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| **Name**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Date**\_\_\_\_\_\_\_\_\_\_ |  |
| **Stretching and Shrinking the Graph of *f*(*x*) = *x*2** |  |

**1    EXAMPLE   Graphing *f*(*x*) = *ax*2 when |*a*| > 1**

**Graph each quadratic function using the same coordinate plane. (The graph of the parent function is shown.)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| * **A**  *g*(*x*) = 2*x*2  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | ***x*** | −3 | −2 | −1 | 0 | 1 | 2 | 3 | | ***g*(*x*) = 2*x*2** |  |  |  |  |  |  |  |   C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p37_001.jpg |  |

* **1a.** In general, how does the *y*-coordinate of a point on the graph of *g*(*x*) = 2*x*2  
  compare with the *y*-coordinate of a point on the graph of *f*(*x*) = *x*2 when the points  
  have the same *x*-coordinate?  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **1b.** Describe the graph of *g*(*x*) = 2*x*2 as a transformation of the graph of *f*(*x*) = *x*2.  
  Use the word *stretch* in your description.  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **1c.** What transformation occurs when the value of *a* in *g*(*x*) = *ax*2 is negative?  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

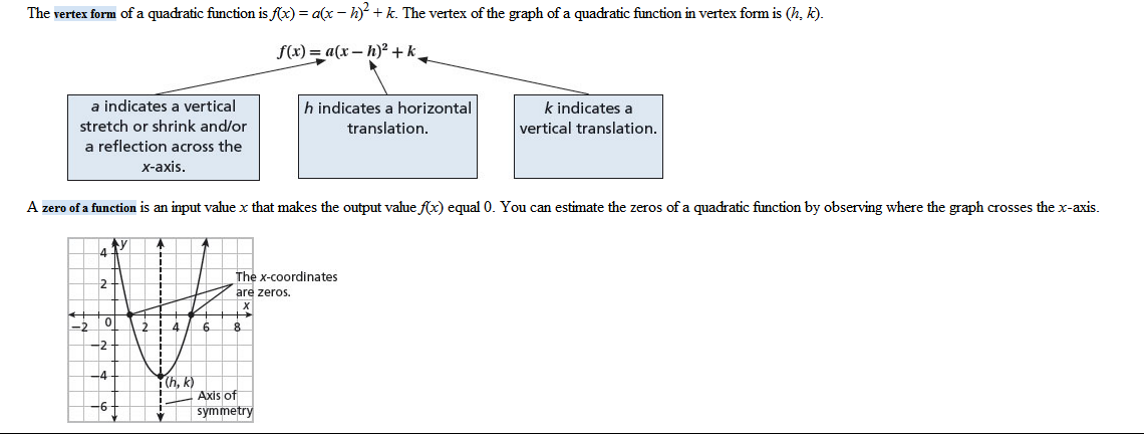
**EXAMPLE  Graphing *f*(*x*) = *ax*2 when |*a*| < 1**

**Graph each quadratic function using the same coordinate plane. (The graph of the parent function is shown.)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| * **A**  *g*(*x*) = C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_001.jpg  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | ***x*** | −6 | −4 | −2 | 0 | 2 | 4 | 6 | | ***g*(*x*) = C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_002.jpg** |  |  |  |  |  |  |  |  * **B**  *g*(*x*) = C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_003.jpg  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | ***x*** | −6 | −4 | −2 | 0 | 2 | 4 | 6 | | ***g*(*x*) = C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_004.jpg** |  |  |  |  |  |  |  | | C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_005.jpg |

* **2a.** Describe the graph of *g*(*x*) = C:\Users\asweeney\AppData\Roaming\Holt McDougal\HS Activity Generator\Profiles\2a580yk2.default\UserLabs\10001_files\p38_006.jpgas a transformation of the graph of *f*(*x*) = *x*2. Use the word *shrink* in your description.  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **2b.** Compare the domain and range of *g*(*x*) = *ax*2 when *a* > 0 and when *a* < 0.  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **2c.** Summarize your observations about the graph of *g*(*x*) = *ax*2 compared with the graph of *f*(*x*) = *x*2.

|  |  |  |
| --- | --- | --- |
| **Value of a** | **Vertical stretch or shrink?** | **Reflection across *x*-axis?** |
| *a* > 1 |  |  |
| 0 < *a* < 1 |  |  |
| −1 < *a* < 0 |  |  |
| *a* = 1 |  |  |
| *a* < −1 |  |  |
| **Graphing Quadratic Functions in Vertex Form** | | |  |
|  | | |

  
**1a.** For the function *f*(*x*) = 2(*x* − 3)2 + 1, what are the values of *a, h,* and *k*? What do each of these values indicate about the graph of the function?  
  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* **1b.** If you estimate a zero of a quadratic function from a graph, how could you use algebra to check your answer?  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**2    EXAMPLE   Graphing *f*(*x*) = *a*(*x* − *h*)2 + *k***

**Graph the function *f*(*x*) = 2(*x* + 1)2 − 2. Identify the vertex, minimum or maximum, axis of symmetry, and zeros of the function.**

* **A** Identify and graph the vertex.  
    
  *h* =   
    
  *k* =   
    
  The vertex of the graph is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* **B** Identify the coordinates of points to the left and right of the vertex.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***x*** | −3 | −2 | 0 | 1 |
| ***f*(*x*)** |  |  |  |  |

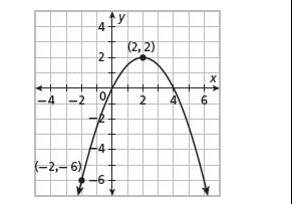
**C** Graph the points and connect them with a smooth curve.

* **D** Identify the minimum or maximum.  
    
  The graph opens upward, so the function has a\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.  
    
  The minimum is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* **E** Identify the axis of symmetry.  
    
  The axis of symmetry is the vertical line *x* =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* **F** Identify the zeros of the function.  
    
  The graph appears to cross the *x*-axis at the points \_\_\_\_\_\_\_\_\_\_\_ and  
    
  \_\_\_\_\_\_\_\_\_\_\_, so the zeros of the function appear to be \_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_.

**REFLECT**

* **2a.**  How could you use the value of *a* to determine whether the function *f*(*x*) = 2(*x* + 1)2 − 2 has a minimum or a maximum?  
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* **2b.** How could you use the table in part B (or on your calculator) to confirm that you correctly identified the zeros of the function from its graph?  
    
  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**3    EXAMPLE   Writing Equations in Vertex Form**

**Write the vertex form of the quadratic function whose graph is shown.**

* **A** Use the vertex of the graph to identify the values of *h* and *k*.  
    
  The vertex of the graph is\_\_\_\_\_\_\_\_\_\_\_.  
    
  *h* =   
    
  *k* =   
    
  Substitute the values of *h* and *k* into the vertex form:  
  *f*(*x*) = *a* (*x* − )2 +
* **B** Use the point (−2, −6) to identify the value of *a*.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *f*(*x*) | = | *a*(*x* − 2)2 + 2 |  | Vertex form |
|  | = | *a*( − 2)2 + 2 |  | Substitute −6 for *f*(*x*) and −2 for *x*. |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| −6 | = | *a*() + 2 |  | Simplify. |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  | = | *a*(16) |  | Subtract 2 from both sides. |
|  |  |  |  |  |
|  |  |  |  |  |
|  | = | *a* |  | Divide both sides by 16. |

Substitute the value of *a* into the vertex form:  
*f*(*x*) = (*x* − 2)2 + 2   
  
So, the vertex form of the function shown in the graph is  
  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**PRACTICE**

**Graph each quadratic function. Identify the vertex, minimum or maximum, axis  
of symmetry, and zeros of the function.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1.** | *f*(*x*) = −2*x*2 + 8 | |  | **2.** | | *f*(*x*) = (*x* − 2)2 − 4 | |
|  |  | |  |  | |  | |
|  | [https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA) | |  |  | | [https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA) | |
|  |  | |  |  | |  | |
|  | Vertex:  Min/Max:  AOS:  Zeros: | |  | Vertex:  Min/Max:  AOS:  Zeros: | |  | |  |
|  |  | |  |  | |  | |
|  |  | |  |  | |  | |
|  |  | |  |  | |  | |
| 3. | *f*(*x*) = −(*x* + 4)2 + 1 | |  | 4. | | *f*(*x*) = (*x* − 2)2 – 3 | |
|  |  | |  |  | |  | |
|  | [https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA) | |  |  | | [https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA) | |
|  |  | |  |  | |  | |
|  | Vertex:  Min/Max:  AOS:  Zeros: | |  | Vertex:  Min/Max:  AOS:  Zeros: | |  | |  |
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| **5.** | The function *f*(*x*) = −16(*x* − 1)2 + 16 gives the height in feet of a football *x* seconds after it is kicked from ground level.   * **a.**   Sketch a graph of the function. * **b.**   What is the maximum height that the ball reaches?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ * **c.**   How long does the ball stay in the air? Explain how you determined your answer.  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | [https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA) |

|  |  |  |
| --- | --- | --- |
| **6.** | A technician is launching an aerial firework from a tower. The height of the firework in feet is modeled by the function *f*(*x*) = −16(*x* − 3)2 + 256 where *x* is the time in seconds after the firework is launched.   * **a.** Sketch a graph of the function. * **b.** Professional fireworks are usually timed to explode as they reach their highest point. How high will the firfirework be when it reaches its highest point?  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ * **[https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRFHZb2GPUaPOZCz6QQYuVgsxXVHYu0x3cjCYlgk76mT3kojqLLw5ED7VVw](https://www.google.com/imgres?imgurl&imgrefurl=http%3A%2F%2Fetc.usf.edu%2Fclipart%2Fgalleries%2F648-coordinate-grids&h=0&w=0&tbnid=EeICPBgAbpJkTM&zoom=1&tbnh=225&tbnw=225&docid=7SRnHIiWjGSPyM&tbm=isch&ei=gMtkVO_1L9OxuASmqoCQDw&ved=0CAQQsCUoAA)c.** What is the height of the tower from which the firework is launched? Explain how you determined your ananswer. |  |