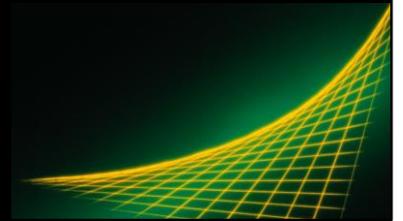
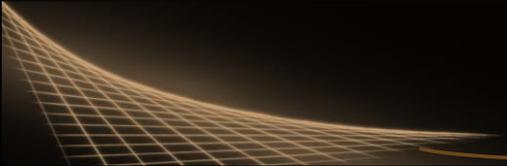


ALGEBRA 2
CHAPTER 4

QUADRATIC FUNCTIONS AND FACTORING

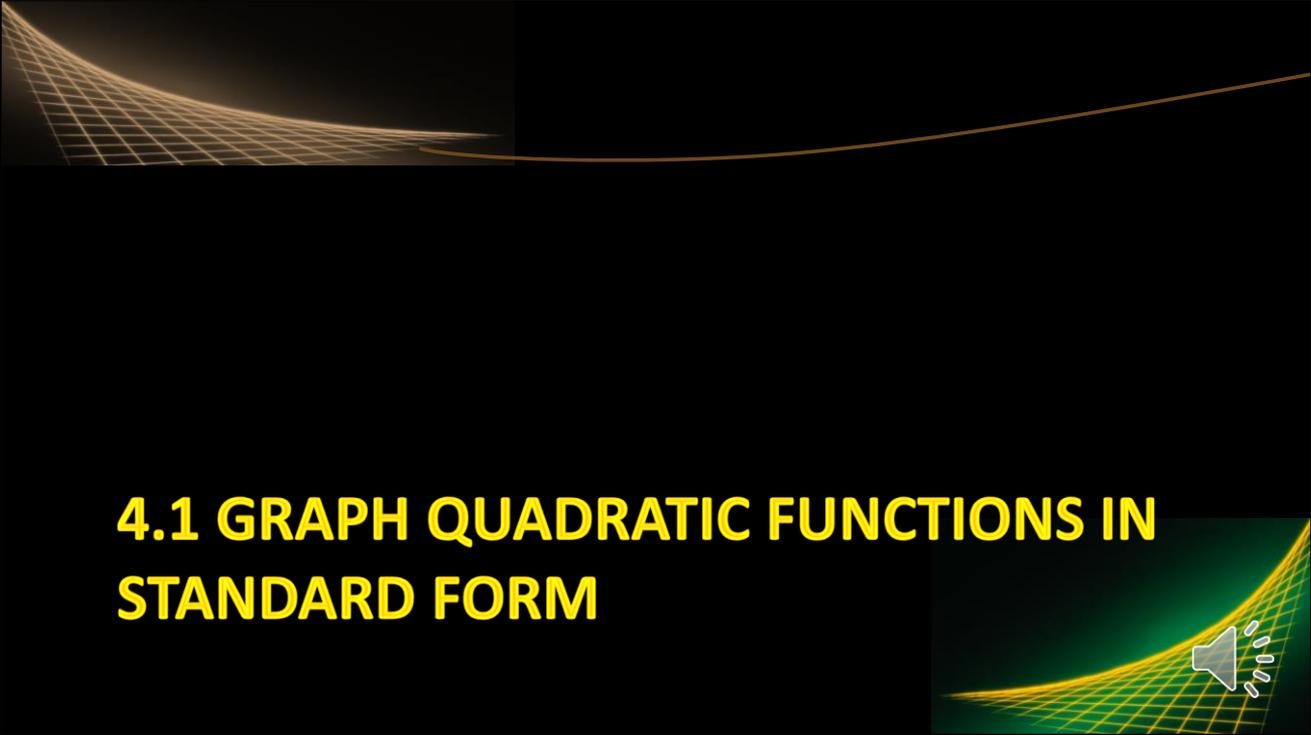


Algebra II 4

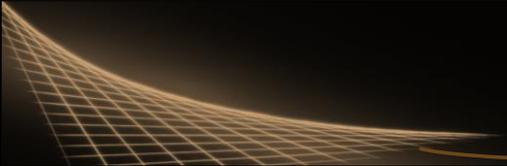
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The background features a dark field with a glowing grid pattern. A smooth, upward-curving line, characteristic of a parabola, is drawn across the top. The grid is colored in shades of orange and yellow, while the curve is a bright yellow. In the bottom right corner, there is a small icon of a speaker with sound waves, set against a greenish-yellow grid background.

4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

- 
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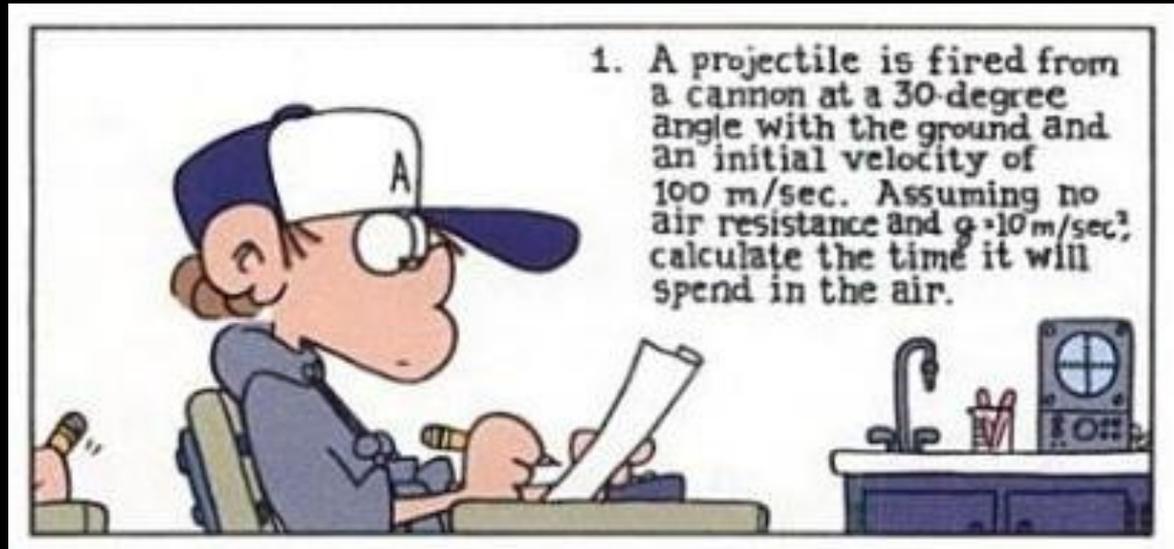
4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

- Many physical events can be modeled with quadratic equations such as projectile motion.
- The graph of a projectile versus time looks exactly like the path the projectile takes.

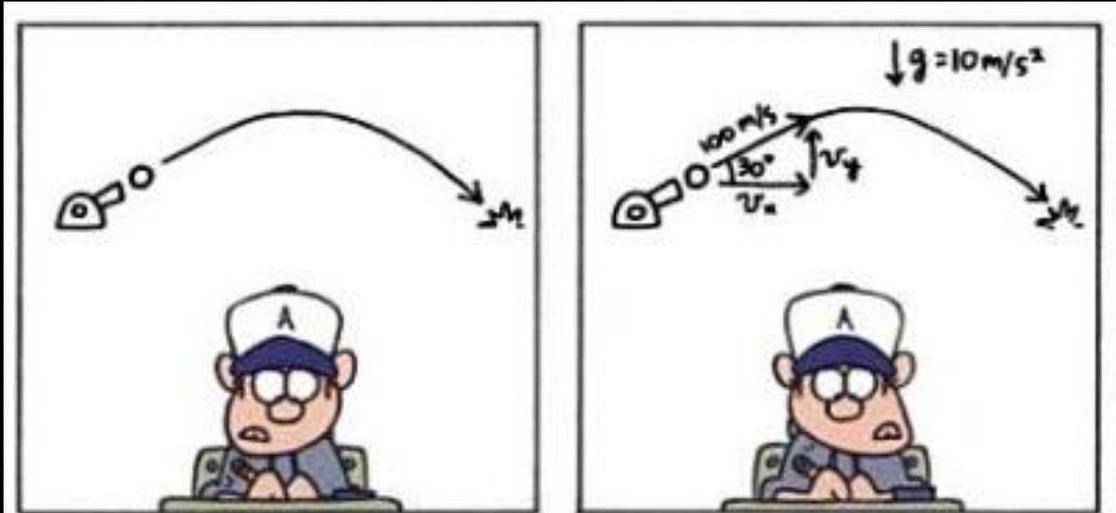
FoxTrot
BILL AMEND



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

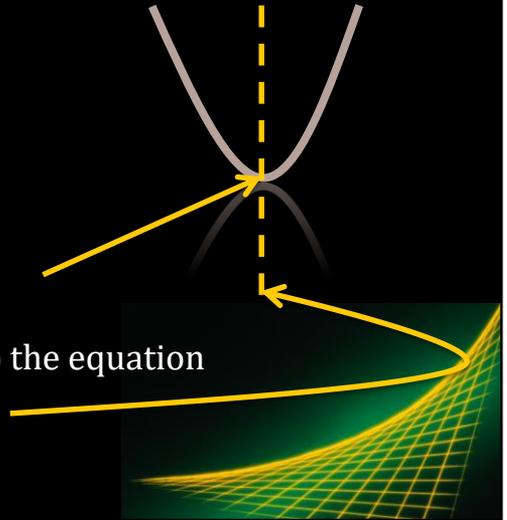


4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM



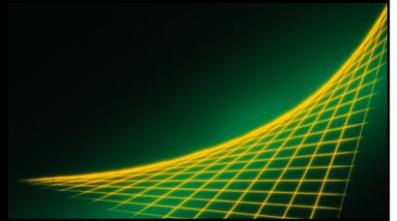
4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

- Quadratic Function
 - $y = ax^2 + bx + c$
- Shape is a “u” or **parabola**
 - Opens up if $a > 0$; down if $a < 0$
 - If $|a| > 1$, then narrower than $y = x^2$
 - If $|a| < 1$, then wider than $y = x^2$
- **Vertex** → highest or lowest point
 - x-coordinate is found by $-\frac{b}{2a}$
 - y-coordinate found by plugging $-\frac{b}{2a}$ into the equation
- Axis of symmetry → $x = -\frac{b}{2a}$



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

- How to Graph (Standard Form)
 - Find and plot the vertex
 - Make a table around the vertex
 - Draw the curve through all 5 points



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

• Graph $y = -x^2 + 2x$

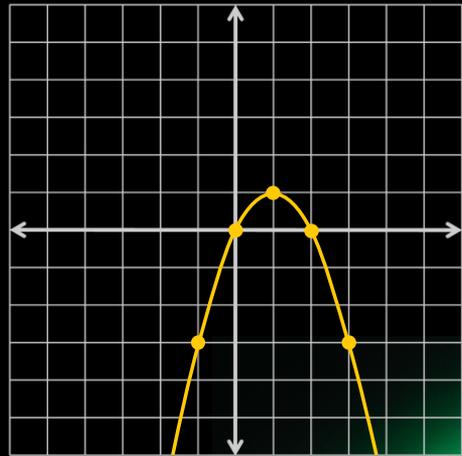
▪ Find the vertex

➤ $x = -\frac{b}{2a}$

➤ $x = -\frac{2}{2(-1)} = 1$

▪ Make a table of values with vertex in the middle

x	-2	-1	0	1	2	3	4
y	-8	-3	0	1	0	-3	-8



4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

• Graph $y = 2x^2 + 6x + 3$

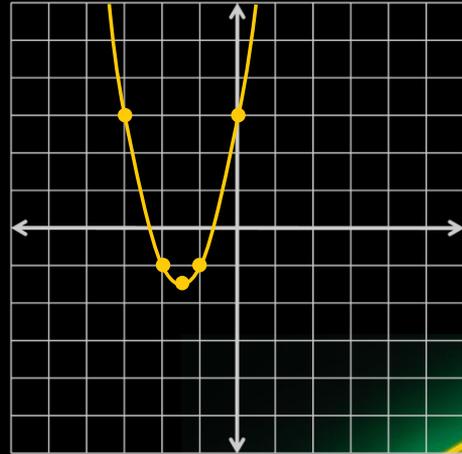
▪ Find the vertex

➤ $x = -\frac{b}{2a}$

➤ $x = -\frac{6}{2(2)} = -\frac{3}{2}$

▪ Make a table of values with vertex in the middle

x	-4	-3	-2	$-\frac{3}{2}$	-1	0	1
y	11	3	-1	$-\frac{3}{2}$	-1	3	11



Vertex at $(-1.5, -1.5) \rightarrow$ other points $(-3, 3), (-2, -1), (-1, -1), (0, 3), (1, 11)$

4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

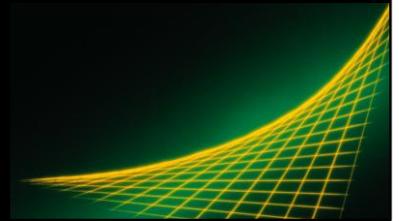
- Find the minimum value of $y = 4x^2 + 16x - 3$
 - The minimum of a quadratic is at the vertex.
 - $x = -\frac{b}{2a}$
 - $x = -\frac{16}{2 \cdot 4}$
 - $x = -2$
- Find the y-value by plugging in the x.
- $y = 4(-2)^2 + 16(-2) - 3$
- $y = -19$
- The minimum value is -19



Minimum occurs at vertex: $x = -b/2a \rightarrow x = -16/(2 \cdot 4) = -2$
 $y = 4(-2)^2 + 16(-2) - 3 = -19$
The minimum value is -19

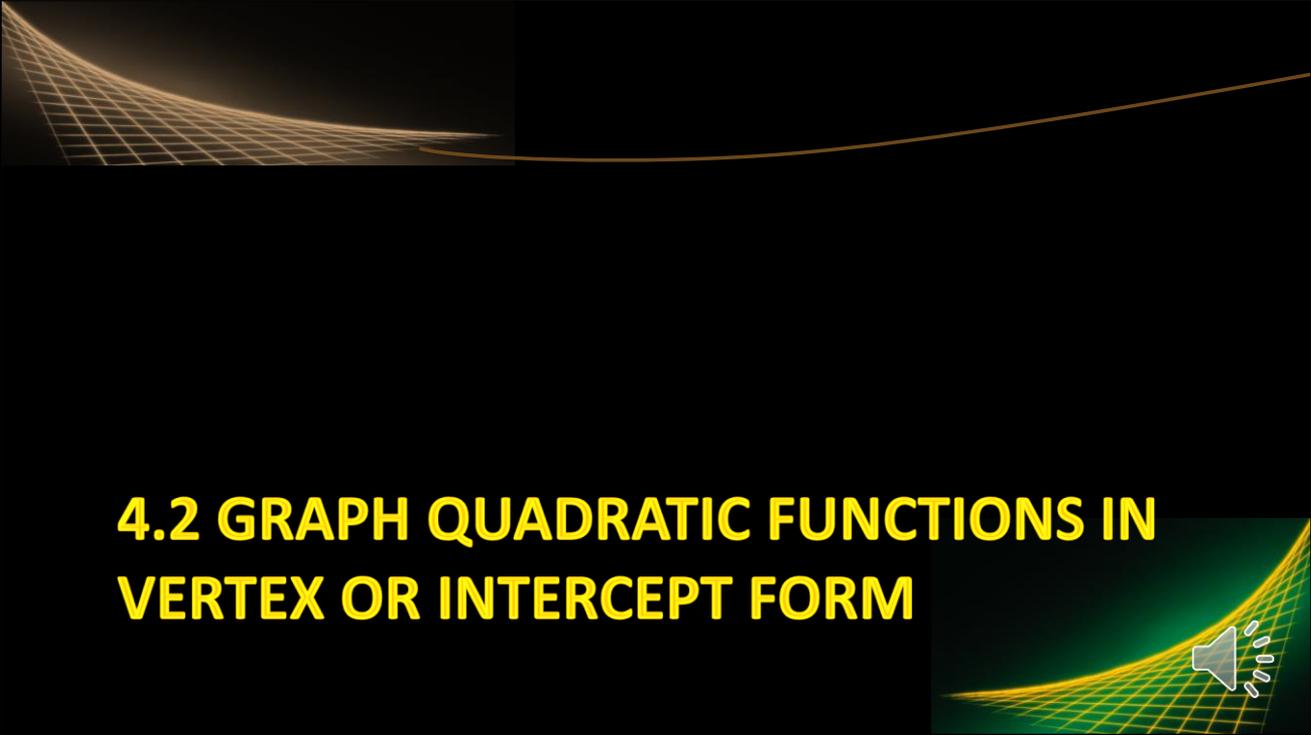
4.1 GRAPH QUADRATIC FUNCTIONS IN STANDARD FORM

- A video store sells about 150 DVDs a week for \$20 each. The owner estimates that for each \$1 decrease in price, about 25 more DVDs will be sold each week. How can the owner maximize weekly revenue?
- Revenue is how much money comes in.
- Revenue = Price \times Number sold
- Price = \$20 minus the \$1 \times number of decreases
- Number sold = 150 + 25 \times number of decreases
- $R = (20 - x)(150 + 25x)$
- $R = 3000 + 500x - 150x - 25x^2$
- $R = -25x^2 + 350x + 3000$
- Maximum occurs at vertex
- $x = -\frac{b}{2a}$
- $x = -\frac{350}{2(-25)} = 7$
- $y = -25(7)^2 + 350(7) + 3000 = 4225$
- The owner should drop the price 7 times making the revenue \$4225

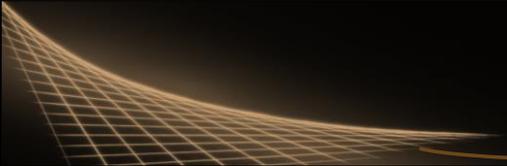


HOMEWORK QUIZ

- [4.1 Homework Quiz](#)

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4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

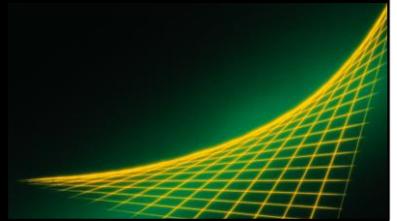
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4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

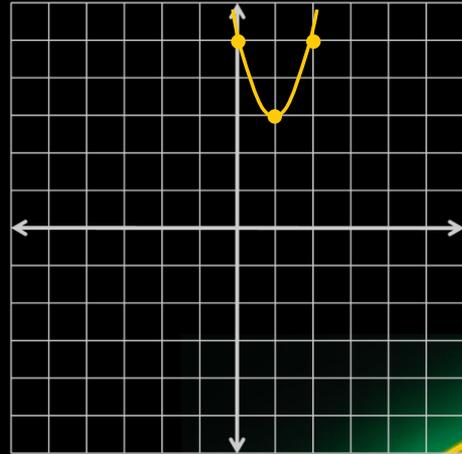
- Vertex Form
 - $y = a(x - h)^2 + k$
 - (h, k) is vertex
 - $x = h$ is axis of symmetry
- (h, k) is the vertex because, if h and $k = 0$, then $y = ax^2$
 - The vertex of this is zero (from yesterday)
 - We learned before that
 - h is how far the graph moves right
 - k is how far the graph moves up
- Graph same way as before
 - Find the vertex and make a table



4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- Graph $y = 2(x - 1)^2 + 3$
- Compare to $y = a(x - h)^2 + k$
- $a = 2$, $h = 1$ and $k = 3$
- Vertex is $(h, k) = (1, 3)$
- Make a table with $x = 1$ in the middle

x	-2	-1	0	1	2	3	4
y	21	11	5	3	5	11	21



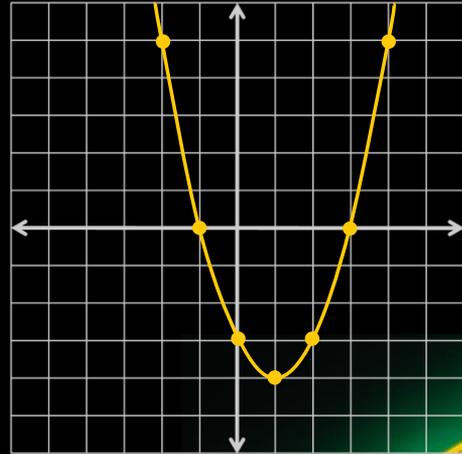
4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- Intercept Form
 - $y = a(x - p)(x - q)$
 - x -intercepts are p and q
 - axis of symmetry is halfway between p and q
- Graph the intercepts and find the axis of symmetry.
 - Vertex \rightarrow x -coordinate is axis of symmetry, plug in to equation to find y -coordinate

4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- Graph $y = (x - 3)(x + 1)$
- Compare to $y = a(x - p)(x - q)$
- $a = 1, p = 3, q = -1$
- x -int: 3 and -1
- Vertex is half-way between
 - $x = \frac{3+(-1)}{2} = 1$
- Make a table with $x = 1$ in center

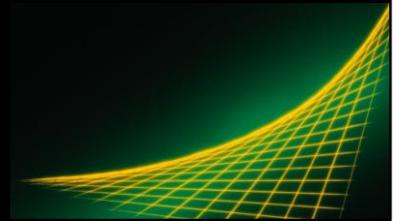
x	-2	-1	0	1	2	3	4
y	5	0	-3	-4	-3	0	5



Vertex at $(1, -4) \rightarrow$ x -int at $(3, 0)$ and $(-1, 0)$

4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- If an object is propelled straight upward from Earth at an initial velocity of 80 feet per second, its height after t seconds is given by $h(t) = -16t(t - 5)$.
 - How many seconds after it is propelled will the object hit the ground?
 - This is in intercept form
 $y = -16(t - 0)(t - 5)$
 - Thus it will be at zero height at the x -intercepts which are at $t = 0$ or $t = 5$ seconds
 - Choose the answer that makes sense:
 $t = 5$ s
 - What is the object's maximum height?
 - Maximum height occurs at the vertex:
 - x -intercepts are 0 and 5, so vertex is halfway between.
 - $t = \frac{0+5}{2} = 2.5$
 - Plug this into the function to get h
 - $h = -16(2.5)(2.5 - 5)$
 - $h = 100$ feet



This is in intercept form $y = -16(t - 0)(t - 5)$

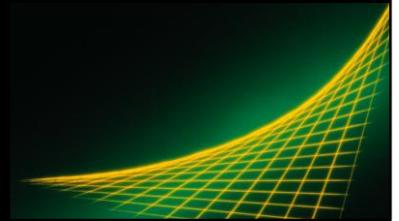
Thus it will be at zero height when either $(t - 0) = 0$ or $(t - 5) = 0$. $t - 5 = 0 \rightarrow t = 5$ seconds

Maximum height occurs at the vertex: intercepts are 0 and 5, so vertex is at $t = 2.5$
 $h(2.5) = -16(2.5)(2.5 - 5) = 100$ feet

4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

FOIL

- To multiply $(x + 2)(x - 3)$
 - First $\rightarrow x \cdot x = x^2$
 - Outer $\rightarrow -3x$
 - Inner $\rightarrow 2x$
 - Last $\rightarrow 2 \cdot -3 = -6$
 - Add together $\rightarrow x^2 - x - 6$
- To multiply $(x - 2)^2$
 - $(x - 2)(x - 2)$
 - FOIL
 - $x^2 - 4x + 4$



4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- Write the quadratic function in standard form
 - $y = -(x - 2)(x - 7)$
- FOIL
 - $y = -(x^2 - 7x - 2x + 14)$
- Simplify
 - $y = -(x^2 - 9x + 14)$
 - $y = -x^2 + 9x - 14$

$$y = -(x - 2)(x - 7) \rightarrow y = -(x^2 - 7x - 2x + 14) \rightarrow y = -(x^2 - 9x + 14) \rightarrow y = -x^2 + 9x - 14$$

4.2 GRAPH QUADRATIC FUNCTIONS IN VERTEX OR INTERCEPT FORM

- Write the quadratic function in standard form

- $f(x) = -(x + 2)^2 + 4$

- $(x + 2)^2 = (x + 2)(x + 2)$

- $f(x) = -(x + 2)(x + 2) + 4$

- FOIL

- $f(x) = -(x^2 + 2x + 2x + 4) + 4$

- Simplify

- $f(x) = \cancel{x^2} + 4x + 4 + 4$

- Distribute

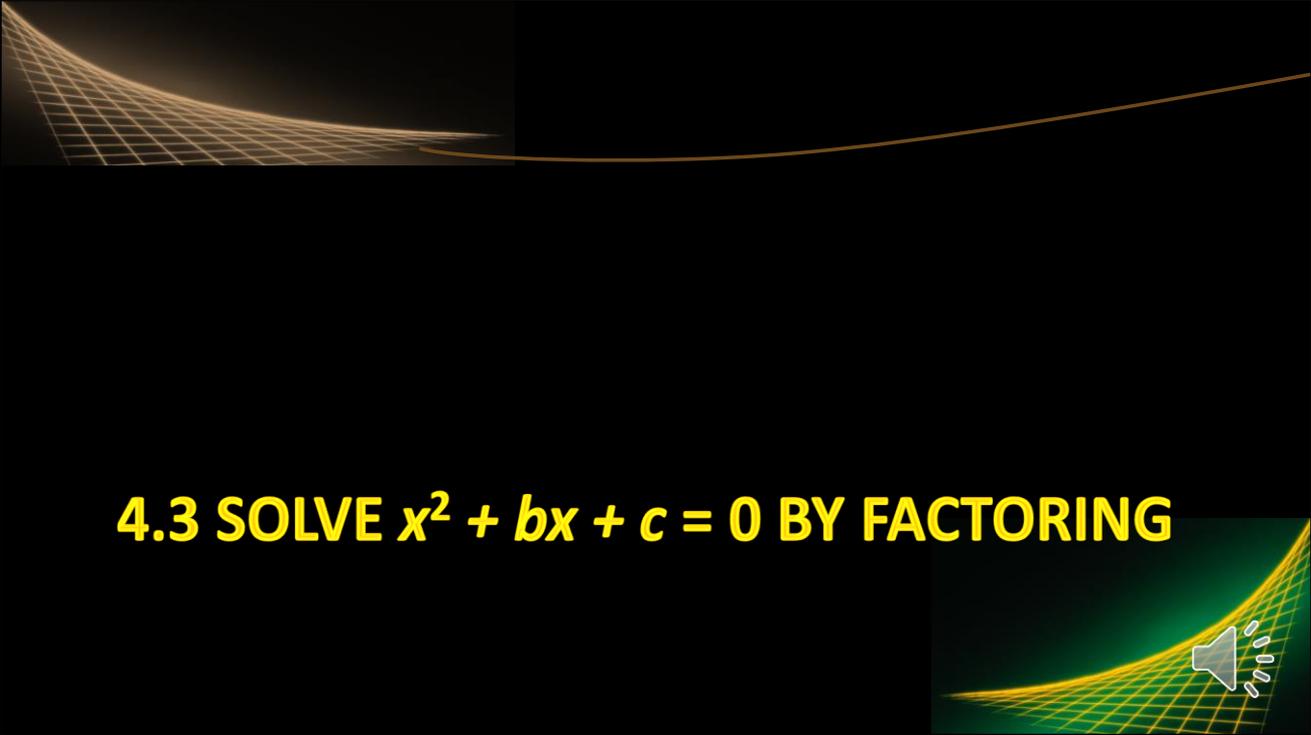
- $f(x) = -x^2 - 4x - 4 + 4$

- $f(x) = -x^2 - 4x$

$$f(x) = -(x + 2)^2 + 4 \rightarrow f(x) = -(x + 2)(x + 2) + 4 \rightarrow f(x) = -(x^2 + 2x + 2x + 4) + 4 \rightarrow f(x) = -(x^2 + 4x + 4) + 4 \rightarrow f(x) = -x^2 - 4x - 4 + 4 \rightarrow f(x) = -x^2 - 4x$$

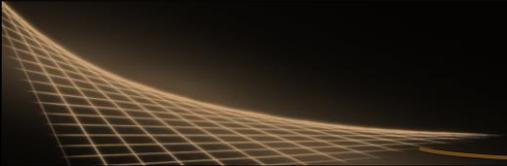
HOMWORK QUIZ

- [4.2 Homework Quiz](#)

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4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING



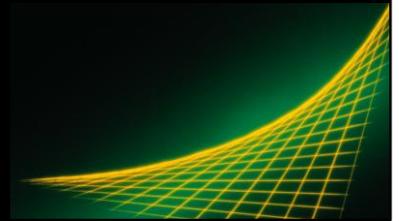
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4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Factoring is the opposite of FOILing
- Factoring undoes multiplication
- $(x + 2)(x + 5) = x^2 + 7x + 10$
 - $x + 2$ called **binomial**
 - $x^2 + 7x + 10$ called **trinomial**



4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Factoring trinomial
 - $ax^2 + bx + c$
- 1. Write two sets of parentheses ()()
- 2. Guess and Check
- 3. The Firsts multiply to make ax^2
- 4. The Lasts multiply to make c
- 5. Check to make sure the Outers + Inners make bx

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Factor the expression
 - $x^2 - 3x - 18$
 - ~~$(x - 9)(x + 2)$~~
 - Test outers + inners: $2x + -9x = -7x$
 - Not $-3x$ so doesn't work
 - $(x - 6)(x + 3)$
 - Test outers + inners: $3x + -6x = -3x$
 - This is $-3x$, so it works
 - $n^2 - 3n + 9$
 - ~~$(n - 3)(n - 3)$~~
 - Test outers + inners: $-3n + -3n = -6n$
 - Not $-3n$ so doesn't work
 - ~~$(n - 9)(n - 1)$~~
 - Test outers + inners: $-1n + -9n = -10n$
 - Not $-3n$, so doesn't work
 - We have no more factors of 9 so this is not factorable

$$(x - 6)(x + 3)$$

Cannot be factored

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Factor the expression
 - $r^2 + 2r - 63$
 - ~~$(r - 9)(r + 7)$~~
 - Test outers + inners: $7r + -9r = -2r$
 - Not $2r$ so doesn't work
 - $(r + 9)(r - 7)$
 - Test outers + inners: $-7r + 9r = 2r$
 - This is $2r$, so it works

$$(r + 9)(r - 7)$$

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Special patterns
 - Difference of Squares
 - $a^2 - b^2 = (a - b)(a + b)$
 - Perfect Squares
 - $a^2 \pm 2ab + b^2 = (a \pm b)^2$
- Factor
 - $x^2 - 9$
 - Difference of squares
 - $x^2 - 3^2$
 - $(x - 3)(x + 3)$

Difference of Squares: $x^2 - 9 = (x - 3)(x + 3)$

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Special patterns
 - Difference of Squares
 - $a^2 - b^2 = (a - b)(a + b)$
 - Perfect Squares
 - $a^2 \pm 2ab + b^2 = (a \pm b)^2$
- Factor
 - $w^2 - 18w + 81$
 - Perfect Square
 - $w^2 - 2 \times 9 \times w + 9^2$
 - $(w - 9)^2$

Perfect Squares: $w^2 - 18w + 81 = (w - 9)^2$

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Solving quadratic equations by factoring
 - The solutions to quadratic equation are called zeros
- Zero Product Property
 - Zero times anything = 0
 - If $ab = 0$, then $a = 0$, $b = 0$, or both.
 - Thus we can factor a quadratic equation (remember factoring gives you at least two pieces multiplied together) and set each factor equal to zero to solve.

4.3 SOLVE $x^2 + bx + c = 0$ BY FACTORING

- Solve

- $x^2 - x - 42 = 0$

- $(x - 7)(x + 6) = 0$

- Check outers + inners = bx :
 $6x + -7x = -x$ ✓

- $x = 7$ $x = -6$

- Solutions are $x = -6, 7$

- $x^2 - 8x + 16 = 0$

- $(x - 4)(x - 4) = 0$

- Check outers + inners = bx :
 $x - 4 = 0$ $x = 4 = 0$

- $-4x + -4x = -8x$ ✓ $x = 4$

- Solutions are $x = 4$

$$x^2 - 8x + 16 = 0 \rightarrow (x - 4)(x - 4) = 0 \rightarrow$$

$$x - 4 = 0 \rightarrow x = 4$$

Solutions are $x = 4$

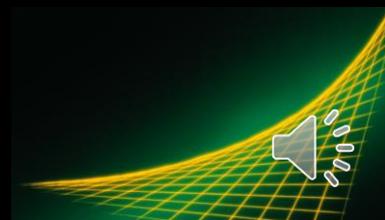
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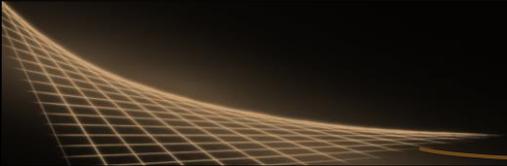
- Finding Zeros
 - Zeros are the values of x when $y = 0$
 - Also called x -intercepts or roots
 - When you find zeros make $y = 0$ and solve
- Find the zeros of $y = x^2 - 7x - 30$ by rewriting the function in intercept form.
 - $y = x^2 - 7x - 30$
 - $y = (x - 10)(x + 3)$
 - $x - 10 = 0$ $x + 3 = 0$
 - $x = 10$ $x = -3$
 - Zeros are -3, 10

HOMWORK QUIZ

- [4.3 Homework Quiz](#)

**4.4 SOLVE $ax^2 + bx + c = 0$ BY
FACTORING**



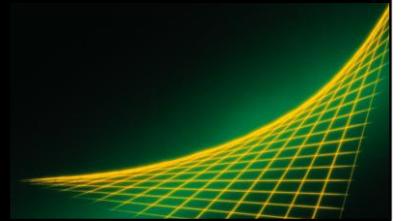
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4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- Very similar to yesterday's lesson
- Two differences
 - Factor monomial first
 - Make a work just like c



4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- Monomial First
 - Factor out any common terms first, then factor what's left
- $14x^2 + 2x - 12$
- $2(7x^2 + x - 6)$
- $2(7x - 6)(x + 1)$
- Check outers + inners:
 - $7x + -6x = x$ ✓
- $3x^2 - 18x$
- $3x(x - 6)$
- There are no more x 's with exponents and we factored the monomial, so we are done factoring.

$$\rightarrow 2(7x^2 + x - 6) \rightarrow 2(7x - 6)(x + 1)$$

$$\rightarrow 3x(x - 6)$$

4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- Factor

- $12x^2 + 3x + 3$

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

- ~~▪ $3(4x + 1)(x + 1)$~~

- Check outers + inners:

- $4x + 1x = 5x$ Nope

- ~~▪ $3(2x + 1)(2x + 1)$~~

- Check $2x + 2x = 4x$ Nope

- No other options, so just

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

- $2x^2 - 32$

- $2(x^2 - 16)$

- Difference of squares

- $2(x - 4)(x + 4)$

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

$$2(x^2 - 16) \rightarrow 2(x - 4)(x + 4)$$

4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- Solve
 - $9t^2 - 12t + 4 = 0$
 - Monomial first: there is none
 - $(3t - 2)(3t - 2) = 0$
 - Check outers + inners:
 ▪ Each factor $\equiv 0$ ✓
 $-6t + -6t = -12t$ ✓
 - $3t - 2 = 0$
 - $3t = 2$
 - $t = \frac{2}{3}$
- $3x - 6 = x^2 - 10$
- Put in standard form (subtract $3x$ and add 6)
 - $0 = x^2 - 3x - 4$
- Factor
 - $0 = (x - 4)(x + 1)$
- Check outers + inners:
 ▪ Each factor $= 0$ ✓
 $1x + -4x = -3x$ ✓
 - $x - 4 = 0$ $x + 1 = 0$
 - $x = 4$ $x = -1$

ANS: $(3t - 2)^2 = 0 \rightarrow 3t - 2 = 0 \rightarrow 3t = 2 \rightarrow t = 2/3$

ANS: Put in standard form

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

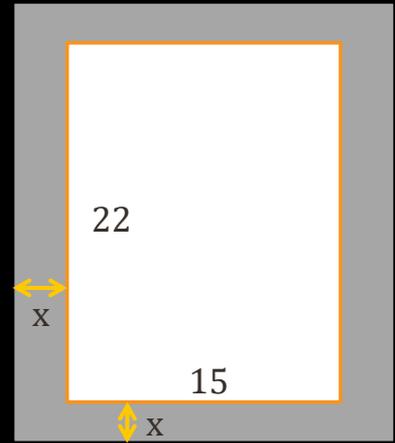
$$(x - 4)(x + 1) = 0$$

$$x - 4 = 0 \rightarrow x = 4$$

$$x + 1 = 0 \rightarrow x = -1$$

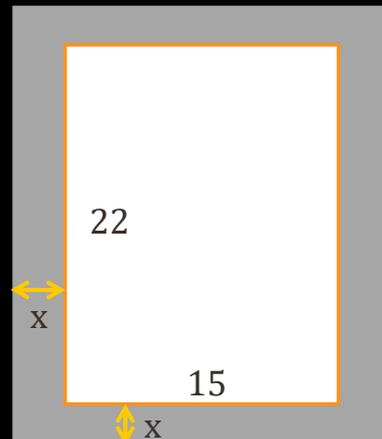
4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- You are designing a garden. You want the garden to be made up of a rectangular flower bed surrounded by a border of uniform width to be covered with decorative stones. You have decided that the flower bed will be 22 feet by 15 feet, and your budget will allow for enough stone to cover 120 square feet. What should be the width of the border?



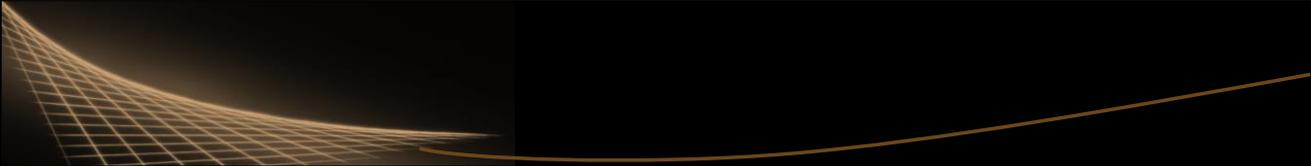
4.4 SOLVE $ax^2 + bx + c = 0$ BY FACTORING

- Outer rectangle area - inner rectangle area = 120
- $(2x + 22)(2x + 15) - (22)(15) = 120$
- $4x^2 + 30x + 44x + 330 - 330 = 120$
- $4x^2 + 74x = 120$
- $4x^2 + 74x - 120 = 0$
- Factor monomial:
 - $2(2x^2 + 37x - 60) = 0$
- Factor trinomial:
 - $2(2x - 3)(x + 20) = 0$
- Each factor = 0
 - $2x - 3 = 0$ $x + 20 = 0$
 - $2x = 3$ ~~$x = -20$~~
 - $x = \frac{3}{2}$ Can't use negative numbers
- Border is $\frac{3}{2}$ feet or 1.5 feet or 18 inches



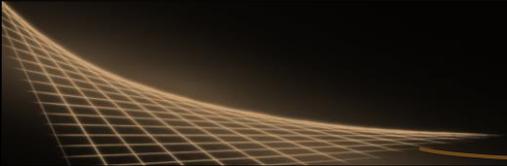
HOMEWORK QUIZ

- [4.4 Homework Quiz](#)



4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS



- 
- This Slideshow was developed to accompany the textbook
 - *Larson Algebra 2*
 - *By Larson, R., Boswell, L., Kanold, T. D., & Stiff, L.*
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4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Find
 - $\sqrt{36}$
➤ 6
 - $\sqrt{9}$
➤ 3
 - $\sqrt{4}$
➤ 2
- What do you notice?
 - $6 = 3 \times 2$ and $\sqrt{36} = \sqrt{9} \times \sqrt{4}$

$$\sqrt{36} = \sqrt{9}\sqrt{4}$$

4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Square Root Definition
 - If $a^2 = b$, then a is the square root of b
 - A positive number has 2 square roots shown by \sqrt{b} and $-\sqrt{b}$

radical sign $\sqrt{36}$ radicand

- Expression with radical sign is called a radical expression
- Simplifying
 - All perfect squares taken out
 - No radicals in denominator

The term radical comes from Latin “radix” which means “root”. Other terms with same root: “Radish”, “eradicate” (pull out be roots)

4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Properties of square roots
- Product Property
 - $\sqrt{ab} = \sqrt{a}\sqrt{b}$
- Quotient Property
 - $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$
- Simplify
 - $\sqrt{500}$
 - $\sqrt{100}\sqrt{5}$
 - $10\sqrt{5}$
 - $3\sqrt{12}\sqrt{6}$
 - $3\sqrt{72}$
 - $3\sqrt{36}\sqrt{2}$
 - $3(6)\sqrt{2}$
 - $18\sqrt{2}$

4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Simplify

- $\sqrt{\frac{25}{3}}$

- $\frac{5}{\sqrt{3}}$

- $\frac{5\sqrt{3}}{\sqrt{3}\sqrt{3}}$

- $\frac{5\sqrt{3}}{3}$

Multiply top and bottom by conjugate $(2 - \sqrt{3})$ to

remove the radical from the denominator.

Multiply top and bottom by $\sqrt{3}$ to remove the radical from the denominator.

- $\frac{5}{2+\sqrt{3}}$

- $\frac{5(2-\sqrt{3})}{(2+\sqrt{3})(2-\sqrt{3})}$

- $\frac{10-5\sqrt{3}}{4-3}$

- $10 - 5\sqrt{3}$

4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Solving Quadratic Equations by finding square roots
 - When? Only 1 term with x and it is squared
 - Isolate the square and then take the $\pm\sqrt{\quad}$

- Solve
 - $3 - 5x^2 = -9$
 - $-5x^2 = -12$
 - $x^2 = \frac{12}{5}$
 - $x = \pm\sqrt{\frac{12}{5}}$
 - $x = \pm\frac{\sqrt{12}}{\sqrt{5}}$
 - $x = \pm\frac{2\sqrt{3}\sqrt{5}}{\sqrt{5}\sqrt{5}}$
 - $x = \pm\frac{2\sqrt{15}}{5}$

Solve for the x^2 .

Rationalize the denominator by multiplying top and bottom by $\sqrt{5}$.

ANS: $-5x^2 = -12 \rightarrow x^2 = 12/5 \rightarrow x = \pm\sqrt{(12/5)} \rightarrow x = \pm\sqrt{12/\sqrt{5}} \rightarrow x = \pm 2\sqrt{3} \sqrt{5} / \sqrt{5} \sqrt{5} \rightarrow x = \pm 2\sqrt{15} / 5$

ANS: $(x - 2)^2 = 7 \rightarrow x - 2 = \pm\sqrt{7} \rightarrow x = 2 \pm \sqrt{7}$

4.5 SOLVE QUADRATIC EQUATIONS BY FINDING SQUARE ROOTS

- Solve

- $3(x - 2)^2 = 21$

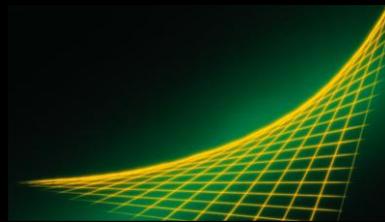
Solve for the squared portion.

- $(x - 2)^2 = 7$

- $x - 2 = \pm\sqrt{7}$

Take \pm square root.

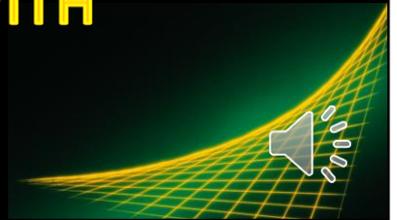
- $x = 2 \pm \sqrt{7}$

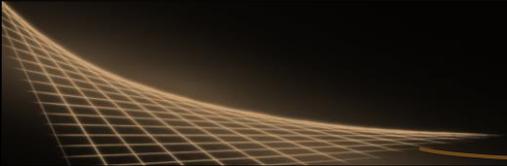


HOMWORK QUIZ

- [4.5 Homework Quiz](#)

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS



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4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- When we were young we learned to count.
- Then as we got older we learned to operate with combining those counting numbers.
- Next we learned about negative numbers and fractions. With this came more rules for the operations.
- Finally we are going to learn about complex numbers and the rules for dealing with them.

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

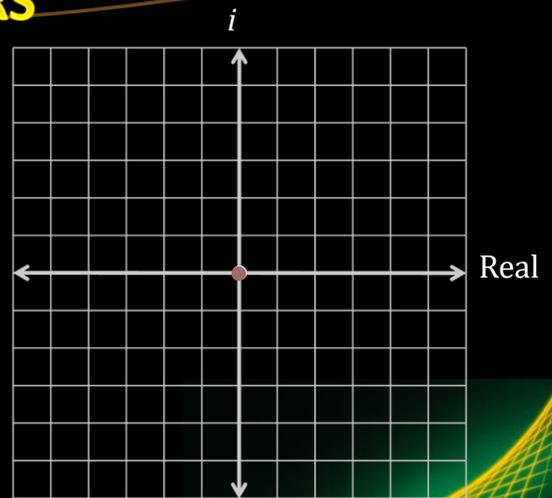
- Imaginary Number (imaginary unit)
 - i
 - $i = \sqrt{-1}$
 - $i^2 = -1$
- Simplify
 - $\sqrt{-9}$
 - $\sqrt{9}\sqrt{-1}$
 - $3i$
 - $\sqrt{-12}$
 - $\sqrt{4}\sqrt{3}\sqrt{-1}$
 - $2\sqrt{3}i$

$$\rightarrow 3i$$

$$\rightarrow i\sqrt{4}\sqrt{3} \rightarrow 2i\sqrt{3}$$

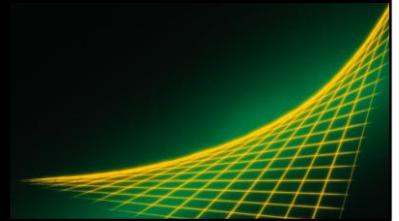
4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Complex Number
 - Includes real numbers and imaginary numbers
- Imaginary numbers are any number with i
 - $(a + bi)$ where a and b are real
- Plotting
 - Complex plane \rightarrow x -axis is the real axis; y -axis is the imaginary axis
- Plot
 - $-4 - i$
 - 5
 - $1 + 3i$



4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Adding and Subtracting Complex Numbers
 - Add the same way you add
 $(x + 4) + (2x - 3) = 3x + 1$
 - Combine like terms
- Simplify
 - $(-1 + 2i) + (3 + 3i)$
 - $(-1 + 3) + (2i + 3i)$
 - $2 + 5i$



4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Simplify
 - $(2 - 3i) - (3 - 7i)$
 - $(2 - 3) + (-3i - -7i)$
 - $-1 + 4i$
 - $2i - (3 + i) + (2 - 3i)$
 - $(-3 + 2) + (2i - i + -3i)$
 - $-1 - 2i$

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Multiplying complex numbers
 - FOIL
 - Remember $i^2 = -1$
- Multiply
 - $-i(3 + i)$
 - $-3i - i^2$
 - $-3i - (-1)$
 - $1 - 3i$

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Multiply

- $(2 + 3i)(-6 - 2i)$
- $-12 - 4i - 18i - 6i^2$
- $-12 - 22i - 6(-1)$
- $-12 - 22i + 6$
- $-6 - 22i$

- $(1 + 2i)(1 - 2i)$
- $1 - 2i + 2i - 4i^2$
- $1 - 4(-1)$
- $1 + 4$
- 5

$$-3i - i^2 = 1 - 3i$$

$$-12 - 4i - 18i - 6i^2 = -6 - 22i$$

$$1 - 2i + 2i - 4i^2 = 5$$

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Notice on the last example that the answer was just real
- **Complex conjugate** → same numbers just opposite sign on the imaginary part
 - When you multiply complex conjugates, the product is real
- Dividing Complex Numbers
 - To divide, multiply the numerator and denominator by the complex conjugate of the denominator
 - No imaginary numbers are allowed in the denominator when simplified

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Divide

- $\frac{2-7i}{1+i}$

- $\frac{(2-7i)(1-i)}{(1+i)(1-i)}$

- $\frac{2-2i-7i+7i^2}{1-i+i-i^2}$

Multiply the top and bottom by the conjugate of the denominator.

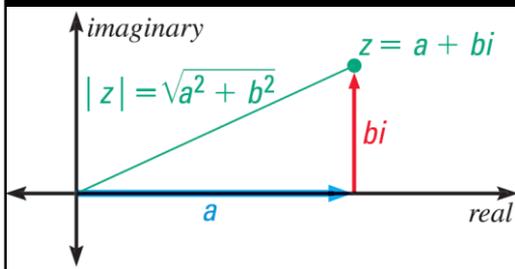
- $\frac{2-9i+7(-1)}{1-(-1)}$

- $\frac{-5-9i}{2}$

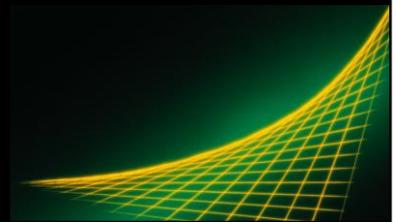
- $-\frac{5}{2} - \frac{9}{2}i$

4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Absolute Value
 - Distance a number is from the origin
 - $|a + bi| = \sqrt{a^2 + b^2}$
 - This is the distance formula (or Pythagorean Theorem)

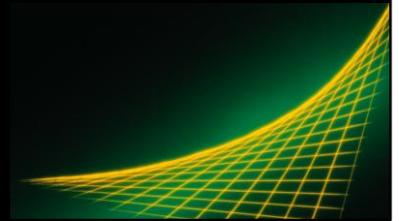


- Find $|2 - 4i|$
 - $\sqrt{2^2 + (-4)^2}$
 - $\sqrt{4 + 16}$
 - $\sqrt{20}$
 - $\sqrt{4}\sqrt{5}$
 - $2\sqrt{5}$

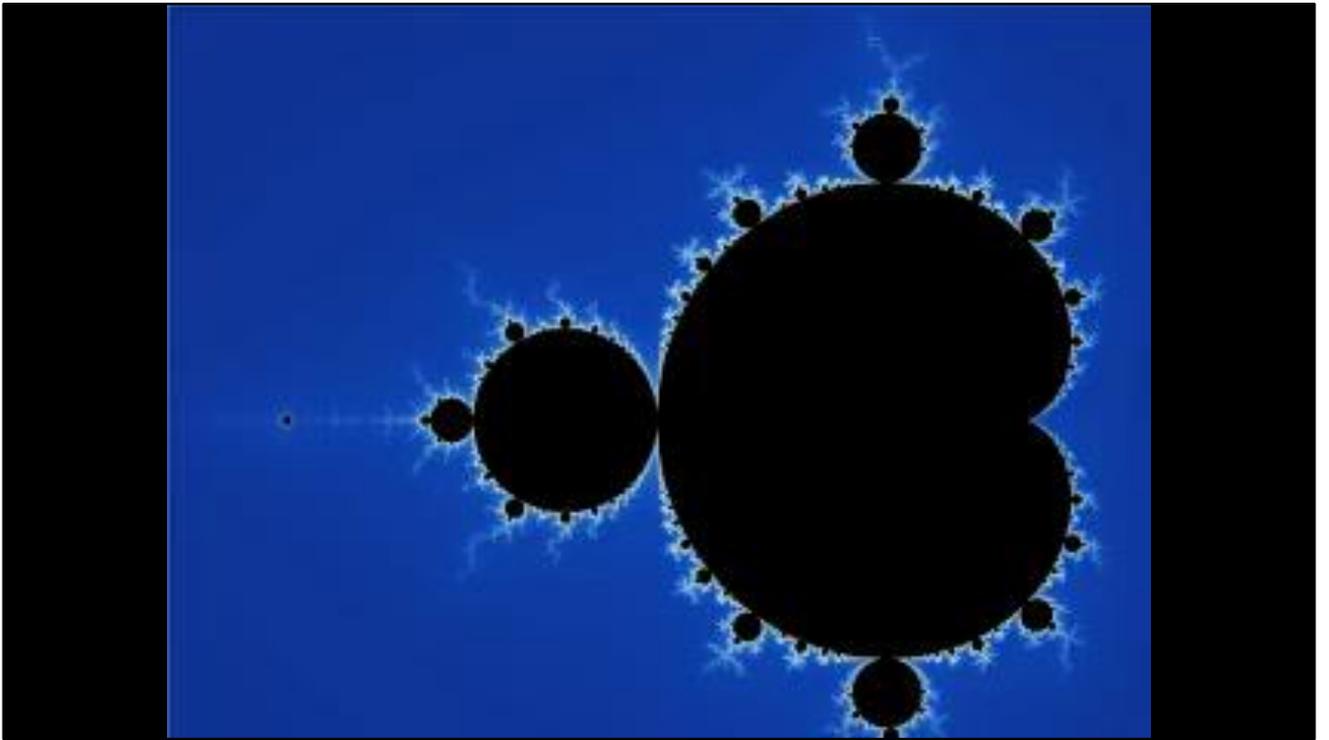


4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Mandelbrot Set
 - Fractal picture created using complex numbers
- In the following pictures
 - the black is part of the Mandelbrot Set
 - The color is based on the number of iterations before $|z| > \sqrt{5}$



We'll find out about z later



4.6 PERFORM OPERATIONS WITH COMPLEX NUMBERS

- Solve the quadratic equation

- $x^2 - 8 = -36$

- $x^2 = -28$

- $x = \pm\sqrt{-28}$

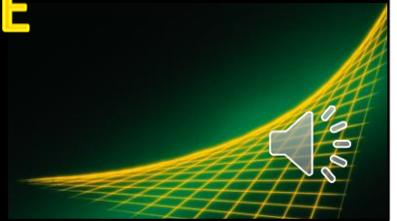
- $x = \pm\sqrt{4}\sqrt{7}\sqrt{-1}$

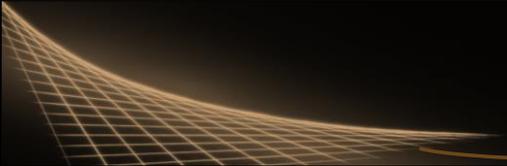
- $x = \pm 2\sqrt{7}i$

HOMWORK QUIZ

- [4.6 Homework Quiz](#)

4.7 COMPLETE THE SQUARE



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4.7 COMPLETE THE SQUARE

- The Perfect Square
- $(x + 3)^2$
- $(x + 3)(x + 3)$
- $x^2 + 3x + 3x + 3^2$
- $x^2 + 2(3x) + 3^2$
- $x^2 + 6x + 9$
- $(x + k)^2 = x^2 + 2kx + k^2$
- Compare to $ax^2 + bx + c$
- If you know the middle coefficient (b), then c is
 - $c = \left(\frac{b}{2}\right)^2$

$$\begin{aligned} &= (x + 3)(x + 3) \\ &= x^2 + 2(3x) + 3^2 \\ &= x^2 + 6x + 9 \end{aligned}$$

4.7 COMPLETE THE SQUARE

- What should c be to make a perfect square
 - $x^2 + 8x + c$
 - $c = \left(\frac{b}{2}\right)^2$
 - $c = \left(\frac{8}{2}\right)^2$
 - $c = 4^2$
 - $c = 16$

you have to add $(8/2)^2 = 4^2 = 16$ to get a perfect square or $(x + 4)^2$

4.7 COMPLETE THE SQUARE

- Rewrite the quadratic so x terms on one side and constant on other.
 - $x^2 + 6x = 16$
- If the leading coefficient is not 1, divide everything by it.
 - It already is
- Complete the square: add $\left(\frac{b}{2}\right)^2$ to both sides.
 - $x^2 + 6x + \left(\frac{6}{2}\right)^2 = 16 + \left(\frac{6}{2}\right)^2$
 - $x^2 + 6x + 3^2 = 16 + 9$
 - $(x + 3)^2 = 25$
- Rewrite the left hand side as a square (factor)
 - $x + 3 = \pm 5$
 - $x = -3 \pm 5$
 - $x = 2, -8$
- Square root both sides
- Solve

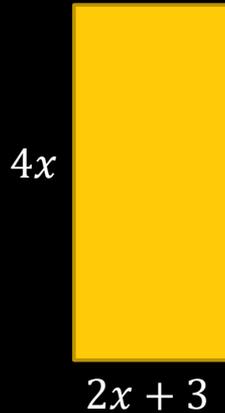
4.7 COMPLETE THE SQUARE

- Solve $2x^2 - 11x + 12 = 0$
 - $2x^2 - 11x = -12$
 - $x^2 - \frac{11}{2}x = -6$
 - $x^2 - \frac{11}{2}x + \left(-\frac{11}{4}\right)^2 = -6 + \left(-\frac{11}{4}\right)^2$
 - $\left(x - \frac{11}{4}\right)^2 = -6 + \frac{121}{16}$
 - $\left(x - \frac{11}{4}\right)^2 = -\frac{96}{16} + \frac{121}{16}$
 - $\left(x - \frac{11}{4}\right)^2 = \frac{25}{16}$
- Get constant on other side.
Divide to get $a = 1$.
- Add $\left(\frac{b}{2}\right)^2$ to both sides.
- Write left as square and simplify right.
- Solve for x .
- $x - \frac{11}{4} = \pm \frac{5}{4}$
 - $x = \frac{11}{4} \pm \frac{5}{4}$
 - $x = \frac{11 \pm 5}{4}$
 - $x = 4, \frac{3}{2}$

4.7 COMPLETE THE SQUARE

The area of the rectangle is 56.
Find the value of x .

- $A = lw$
- $4x(2x + 3) = 56$
- $8x^2 + 12x = 56$
- $x^2 + \frac{3}{2}x = 7$
- $x^2 + \frac{3}{2}x + \left(\frac{3}{4}\right)^2 = 7 + \left(\frac{3}{4}\right)^2$
- $\left(x + \frac{3}{4}\right)^2 = 7 + \frac{9}{16}$



- $\left(x + \frac{3}{4}\right)^2 = \frac{121}{16}$
- $x + \frac{3}{4} = \pm \sqrt{\frac{121}{16}}$
- $x + \frac{3}{4} = \pm \frac{11}{4}$
- $x = -\frac{3}{4} \pm \frac{11}{4}$
- $x = \frac{8}{4} = 2$ and $\frac{-14}{4} = -\frac{7}{2}$

$$4x(2x + 3) = 56$$

$$8x^2 + 12x = 56$$

$$x^2 + \frac{3}{2}x = 7$$

$$x^2 + \frac{3}{2}x + \left(\frac{3}{4}\right)^2 = 7 + \frac{9}{16}$$

$$\left(x + \frac{3}{4}\right)^2 = \frac{121}{16}$$

$$x + \frac{3}{4} = \pm \sqrt{\frac{121}{16}}$$

$$x + \frac{3}{4} = \pm \frac{11}{4}$$

$$x = -\frac{3}{4} \pm \frac{11}{4}$$

$$x = \frac{8}{4} = 2 \text{ and } \frac{-14}{4} = -\frac{7}{2}$$

4.7 COMPLETE THE SQUARE

- Writing quadratic functions in Vertex Form

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

- (h, k) is the vertex

1. Start with standard form
2. Group the terms with the x
3. Factor out any number in front of the x^2
4. Add $\left(\frac{b}{2}\right)^2$ to both sides (inside the group on the right)
5. Rewrite as a perfect square
6. Subtract to get the y by itself

1. $y = 2x^2 + 12x + 16$

2. $y = (2x^2 + 12x) + 16$

3. $y = 2(x^2 + 6x) + 16$

4. $y + 2(9) = 2(x^2 + 6x + 9) + 16$

5. $y + 18 = 2(x + 3)^2 + 16$

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

- Vertex is at $(-3, -2)$

- -2 is the minimum for this function

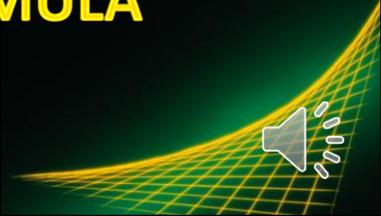
- Find the max or min by completing the square to find the vertex

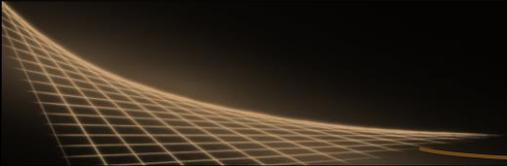
HOMWORK QUIZ

- [4.7 Homework Quiz](#)



4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT



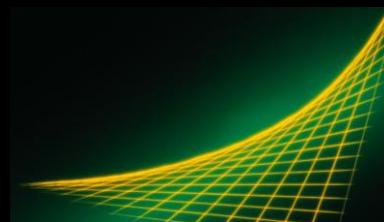
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4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT

- Completing the square was a long laborious process. Today we can develop a method to make it quicker.



4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT

- Solve $ax^2 + bx + c = 0$
- $ax^2 + bx = -c$
- $x^2 + \frac{b}{a}x = -\frac{c}{a}$
- $x^2 + \frac{b}{a}x + \left(\frac{b}{2a}\right)^2 = \left(\frac{b}{2a}\right)^2 - \frac{c}{a}$
- $\left(x + \frac{b}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{4ac}{4a^2}$
- $\left(x + \frac{b}{2a}\right)^2 = \frac{b^2 - 4ac}{4a^2}$
- $x + \frac{b}{2a} = \pm \sqrt{\frac{b^2 - 4ac}{4a^2}}$
- $x = -\frac{b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$

$$2x^2 + 6x - 4 = 0$$

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

$$(c/a) = 0$$

$$x^2 + 3x = 2$$

$$(c/a)$$

$$x^2 + 3x + (3/2)^2 = 2 + (3/2)^2$$

$$(b/2a)^2 = -(c/a) + (b/2a)^2$$

$$(x + 3/2)^2 = 2 + 9/4$$

$$= -c/a + b^2/4a^2$$

$$x + 3/2 = \pm \sqrt{(17/4)}$$

$$4ac + b^2 / (4a^2)$$

$$x = -3/2 \pm \sqrt{(17/4)}$$

$$x = (-3 \pm \sqrt{17})/2$$

$$4ac) / 2a$$

$$ax^2 + bx + c = 0$$

Divide by 2 to get a = 1

$$x^2 + (b/a)x +$$

Add two to get x's by self

$$x^2 + (b/a)x = -$$

Add the square of half of middle to get perfect square

$$x^2 + (b/a)x +$$

Factor left

$$(x + (b/2a))^2$$

Square root

$$x + (b/2a) = \pm \sqrt{((-$$

Subtract

$$x = -b/2a \pm \sqrt{((b^2 - 4ac) / (4a^2))}$$

Simplify

$$x = (-b \pm \sqrt{(b^2 -$$

4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT

- $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
- *This is called the quadratic formula and always works for quadratic equations.*
- *It even finds the complex solutions.*
- *The part under the square root, **discriminant**, tells you what kind of solutions you are going to have.*
 - $b^2 - 4ac > 0 \rightarrow$ two distinct real solutions
 - $b^2 - 4ac = 0 \rightarrow$ exactly one real solution (a double solution)
 - $b^2 - 4ac < 0 \rightarrow$ two distinct imaginary solutions

4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT

- What types of solutions to $5x^2 + 3x - 4 = 0$?
 - Find the discriminant
 - $b^2 - 4ac$
 - $3^2 - 4(5)(-4)$
 - $9 + 80$
 - $89 > 0$
 - Two distinct real roots
- Solve $5x^2 + 3x = 4$
 - Put in standard form
 - $5x^2 + 3x - 4 = 0$
 - Quadratic formula
 - $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
 - $x = \frac{-3 \pm \sqrt{3^2 - 4(5)(-4)}}{2(5)}$
 - Simplify
 - $x = \frac{-3 \pm \sqrt{89}}{10}$

$$3^2 - 4(5)(-4) = 9 + 80 = 89 \rightarrow \text{two distinct real roots}$$

$$\text{Put in standard form} \rightarrow 5x^2 + 3x - 4 = 0$$

$$\text{Quadratic formula} \rightarrow x = \frac{-3 \pm \sqrt{3^2 - 4(5)(-4)}}{2(5)}$$

$$\text{Simplify} \rightarrow \frac{-3 \pm \sqrt{89}}{10}$$

4.8 USE THE QUADRATIC FORMULA AND THE DISCRIMINANT

• Solve $4x^2 - 6x + 3 = 0$

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

$$\blacksquare x = \frac{6 \pm \sqrt{(-6)^2 - 4(4)(3)}}{2(4)}$$

$$\blacksquare x = \frac{6 \pm \sqrt{36 - 48}}{8}$$

$$\blacksquare x = \frac{6 \pm \sqrt{-12}}{8}$$

$$\blacksquare x = \frac{6 \pm 2\sqrt{3}i}{8}$$

$$\blacksquare x = \frac{6}{8} \pm \frac{2\sqrt{3}}{8}i$$

$$\blacksquare x = \frac{3}{4} \pm \frac{\sqrt{3}}{4}i$$

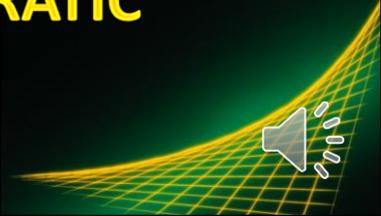
$$\begin{aligned} 4x^2 - 6x + 3 &= 0 \\ x &= \frac{6 \pm \sqrt{(-6)^2 - 4(4)(3)}}{2(4)} \\ x &= \frac{6 \pm \sqrt{36 - 48}}{8} \\ x &= \frac{6 \pm \sqrt{-12}}{8} \\ x &= \frac{6 \pm 2\sqrt{3}i}{8} \\ x &= \frac{3 \pm \sqrt{3}i}{4} \quad (\text{reduce top and bottom by 2}) \end{aligned}$$

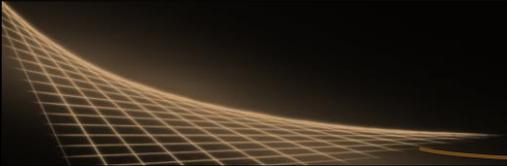
HOMWORK QUIZ

- [4.8 Homework Quiz](#)



4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES



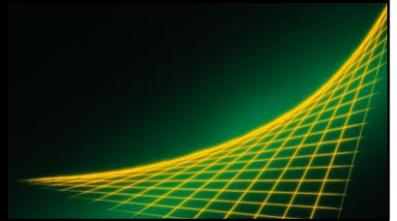
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 - *By Larson, R., Boswell, L., Kanold, T. D., & Stiff, L.*
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4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

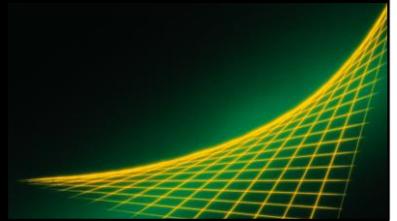
- Often in real-life, what we are looking for is a range instead of just one value.
- An example is how many tickets must be purchased to make at least \$500?
- That means real-life often uses inequalities.



4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

Graph inequalities

- Graph the quadratic as if it were an equation
 - Find the vertex $\left(-\frac{b}{2a}\right)$
 - Make a table of values choosing points on both sides of the vertex
 - Graph the points and connect the dots



4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

- Dotted line or solid line
- Shade
 - Pick a test point (not on the line)
 - Try plugging it in the inequality
 - If you get a true statement shade that side of the line
 - If you get a false statement shade the other side of the line.

4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

• Graph $y \geq x^2 + 4x + 1$

▪ Find vertex:

➤ $x = -\frac{b}{2a}$

➤ $x = -\frac{4}{2(1)} = -2$

▪ Make table

▪ Solid line because equal to

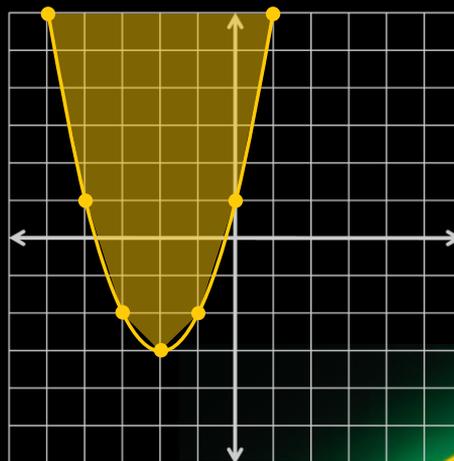
▪ Pick $(0, 0)$ to test

➤ $0 \geq 0^2 + 4(0) + 1$

➤ $0 \geq 1$

➤ False, shade other side of curve

x	y
-5	6
-4	1
-3	-2
-2	-3
-1	-2
0	1
1	6



4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

Solve inequalities in one variable.

1. Make = 0
2. Factor or use the quadratic formula to find the zeros
3. Graph the zeros on a number line (notice it cuts the line into three parts)
4. Pick a number in each of the three parts as test points
5. Test the points in the original inequality to see true or false
6. Write inequalities for the regions that were true

$$\square p^2 - 4p \leq 5$$

1. $p^2 - 4p - 5 \leq 0$

2. $(p - 5)(p + 1) \leq 0$

- Zeros are 5, -1



4. test points = -2, 0, 6

- $-2 \rightarrow 4 - 4(-2) \leq 5 \rightarrow 12 \leq 5$ false

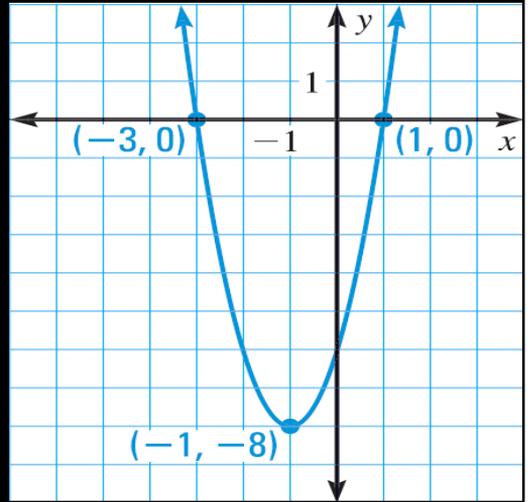
- $0 \rightarrow 0 - 4(0) \leq 5 \rightarrow 0 \leq 5$ true

- $6 \rightarrow 36 - 4(6) \leq 5 \rightarrow 12 \leq 5$ false

6. middle region true so $-1 \leq p \leq 5$

4.9 GRAPH AND SOLVE QUADRATIC INEQUALITIES

- Or You could also solve the quadratic inequality in one variable by graphing the quadratic
 - Make the equation = 0
 - Graph
 - When the graph is below the x-axis; ≤ 0
 - When the graph is above the x-axis; ≥ 0



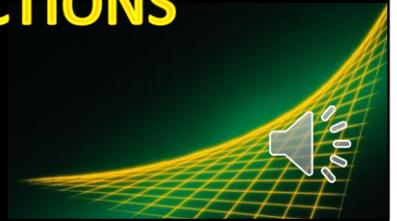
$$2x^2 + 4x - 6 \leq 0 \text{ when } -3 \leq x \leq 1$$

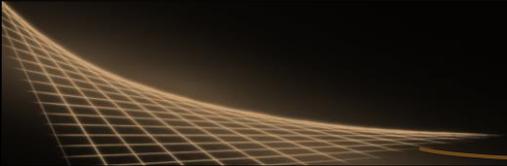
$$2x^2 + 4x - 6 \geq 0 \text{ when } x \leq -3 \text{ or } x \geq 1$$

HOMEWORK QUIZ

- [4.9 Homework Quiz](#)

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS



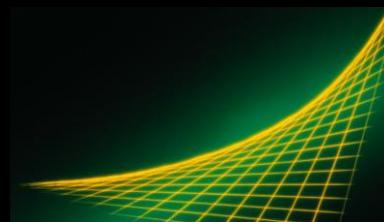
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4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- We can easily find the equations of lines ($y = mx + b$), but curves are a little more tricky.
- Today we will learn how to fit a quadratic function to some given points.



4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- Vertex Form \rightarrow given vertex and one other point
 - $y = a(x - h)^2 + k$
 - Fill in the vertex (h, k)
 - Plug in your other point (x, y) and find a
 - Write the equation
- Write the equation of the parabola with vertex at $(-2, 1)$, point at $(1, -1)$.
 - $y = a(x + 2)^2 + 1$
 - $-1 = a(1 + 2)^2 + 1$
 - $-1 = 9a + 1$
 - $-2 = 9a$
 - $a = -\frac{2}{9}$
 - $y = -\frac{2}{9}(x + 2)^2 + 1$

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- Intercept Form \rightarrow given the x-intercepts and one other point
 - Fill in $y = a(x - p)(x - q)$ with the intercepts (p and q)
 - Plug in your other point (x, y) and find a
 - Write the equation
- Write the equation of parabola with x-ints of 1 and 4, point at (2, -6).
 - $y = a(x - 1)(x - 4)$
 - $-6 = a(2 - 1)(2 - 4)$
 - $-6 = a(1)(-2)$
 - $a = 3$
 - $y = 3(x - 1)(x - 4)$

ANS: $y = a(x - 1)(x - 4) \rightarrow -6 = a(2 - 1)(2 - 4) \rightarrow -6 = a(1)(-2) \rightarrow a = 3 \rightarrow y = 3(x - 1)(x - 4)$

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- Standard Form \rightarrow any 3 points
 - Use one of the above two and simplify OR
 - Fill in the x and y of $ax^2 + bx + c = y$ with each of the three points creating a system of three equations with the variables of a , b , and c
 - Solve the system
 - Write your equation

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

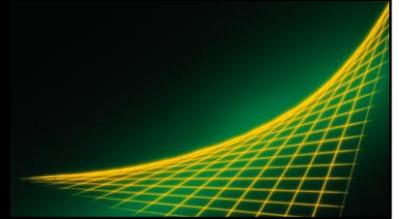
- Find the equation of the parabola through points $(-2, -1)$, $(1, 11)$, $(2, 27)$.
- Fill in the x and y of $ax^2 + bx + c = y$ with each of the three points.
 - $a(-2)^2 + b(-2) + c = -1$
 - $4a - 2b + c = -1$
 - $a(1)^2 + b(1) + c = 11$
 - $a + b + c = 11$
 - $a(2)^2 + b(2) + c = 27$
 - $4a + 2b + c = 27$
- Solve the system of the three equations.
 - $\begin{cases} 4a - 2b + c = -1 \\ a + b + c = 11 \\ 4a + 2b + c = 27 \end{cases}$
 - Use a method from chapter 3 like elimination to solve.

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- $\begin{cases} 4a - 2b + c = -1 \\ a + b + c = 11 \\ 4a + 2b + c = 27 \end{cases}$
- First two equations (2^{nd} times -1)
 - $4a - 2b + c = -1$
 - $\frac{-a - b - c = -11}{3a - 3b = -12}$
 - $a - b = -4$
- Last two equations (2^{nd} times -1)
 - $-a - b - c = -11$
 - $\frac{4a + 2b + c = 27}{3a + b = 16}$
 - $3a + b = 16$
- Combine shorter equations
 - $\frac{a - b = -4}{3a + b = 16}{4a = 12}$
 - $a = 3$
- Back substitute to find b and c
 - $a - b = -4$
 - $3 - b = -4$
 - $b = 7$
 - $a + b + c = 11$
 - $3 + 7 + c = 11$
 - $c = 1$
- $y = 3x^2 + 7x + 1$

4.10 WRITE QUADRATIC FUNCTIONS AND MODELS

- Best-Fitting Quadratic Regression
 - (Graphing Calculators)
 - Gives the best-fitting quadratic model for a given set of at least 3 data points
- Steps
 - Push STAT
 - Select Edit...
 - Enter x values in L1 and y values in L2
 - Push STAT
 - Select CALC \rightarrow QuadReg
 - Push Enter to Calculate.



HOMEWORK QUIZ

- [4.10 Homework Quiz](#)