 3$.

x	y
-3	
-2	
-1	
0	
1	



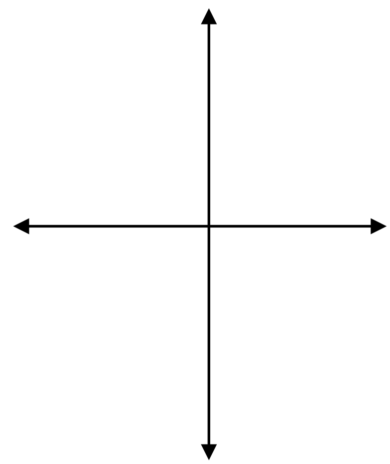
Determine the following:

- y-intercept
- x-intercepts
- equation of the axis of symmetry
- coordinates of the vertex
- domain
- range

Example 2: Graphing a quadratic function given in factored form
Sketch the graph of the quadratic function: $f(x) = 2(x+1)(x+6)$

Zeros:

y-intercept:



Equation of the axis of symmetry:

Vertex:

Domain:

Range:

Max/Min:

Example 3: Analyze the following quadratic function: $y = \frac{1}{2}(x-4)^2 - 2$

(1) direction of opening:

(2) vertex?

(3) max/min value?

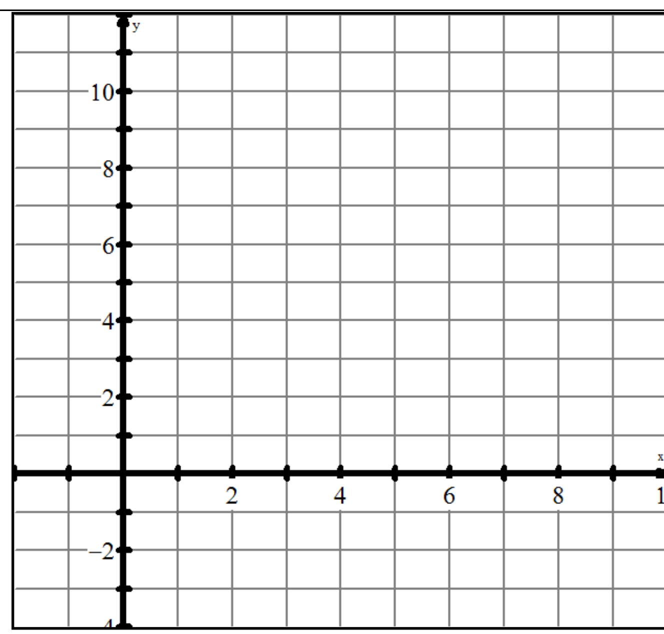
(4) y-intercept?

(5) zeroes?

(6) domain:

(7) range:

(8) axis of symmetry :



1.6 Solving Problems Using Quadratic Models

Example 1: You are an astronaut on the moon. You hit a golf ball with your golf club. The height of the ball, $h(t)$, in metres, over t, in seconds, could be modeled by the function: $h(t) = -0.81t^2 + 5t$. What is the maximum height of the ball?

Example 2: The engineers who designed the Coal River Bridge on the Alaska Highway in BC used a supporting arch with twin metal arcs. The function that describes the arch is $h(x) = -0.005061x^2 + 0.499015x$ where $h(x)$ is the height (in meters) of the arch above the ice at any distance, x (in meters) from one end of the bridge.

a. Determine the distance between the bases of the arch.

b. Determine the maximum height of the arch to the nearest tenth of a meter.

Example 3: The flight time for a long-distance water ski jumper depends on the initial velocity of the jump and the angle of the ramp. For one particular jump, the ramp has a vertical height of 5 m above water level. The height of the ski jumper in flight, *h(t)*, in metres, over time, *t*, in seconds, can be modelled by the following function:
$h(t) = 5.0 + 24.46t - 4.9t^2$

a. How long does this water ski jumper hold his flight pose?

b. When is the ski jumper 21 m above the ground?

c. What height is the ski jumper 3s after he takes off?

Example 5: The height of a baseball can be modeled by the function $f(x) = -4(x-3)^2 + 10$, where *x* is the time in seconds and *f(x)* is the height in metres.

a) When does the baseball reach its maximum height?

b) What is the maximum height of the baseball?