Ch 11

Quadratic and Exponential Functions
Quick Review

- Graphing Equations:
  - \( y = \frac{1}{2} x - 3 \)
  - \( 2x + 3y = 6 \)
Quick Review

- Evaluate Expressions
  - Order of Operations!

- Factor
  - 1st – GCF
  - 2nd – trinomials into two binomials

P - grouping symbols
E - exponents
M/D - mul/div left to right
A/S - add/sub left to right
11.1

Graphing Quadratic Functions
Vocab

• Parabola –
  – The graph of a quadratic function

• Quadratic Function –
  – A function described by an equation of the form $f(x) = ax^2 + bx + c$, where $a \neq 0$
  – A second degree polynomial

• Function –
  – A relation in which exactly one x-value is paired with exactly one y-value
Quadratic Function

- This shape is a parabola
- Graphs of all quadratic functions have the shape of a parabola

**Words:** A quadratic function is a function that can be described by an equation of the form $y = ax^2 + bx + c$, where $a \neq 0$. 

**Models:**
Exploration of Parabolas

• Sketch pictures of the following situations

\[ y = 3x^2 \quad y = 2x^2 \quad y = x^2 \quad y = \frac{1}{2}x^2 \quad y = \frac{1}{4}x^2 \quad y = \frac{1}{8}x^2 \]

\[ y = -2x^2 \quad y = -1x^2 \quad y = 1x^2 \quad y = 2x^2 \]

\[ y = x^2 - 3 \quad y = x^2 - 1 \quad y = x^2 + 1 \quad y = x^2 + 4 \]

\[ y = (x+1)^2 \quad y = (x-1)^2 \quad y = (x+3)^2 \quad y = (x-3)^2 \]
Example

• Graph the quadratic equation by making a table of values.

\[ y = x^2 - 2 \]

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>-2</td>
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</table>
Example

• Graph the quadratic equation by making a table of values.

\[ y = -\frac{1}{2} x^2 + 4 \]
Parts of a Parabola \( \Rightarrow ax^2 + bx + c \)

- + a opens up
  - Lowest point called: minimum
- - a opens down
  - Highest point called: maximum
- Parabolas continue to extend as they open
- Domain (x-values): all real numbers
- Range (y-values):
  - Open up - #s greater than or equal to minimum value
  - Open down - #s less than or equal to the maximum value
- Vertex – minimum or maximum value
- Axis of Symmetry: vertical line through vertex
Axis of Symmetry

Words: The equation of the axis of symmetry for the graph of \( y = ax^2 + bx + c \), where \( a \neq 0 \), is \( x = -\frac{b}{2a} \).

Model: The graph of a parabola with the axis of symmetry at \( x = 2 \).
Example

• Use characteristics of quadratic functions to graph

\[ y = -x^2 + 2x + 1 \]

\[ a = -1 \]
\[ b = 2 \]
\[ c = 1 \]

– Find the equation of the axis of symmetry.
– Find the coordinates of the vertex of the parabola.
– Graph the function.
Example

• Use characteristics of quadratic functions to graph $y = -x^2 + x$
  
  – Find the equation of the axis of symmetry.
  – Find the coordinates of the vertex of the parabola.
  – Graph the function.

$x = \frac{-b}{2a} = \frac{-1}{2(1)} = -\frac{1}{2}$

Graph the function.
Example

• A football player throws a short pass. The height $y$ of the ball is given by the equation $y = -16x^2 + 8x + 5$, where $x$ is the number of seconds after the ball was thrown. What is the maximum height reached by the ball?
Assignments

• #1 – due today
  – P461: 11 – 15

• #2 – due next time
  – P462: 28 – 40, 45 – 47, 49
Families of Quadratic Functions
Families of Quadratic Functions

- Share the same vertex
- Share the same axis of symmetry
- Have the same shape
Example

• Graph the group of equations on the same graph. Compare and contrast the graphs. What conclusions can be drawn?

\[
\begin{align*}
y &= x^2 \\
y &= \frac{1}{2} x^2 \\
y &= 2x^2 \\
y &= 4x^2
\end{align*}
\]
Summary

<table>
<thead>
<tr>
<th>Addition to $y = x^2$ equation</th>
<th>Changes to graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pm ax$ as $a$ increases</td>
<td></td>
</tr>
<tr>
<td>$\pm ax$ as $a$ decreases</td>
<td></td>
</tr>
</tbody>
</table>
Example

- Graph the group of equations on the same graph. Compare and contrast the graphs. What conclusions can be drawn?

\[ y = -x^2 \]
\[ y = -x^2 + 1 \]
\[ y = -x^2 - 4 \]
### Summary

<table>
<thead>
<tr>
<th>Addition to $y = x^2$ equation</th>
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<td>Parabola narrows</td>
</tr>
<tr>
<td>Coefficient on $x^2$ becomes smaller</td>
<td>Parabola widens</td>
</tr>
<tr>
<td>$+c$</td>
<td></td>
</tr>
<tr>
<td>$-c$</td>
<td></td>
</tr>
</tbody>
</table>
Example

- Graph the group of equations on the same graph. Compare and contrast the graphs. What conclusions can be drawn?

\[ y = x^2 \]

\[ y = (x - 3)^2 \]

\[ y = (x + 1)^2 \]
## Summary

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<thead>
<tr>
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</tr>
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<td>Parabola narrows</td>
</tr>
<tr>
<td>Coefficient on $x^2$ becomes smaller</td>
<td>Parabola widens</td>
</tr>
<tr>
<td>Constant is greater than zero</td>
<td>Shifts parabola upwards</td>
</tr>
<tr>
<td>Constant is less than zero</td>
<td>Shifts parabola downwards</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
&\text{(x + )^2} \\
&\text{(x - )^2}
\end{align*}
\]
Example

- Describe how each graph would change from the parent graph of \( y = x^2 \). Then name the vertex.

\[
y = -2x^2 \quad \text{opens down, narrows} \quad (0,0)
\]

\[
y = x^2 - 6 \quad \text{shifts down 6} \quad (0,-6)
\]

\[
y = (x+2)^2 \quad \text{shifts left 2} \quad (-2,0)
\]

\[
y = (x-7)^2 + 2 \quad \text{shifts right 7, shifts up 2} \quad (7,2)
\]

\[
y = (x+2)^2 - 1 \quad \text{shifts left 2, shifts down 1} \quad (-2,-1)
\]
Example

• In a computer game, a player dodges space shuttles that are shaped like parabolas. Suppose the vertex of one shuttle is at the origin. The space shuttle begins with original equation $y=-2x^2$. The shuttle moves until its vertex is at (-2, 3). Find an equation to model the shape and position of the shuttle at its final location.

$y=-2(x-4)^2-6$
Assignments

• #1 – due today
  – P466: 3, 4, 5, 7, 9, 11, 13, 15, 17

• #2 – due next time
  – P466: 6 – 24 even, 25 – 27, 30 – 35
11-3

Solving Quadratic Equations by Graphing
Quadratic Equations

• Quadratic Equations –
  – Value of the related quadratic function at 0
  – What does that mean?
    \[ y = ax^2 + bx + c \]

• At 0 means that \( y = 0 \)
  \[ 0 = ax^2 + bx + c \]

• The solutions (the two things that \( x \) equals) are called the roots
  – The roots are the solutions to quadratic equations
• The roots can be found by finding the x-intercepts or zeros
Example

• The path of water streaming from a jet is in the shape of a parabola. Find the distance from the jet where the water hits the ground by graphing. Use the function $h(d) = -2d^2 + 4d + 6$, where $h(d)$ represents the height of a stream of water at any distance $d$ from the jet in feet.

$$x = \frac{-b}{2a} = \frac{-4}{2(-2)} = \frac{-4}{-4} = 1$$

$\quad x\ 2\ 3$
Example

• Suppose the function \( h(t) = -16t^2 + 29t + 6 \) represents the height of the water at any time \( t \) seconds after it has left its jet. Find the number of seconds it takes the water to hit the ground by graphing.

\[
x = \frac{-b}{2a} = \frac{-29}{2(-16)} = \frac{29}{32} = .906
\]
Example

- Find the roots of \( x^2 + 2x - 15 = 0 \) by graphing the related function.

\[
\begin{align*}
A &= 1 \\
b &= 2 \\
c &= -15
\end{align*}
\]

\[
x = \frac{-b}{2a} = \frac{-2}{2(1)} = -1
\]

\[
x = -5, 3
\]
Example

• Find the roots of $0 = x^2 - 5x + 4$ by graphing the related function.

$$x = \frac{-b}{2a} = \frac{5}{2(1)} = 2.5$$

$x = 1, 4$
Example

- Estimate the roots of \( -x^2 + 4x - 1 = 0 \).

\[ x = \frac{-b}{2a} = \frac{-4}{2(-1)} = \frac{4}{2} = 2 \]

Between 3 and 4
Between 0 and 1
Example

• Estimate the roots of $y = x^2 - 2x - 9$.

\[ x = \frac{-b}{2a} = \frac{2}{2(-9)} = 1 \]

Between 4 and 5
Between -3, -2

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>3</td>
</tr>
<tr>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>-1</td>
<td>-1</td>
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<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>-10</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>-10</td>
</tr>
</tbody>
</table>
Example

• Find two numbers whose sum is 10 and whose product is -24.

\[ x(10-x) = -24 \]

\[ 10x - x^2 = -24 \]

\[ x = \frac{-b}{2a} = \frac{-10}{2(-1)} = 5 \]

\[ x -2 \]

\[ x = 0 \]

\[ x = 12 \]

\[ x = -2 \]

\[ x = 0 \]

\[ x = 12 \]

\[ x = -2 \]
Example

• Find two numbers whose sum is 4 and whose product is 5.

\[
x(4-x) = 5
\]
\[
4x-x^2 = 5
\]
\[
x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}
\]
\[
x = \frac{4 \pm \sqrt{4^2-4(-5)}}{2(-1)}
\]
\[
x = \frac{4 \pm \sqrt{24}}{-2}
\]
\[
x = \frac{4 \pm 2\sqrt{6}}{-2}
\]

No real solutions.
Assignments

• #1 – due today
  – P471: 1, 2, 3, 5, 7, 11, 13, 21, 23

• #2 – due next time
  – P471: 4 – 24 even, 28 – 32
Solving Quadratic Equations by Factoring
Factoring to Solve a Quadratic Equ

\[ y = 3x^2 - 3x \]

• In the last chapter, we set the quadratic equation equal to what number?

\[ 0 = 3x^2 - 3x \]

Zero Product Property

For all numbers \( a \) and \( b \), if \( ab = 0 \), then \( a = 0 \), \( b = 0 \) or both \( a \) and \( b \) equal 0.
Example

• Solve \(-2x(x + 5) = 0\). Check your solution.

\[
\begin{align*}
-2x &= 0 \\
-2 &= -2 \\
x &= 0
\end{align*}
\]

\[
\begin{align*}
x + 5 &= 0 \\
-5 &= -5 \\
x &= -5
\end{align*}
\]

Checks

\[
\begin{align*}
-2(0)(0 + 5) &= 0 \\
-2(0)(0) &= 0 \quad \checkmark
\end{align*}
\]

\[
\begin{align*}
-2(-5)(-5 + 5) &= 0 \\
-2(-5)(0) &= 0 \quad \checkmark
\end{align*}
\]
Example

• Solve $z(z - 8) = 0$. Check your solution.

\[ z = 0 \]

\[ z - 8 = 0 \]
\[ + \quad + \quad + \]
\[ z = 8 \]

Check

$0(0 - 8) = 0$
$0(-8) = 0$
$0 = 0 \checkmark$

$8(8 - 8) = 0$
$8(0) = 0$
$0 = 0 \checkmark$
Example

• Solve \((a - 4)(4a + 3) = 0\). Check your solution.

\[
\begin{align*}
0 - 4 &= 0 \\
+4 &+4 \\
\underline{0} &= \underline{4} \\
\end{align*}
\]

\[
\begin{align*}
4a + 3 &= 0 \\
-3 &-3 \\
\underline{4a} &= \underline{-3} \\
\frac{4a}{4} &= \frac{-3}{4} \\
\end{align*}
\]

\(a = \frac{-3}{4}\)

Checks

\[
\begin{align*}
(4 - 4)(4 \cdot 4 + 3) &= 0 \\
0 \cdot 19 &= 0 \\
0 &= 0 \checkmark \\
\end{align*}
\]

\[
\begin{align*}
(-\frac{3}{4} - 4)(4 \cdot -\frac{3}{4} + 3) &= 0 \\
(-\frac{3}{4}) \cdot (-3 + 3) &= 0 \\
0 &= 0 \checkmark \\
\end{align*}
\]
Example

• A child throws a ball up in the air. The height $h$ of the ball $t$ seconds after it has been thrown is given by the equation $h = -16t^2 + 8t + 4$. Solve $4 = -16t^2 + 8t + 4$ to find how long it would take the ball to reach the height from which it was thrown.

\[
\begin{align*}
4 &= -16t^2 + 8t + 4 \\
0 &= -16t^2 + 8t \\
0 &= 8t(-2t+1) \\
-2t+1 &= 0 \\
-t &= -1 \\
-t &= -1 \\
\frac{-2t}{-2} &= \frac{1}{-2} \\
-t &= \frac{1}{2} \\
-t &= \frac{1}{2} \\
\end{align*}
\]

$t = \frac{1}{2}$ s
Example

• Solve $x^2 - 4x - 21 = 0$. Check your solution.

$(x-7)(x+3) = 0$

\[
\begin{align*}
\text{Check} & : \\
7^2 - 4(7) - 21 &= 0 \\
49 - 28 - 21 &= 0 \\
0 &= 0 \checkmark \\
\end{align*}
\]

\[
\begin{align*}
\text{Check} & : \\
(-3)^2 - 4(-3) - 21 &= 0 \\
9 + 12 - 21 &= 0 \\
0 &= 0 \checkmark \\
\end{align*}
\]
Example

- Solve \(x^2 - 2x = 3\). Check your solution.

\[
x^2 - 2x - 3 = 0 \\
(x - 3)(x + 1) = 0 \\
x - 3 = 0 \quad \text{or} \quad x + 1 = 0 \\
x = 3 \quad \text{or} \quad x = -1
\]

Check

\[
3^2 - 2(3) = 3 \\
9 - 6 = 3 \\
3 = 3 \checkmark
\]

\[
(-1)^2 - 2(-1) = 3 \\
1 + 2 = 3 \\
3 = 3 \checkmark
\]
Example

- The length of a rectangle is 4 feet less than three times its width. The area of the rectangle is 55 square feet. Find the measures of the sides.

\[ A = 2lw \]

\[ 55 = (3x - 4)(x) \]

\[ 55 = 3x^2 - 4x - 55 \]

\[ 0 = 3x^2 - 4x - 55 \]

\[ 0 = (3x + 11)(x - 5) \]

For the first factor:

\[ 3x + 11 = 0 \]

\[ x = -\frac{11}{3} \]

For the second factor:

\[ x - 5 = 0 \]

\[ x = 5 \]

So, the possible values for the width are 5 and 11/3, making the measures of the sides 11' and 11'.
Example

- The length of a rectangle is 2 feet more than twice its width. The area of the rectangle is 144 square feet. Find the measure of its sides.

\[ A = l \cdot w \]

\[ 144 = (2x + 2)(x) \]

\[ 144 = 2x^2 + 2x \]

\[ -144 \]

\[ 0 = 2x^2 + 2x - 144 \]

\[ 0 = 2(x^2 + x - 72) \]

\[ 0 = 2(x - 8)(x + 9) \]

\[ x - 8 = 0 \]

\[ x = 8 \]

\[ x + 9 = 0 \]

\[ x = -9 \]
Assignments

• #1 – due today
  – P476: 4 – 10

• #2 – due next time
  – P476: 12 – 28 even, 29 – 32, 36 – 42
11-5

Solving Quadratic Equations by Completing the Square
Situation

• Sometimes you can’t factor a polynomial
• So to solve for the roots, complete the square

• Completing the Square
  1. Move the constant to the other side
  2. Take half of the coefficient of $x$
  3. Square that number $\uparrow$
  4. Add that number $\uparrow$ to both sides of the equation
  5. Then solve by factoring!
Example

• Find the value of $c$ that makes $x^2 - 8x + c$ a perfect square.

$x^2 - 8x + 16$
$(x-4)(x-4)$

$c = 16$
Example

• Find the value of $c$ that makes $x^2 - 6x + c$ a perfect square.

\[ x^2 - 6x + 9 \]
\[ (x - 3)(x - 3) \]

$c = 9$
Example

• Solve $x^2 + 12x - 13 = 0$ by completing the square.

\[
x^2 + 12x + 36 = 13 + 36
\]

\[
(x + 6)^2 = 49
\]

\[
\sqrt{(x+6)^2} = \sqrt{49}
\]

\[
x + 6 = \pm 7
\]

\[
-x - 6
\]

\[
x = -6 \pm 7
\]

\[
x = 1, -13
\]
Example

• Solve $x^2 + 6x - 16 = 0$ by completing the square.

\[
\begin{align*}
\quad & x^2 + 6x + 9 = 10 + 9 \\
\quad & (x + 3)^2 = 25 \\
\quad & \sqrt{(x + 3)^2} = \sqrt{25} \\
\quad & x + 3 = \pm 5 \\
\quad & x = -3 \pm 5 \\
\quad & x = -3 \pm 5 \\
\quad & x = 2, -8 \\
\end{align*}
\]
Special Note

• You can only complete the square if the coefficient of the first term is 1. If it is not 1, first divide each term by the coefficient.

\[
\frac{2x^2}{a} + \frac{6x}{a} + \frac{12}{a} = \frac{4}{a}
\]

\[
x^2 + 3x + 6 = 2
\]
Example

- When constructing a room, the width is to be 10 feet more than half the length. Find the dimensions of the room to the nearest tenth of a foot, if its area is to be 135 square feet.

\[ A = lw \]

\[ x \left( \frac{1}{2}x + 10 \right) = 135 \]

\[ 2 \left[ \frac{1}{2}x^2 + 10x \right] = 135 \]

\[ x^2 + 20x + 100 = 270 - 100 \]

\[ (x + 10)^2 = 370 \]

\[ x = 9.24, -21.4 \]

\[ x + 10 = \pm \sqrt{370} \]

\[ x = -10 \pm \sqrt{370} \]
Assignments

• #1 – due today
  – P481: 3 – 17 odd, 23 – 25 odd

• #2 – due next time
  – P481: 4 – 34 even, 36, 38 – 41
11-6

The Quadratic Formula
Summary of Methods to Solve Quadratic Equations

<table>
<thead>
<tr>
<th>Method</th>
<th>When Is the Method Useful?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphing</td>
<td>Use only to estimate solutions.</td>
</tr>
<tr>
<td>Factoring</td>
<td>Use when the quadratic expression is easy to factor.</td>
</tr>
<tr>
<td>Completing the Square</td>
<td>Use when the coefficient of $x^2$ is 1 and all other coefficients are fairly small.</td>
</tr>
</tbody>
</table>

• So, what happens with the leading coefficient is not 1?
• Use the Quadratic Formula
Quadratic Formula

- Form: \( ax^2 + bx + c = 0 \)
- Can’t have a negative under the square root
  - Not a real number
- Equations can have 2, 1, or 0 real number solutions

\[
x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \quad a \neq 0
\]
Example

• Use the Quadratic Formula to solve \(2x^2 - 5x + 3 = 0\).

\[
\begin{align*}
  a &= 2 \\
  b &= -5 \\
  c &= 3 \\

  x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\
  x &= \frac{5 \pm \sqrt{25 - 24}}{4} \\
  x &= \frac{5 \pm 1}{4} \\
  x &= \frac{6}{4} = \frac{3}{2} \\
  x &= \frac{4}{4} = 1
\end{align*}
\]

\(x = \frac{3}{2}, 1\)
Example

- Use the Quadratic Formula to solve \( x^2 + 4x + 2 = 0 \).

\[ \begin{align*}
\sqrt{b^2 - 4ac} & = \sqrt{4^2 - 4(1)(2)} \\
& = \sqrt{16 - 8} \\
& = \sqrt{8} \\
& = 2\sqrt{2}.
\end{align*} \]

\[ \begin{align*}
x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\
x &= \frac{-4 \pm \sqrt{8}}{2(1)} \\
x &= \frac{-4 \pm 2\sqrt{2}}{2} \\
x &= -2 \pm \sqrt{2}.
\end{align*} \]
Example

• Use the Quadratic Formula to solve \(-x^2 + 6x - 9 = 0\).

\[
x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\]

\[
a = -1, \quad b = 6, \quad c = -9
\]

\[
x = \frac{-6 \pm \sqrt{6^2 - 4(-1)(-9)}}{2(-1)} = \frac{-6 \pm \sqrt{36 - 36}}{-2} = \frac{-6 \pm \sqrt{0}}{-2} = \frac{-6}{-2} = 3
\]
Example

• Use the Quadratic Formula to solve \(-3x^2 + 6x + 9 = 0\).
Example

• A punter kicks the football with an upward velocity of 58 ft/s and his foot meets the ball 1 foot off the ground. His formula is \( h(t) = -16t^2 + 58t + 1 \), where \( h(t) \) is the ball’s height for any time \( t \) after the ball was kicked. What is the hang time (total amount of time the ball stays in the air)?

\[
\begin{align*}
\text{Given:} & \quad a = -16, \quad b = 58, \quad c = 1 \\
\text{Quadratic formula:} & \quad t = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \\
& \quad = \frac{-58 \pm \sqrt{58^2-4(-16)(1)}}{2(-16)} \\
& \quad = \frac{-58 \pm \sqrt{3428}}{-32} \\
& \quad = \frac{-58 \pm 58.55}{-32} \\
& \quad = -0.17, 3.64
\end{align*}
\]

\( t = 3.64 \)
Assignments

• #1 – due today
  – P486: 3 – 9 odd, 10

• #2 – due next time
  – P486: 12 – 24 even, 26 – 31
11-7

Exponential Functions
Exponential Function

• A function in the form $y = a^x$
  – Where $a > 0$ and $a \neq 1$
  – Another form is: $y = ab^x + c$
    • In this case, $a$ is the coefficient

• To graph exponential function, make a table

• Initial Value –
  – The value of the function when $x = 0$
  – Also the y-intercept
Example

- Graph $y = 1.5^x$

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>2.25</td>
</tr>
<tr>
<td>3</td>
<td>3.375</td>
</tr>
<tr>
<td>5</td>
<td>7.59</td>
</tr>
<tr>
<td>-1</td>
<td>$\sqrt[3]{3}$</td>
</tr>
<tr>
<td>-2</td>
<td>$\sqrt{2}$</td>
</tr>
<tr>
<td>-5</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Example

• Graph $y = 2.5^x$

<table>
<thead>
<tr>
<th>$x$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>6.25</td>
</tr>
<tr>
<td>-1</td>
<td>.4</td>
</tr>
<tr>
<td>-3</td>
<td>.004</td>
</tr>
</tbody>
</table>
Example

Graph \( y = 3^x + 1 \). Then state the y-intercept.

\[
\begin{array}{c|c}
  x & y \\
  \hline
  0 & 2 \\
  -1 & 4 \\
  -1.1 & 1.1 \\
  -2 & 1.04 \\
  -3 & \\
\end{array}
\]

\( y = 2 \)
Example

• Graph $y = 5^x - 4$. Then state the $y$-intercept.

$y = -3$
Growth and Decay

• Exponential functions are used to represent situations of exponential growth and decay
  – Exponential growth – growth that occurs rapidly
    • Money in a bank
  – Exponential decay – decay that occurs rapidly
    • Half-life of radioactive materials
Example

• When Taina was 10 years old, she received a certificate of deposit (CD) for $2000 with an annual interest rate of 5%. After eight years, how much money will she have in the account?

\[
B = P \left(1 + \frac{r}{t}\right)^{nt}
\]

\[
B = 2000 \left(1 + \frac{0.05}{1}\right)^{8}
\]

\[
= 2000 \left(1.05\right)^{8}
\]

\[
= 2000 \left(1.477\right)
\]

\[
= \$ 2954.91
\]
Example

• When Marcus was 2 years old, his parents invested $1000 in a money market account with an annual average interest rate of 9%. After 15 years, how much money will he have in the account?

\[ B = P(1+r)^t \]
\[ = 1000(1 + .09)^{15} \]
\[ = 1000 (1.09)^{15} \]
\[ = 1000 (3.04) \]
\[ = \$ 3042.48 \]
Assignments

• #1 – due today
  – P492: 3 – 5, 7 – 19 odd
• #2 – due next time
  – P492: 6 – 22 even, 23, 27 – 31
Ch 11 Review

• #1 – due today
  – P496: 11 – 49 odd

• #2 – due next time
  – P496: 1 – 10, 12 – 50 even, 51, 52