What Type of Function?

Linear Functions:
\[ y = 3x + 2 \]
- exponents = 1
- table has a constant rate of change

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>

Quadratic Functions:
\[ y = 2x^2 - x + 4 \]
- highest exponent is 2
- table has a constant change in the change

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>7</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
</tr>
</tbody>
</table>

Exponential Functions:
\[ y = 3^x \]
- \( x \) is the exponent
- table has a constant ratio

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>( \frac{1}{3} \times 3 )</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
</tr>
</tbody>
</table>

WORDS TO KNOW

Exponential function - A function that forms a curve that always increases or always decreases and has a constant ratio \( y = 2^x \)
Linear function - A function that forms a straight line when graphed and has a constant rate of change (slope) \( y = 2x \)
Quadratic function - A function that forms a parabola when graphed and has a constant change in the change \( y = 2x^2 - 5 \)
## Classifying

### Classifying by Equations!

**Directions:** Analyze each equation and circle the word that describes the function.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Linear</th>
<th>Quadratic</th>
<th>Exponential</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$y = 3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$y = 5^x$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>$2x^2 + x = y$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>$y =</td>
<td>2x - 6</td>
<td>$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>$y = 3x^3 + 4x - 1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$y = 3^x$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>$8y = x + 2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>$y = 4x^2 + 3x - 2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Classifying by Tables!

**Directions:** Analyze each table and circle the word that describes the function.

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>$x$</td>
<td>$y$</td>
<td>Lin</td>
<td>Quad</td>
<td>Exp</td>
<td>Other</td>
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<th>Exp</th>
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<th>$y$</th>
<th>Lin</th>
<th>Quad</th>
<th>Exp</th>
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</thead>
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<td></td>
<td>3</td>
<td>8</td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>16</th>
<th>$x$</th>
<th>$y$</th>
<th>Lin</th>
<th>Quad</th>
<th>Exp</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>67</td>
<td></td>
<td></td>
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<td>5</td>
<td>129</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Classifying
(continued)

Classifying by Graphs!

Directions: Analyze each graph and circle the word that describes the function.

17. Linear Quadratic Exponential

18. Linear Quadratic Exponential

19. Linear Quadratic Exponential

20. Linear Quadratic Exponential

21. Linear Quadratic Exponential

22. Linear Quadratic Exponential
Review of Graphs we have done so far!

Graph each of the following functions WITHOUT making a table of values (unless of course you are desperate!) Use your book or notes to assist you. Think about what the parent graph for each function looks like and what properties it has. Remember every number has a job!

1. \( y = 2x + 3 \)

2. \( y = 2|x - 4| + 3 \)

3. \( y = 2\sqrt{x - 4} + 3 \)

Analysis:

1. What do all three graphs have in common?

2. What is different about each graph?

3. What is the job of the “3” in each function?

4. What is the job of the “2” in each function?
Introduction to Transformations of Parabolas!

Can you apply what you have learned about parent functions and transformations to a new kind of graph? The Parabola!

There are several forms of every type of function, each beneficial in its own way. Our task is to learn what can be gained from each form and how to convert any form to any other form (similar to converting fractions, decimals and percents back and forth). Here are the three forms of a parabola. This activity will be exploring vertex form. This should remind you of several other graphs we have done before.

1. Standard Form: \( y = ax^2 + bx + c \)
2. Vertex Form: \( y = a(x-h)^2 + k \)
3. Factored Form (or Intercept Form): \( y = a(x-p)(x-q) \)

Part I: The Parent Function

Using a table of values, graph the parent parabola, \( y = x^2 \), and then describe any patterns you see in the table, patterns you see in the graph, properties of the graph, important points. Basically, what do you need to memorize in order to always be able to graph this parent function?

Patterns???

Part II: Transformations

Using a table of values, graph each of the following functions and describe what the job of the “3” is in each function.

1. \( y = x^2 + 3 \)
   
   Job of the 3?
2. \[ y = 3x^2 \]
   
   Job of the 3?

3. \[ y = (x+3)^2 \]
   
   Job of the 3?

4. \[ y = -\frac{1}{3} x^2 \]
   
   Job of the 3?
**Part III: Generalizations**

Here is the general function in Vertex Form: $y = a(x-h)^2 + k$. In as much detail as possible, describe the jobs of $a$, $h$, and $k$. Include what happens when the numbers are both positive and negative, and whole and fractional numbers.

**Job of $a$:**

**Job of $h$:**

**Job of $k$:**

Based on what you have just learned, write an equation in Vertex Form ($y = a(x-h)^2 + k$) for each of the following graphs.

**Function:**

**Function:**

4
Homework: Graph each function using what you now know about a, h, and k.

1. \( y = x^2 - 2 \)
2. \( y = (x - 5)^2 \)
3. \( y = -(x + 2)^2 \)
4. \( y = \frac{1}{4} x^2 + 2 \)
5. \( y = (x - 2)^2 - 3 \)
6. \( y = 2(x - 2)^2 \)
7. \( y = \frac{1}{2} (x + 4)^2 - 1 \)
8. \( y = -2(x + 1)^2 + 5 \)
9. \( y = -(x - 3)^2 + 2 \)
About Projectile Motion

A PROJECTILE is any object that is thrown or "projected" into the air. A projectile moves only under the influence of gravity. Some examples might be throwing a ball into the air or a coin rolling off a table top. When an object is thrown into the air, it makes a parabolic path that is known as its TRAJECTORY.

If we ignore air resistance, the only force acting on the object is the weight of the object itself - the downward acceleration due to gravity decreases its upward speed as the object travels upwards, and increases its speed downwards as the object travels downwards. There is no force acting on the object in its forward, or horizontal, movement - so the movement forward is at a constant speed, whereas the vertical speed changes continually.

Projectile motion is an example of two-dimensional motion. The defining characteristics of projectile motion are:

1. constant speed in the horizontal direction
2. constant acceleration in the vertical direction. (10 m/s/s)

To analyze projectiles we consider the horizontal motion and vertical motion separately.

If a projectile is launched at an angle $\theta$, with velocity $v_o$, then it has

initial vertical velocity, $v_{oy} = v_o \sin \theta$

initial horizontal velocity, $v_{ox} = v_o \cos \theta$

Notice that the vector pointing horizontally, labeled $v_x$ in the diagram, remains the same length throughout the course of the "flight" while the vector in the vertical direction, labeled $v_y$, changes during the flight - getting shorter as it goes up, reaching zero at the top, and getting longer as it descends. From what we know about vector addition, we can see the resultant as the angled dotted red arrow which gives us our resulting parabolic trajectory.

http://www.phys.virginia.edu/classes/109N/more_stuff/Applets/ProjectileMotion/jarapplet.html

velocity = dist/time $\times \cos \ x$
LINEAR/QUADRATIC/EXPONENTIAL TABLES

HOW TO RECOGNIZE THE TYPE OF GRAPH FROM A TABLE

To recognize if a function is linear, quadratic (a parabola), or exponential without an equation or graph, look at the differences of the y-values between successive integral x-values. If the difference is constant, the graph is linear. If the difference is not constant but the second set of differences are constant, the graph is quadratic. If the differences follow a pattern similar to the y-values, the graph is exponential. See the examples below for clarity.

Examples
Based on each table, identify the shape of the graph.

Example 1

<table>
<thead>
<tr>
<th>x</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>-7</td>
<td>-5</td>
<td>-3</td>
<td>-1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

The difference in y-values is always two, a constant. The graph is linear and is verified at right.

Example 2

<table>
<thead>
<tr>
<th>x</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

The first difference in y-values is not constant but the second difference is. The graph is quadratic and is verified at right.

Example 3

<table>
<thead>
<tr>
<th>x</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>1/8</td>
<td>1/4</td>
<td>1/2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

The difference in y-values follows a pattern similar to the y-values. The graph is exponential and is verified at right. (In this case, the difference pattern was exactly the same as the y-values. This is not always necessary.)
## Problems

Based on the difference in y-values, identify the graph as linear, quadratic, exponential, or neither.

1. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 14 & 10 & 6 & 2 & -2 & -6 & -10 \\
\end{array}
\]

2. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & \frac{1}{2} & 1 & 2 & 4 & 8 & 16 & 32 \\
\end{array}
\]

3. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 21 & 12 & 5 & 0 & -3 & -4 & -3 \\
\end{array}
\]

4. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & -16 & -13 & -10 & -7 & -4 & -1 & 2 \\
\end{array}
\]

5. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & -14 & -9 & -4 & 1 & 6 & 11 & 16 \\
\end{array}
\]

6. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & -18 & -6 & -2 & 0 & 2 & 6 & 18 \\
\end{array}
\]

7. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 4 & 8 & 16 & 32 & 64 & 128 & 256 \\
\end{array}
\]

8. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & \frac{1}{27} & \frac{1}{9} & \frac{1}{3} & 1 & 3 & 9 & 27 \\
\end{array}
\]

9. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 30 & 20 & 12 & 6 & 2 & 0 & 0 \\
\end{array}
\]

10. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 11 & 9 & 7 & 5 & 3 & 1 & -1 \\
\end{array}
\]

11. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & \frac{1}{9} & \frac{1}{3} & 1 & 3 & 9 & 27 & 81 \\
\end{array}
\]

12. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & -27 & -9 & -3 & 0 & 3 & 9 & 27 \\
\end{array}
\]

13. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 0 & 5 & 8 & 9 & 8 & 5 & 0 \\
\end{array}
\]

14. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 3 & 0 & -1 & 0 & 3 & 8 & 15 \\
\end{array}
\]

15. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & 1 & 0 & -1 & -2 & -1 & 0 & 1 \\
\end{array}
\]

16. \[
\begin{array}{ccccccc}
  x & -3 & -2 & -1 & 0 & 1 & 2 & 3 \\
  y & \frac{9}{8} & \frac{9}{4} & \frac{9}{2} & 9 & 18 & 36 & 72 \\
\end{array}
\]
Identifying Types of Functions Graphically and Analytically

A. Linear Function  B. Quadratic Function  C. Exponential Function  D. Other

Match the correct function to the equation or graph below.

1. \( y = \frac{3}{4}(x - 2) + 4 \)  2. \( f(x) = 6x^3 - 4x + 17 \)  3. \( h(x) = -4^x - 2 \)

4. \( g(x) = -6|2x - 3| + 10 \)  5. \( y = 7x^2 - 1.4 \)  6. \( 9x - 14y = 65 \)

7. \( h(x) = -9(x - 3)^2 - 6 \)  8. \( y = 8(x - 1)^3 + (x - 1)^2 \)  9. \( f(x) = 2.3|x - 7.9| - 3.5 \)

10.  

11.  

12.  

13.  

14.  

15.
Functions in Context
Match each contextual situation to the appropriate graph.
A. You decide to save money for spring break. You have $300 in your account right now and you think you will save an average of $40 over the next four weeks.

B. A first year college student has opened a special account to cover his education costs. He deposits $1500 in the account and he plans to deduct $350 dollars a month to pay for various expenditures including books, food, and tutoring services.

C. Albert Pujols hits a homerun that clears the 10 foot fence 400 feet away from home plate.

D. You decide to save one penny today, two tomorrow, four the next day, eight the day after that, and so one for 3 months.

E. The path of a diver jumping from a 15 foot high diving board.

F. The temperature in your oven as it preheats to 350 degrees.
Graphing Quadratics Review Worksheet

Fill in each blank using the word bank.

<table>
<thead>
<tr>
<th>vertex</th>
<th>minimum</th>
<th>axis of symmetry</th>
<th>x-intercepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>parabola</td>
<td>maximum</td>
<td>zeros/roots</td>
<td>ax² + bx + c</td>
</tr>
</tbody>
</table>

1. Standard form of a quadratic function is \( y = \) ________________

2. The shape of a quadratic equation is called a ________________

3. ________________

4. ________________

5. When the vertex is the highest point on the graph, we call that a ________________.

6. When the vertex is the lowest point on the graph, we call that a ________________.

7. Our solutions are the ____________________.

8. Solutions to quadratic equations are called ____________________.

Determine whether the quadratic functions have two real roots, one real root, or no real roots. If possible, list the zeros of the function.

9. Number of roots: _____  
   Zero(s): __________

10. Number of roots: _____  
    Zero(s): __________

11. Number of roots: _____  
    Zero(s): __________
12. Given the graph, identify the following.

Axis of symmetry: ____________

Vertex: ____________

How many zeros: ___ which are: _______

Domain: ______________

Range: ______________

Graph the following quadratic functions by using critical values and/or factoring.

You need three points to graph and don't necessarily need all the information listed.

Remember:

Option 1: If it factors, find the zeros.

The middle of the two factors is the axis of symmetry.

Option 2: If it doesn't factor, find the axis of symmetry with \( x = \frac{-b}{2a} \)

Plug the \( x \)-value into the original equation to find the \( y \)-value of the vertex. The \( y \)-intercept is at \((0, c)\)

13. \( y = x^2 - 2x - 3 \) factor or critical values?

Identify the zeros/roots: ____ and ____

Does it have a minimum or maximum? ____

Axis of symmetry: ____________ Vertex: ____________

\( y \)-intercept: ____________

Domain: ____________ Range: ____________

Graph at least 5 points
14. \( y = -x^2 - 4x + 5 \) factor or critical values?

Identify the zeros/roots: ____ and ____
Does it have a minimum or maximum? ____
Axis of symmetry: ________ Vertex: ________
y-intercept: ________ Graph at least 5 points
Domain: ________ Range: ________

15. \( y = x^2 + 4x + 7 \) factor or critical values?

Axis of symmetry: ________ Vertex: ________
Max or Min? ________
y-intercept: ________ Graph at least 3 points

16. \( y = -x^2 - 2x + 2 \) factor or critical values?

Axis of symmetry: ________ Vertex: ________
Max or Min? ________
y-intercept: ________ Graph at least 5 points

17. A bottlenose dolphin jumps out of the water. The path the dolphin travels can be modeled by \( h = -0.2d^2 + 2d \), where \( h \) represents the height of the dolphin and \( d \) represents horizontal distance.

a. What is the maximum height the dolphin reaches?

b. How far did the dolphin jump?