**9-3 Study Guide and Intervention**

***Transformations of Quadratic Functions***

**Translations** A **translation** is a change in the position of a figure either up, down, left, right, or diagonal.
Adding or subtracting constants in the equations of functions translates the graphs of the functions.

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| The graph of ***g***(***x***) = $x^{2}$ + ***k*** translates the graph of ***f***(***x***) = $x^{2}$ vertically.If ***k*** > 0, the graph of ***f***(***x***) = $x^{2}$ is translated ***k*** units up.If ***k*** < 0, the graph of ***f***(***x***) = $x^{2}$ is translated $\left|k\right|$ units down. |

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| The graph of ***g***(***x***) = $(x-h)^{2}$ is the graph of ***f***(***x***) = $x^{2}$ translated horizontally.If ***h*** > 0, the graph of ***f***(***x***) = $x^{2}$ is translated ***h*** units to the right.If ***h*** < 0, the graph of ***f***(***x***) = $x^{2}$ is translated $\left|h\right|$ units to the left. |

**Example: Describe how the graph of each function is related to the graph of *f*(*x*) =** $x^{2}$**.le**

**a. *g*(*x*) =** $x^{2}$ **+ 4**

The value of *k* is 4, and 4 > 0. Therefore, the graph of *g*(*x*) = $x^{2}$ + 4 is a translation of the graph of *f*(*x*) **=** $x^{2}$ up 4 units



**b. *g*(*x*) =** $(x + 3)^{2}$

The value of *h* is –3, and –3 < 0. Thus, the graph of

*g*(*x*) = $(x + 3)^{2}$ is a translation of the graph of *f*(*x*) = $x^{2}$ to the left 3 units.



**Exercises**

**Describe how the graph of each function is related to the graph of *f*(*x*) = *x*2.**

 **1.** *g*(*x*) = $x^{2}$ + 1 **2.** *g*(*x*) = $(x – 6)^{2}$ **3.** *g*(*x*) = $(x + 1)^{2}$

 **4.** *g*(*x*) = 20 + $x^{2}$ **5.** *g*(*x*) = $(-2 + x)^{2}$ **6.** *g*(*x*) = – $\frac{1}{2}$ + $x^{2}$

 **7.** *g*(*x*) = $x^{2}$ + $\frac{8}{9}$ **8.** *g*(*x*) = $x^{2}$ – 0.3 **9.** *g*(*x*) = $(x + 4)^{2}$

**9-3 Study Guide and Intervention** *(continued)*

***Transformations of Quadratic Functions***

**Dilations and Reflections** A **dilation** is a transformation that makes the graph narrower or wider than the parent graph. A **reflection** flips a figure over the *x*- or *y*-axis.

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| 18-f-1.jpgThe graph of ***f***(***x***) = ***ax*2**stretches or compresses the graph of ***f***(***x***) = ***x*2**.If $\left|a\right|$ > 1, the graph of ***f***(***x***) = ***x*2**is stretched vertically.If 0 < $\left|a\right|$ < 1, the graph of ***f***(***x***) = ***x*2**is compressed vertically.  |
| 18-f-2.jpgThe graph of the function –***f***(***x***) flips the graph of ***f***(***x***) = ***x*2** across the *x*-axis.The graph of the function ***f***(–***x***) flips the graph of ***f***(***x***) = ***x*2** across the *y*-axis. |

**Example: Describe how the graph of each function is related to the graph of *f*(*x*) =** $x^{2}$**.**

**a. *g*(*x*) = 2**$x^{2}$

The function can be written as *f*(*x*) = *a*$x^{2}$ where *a* = 2. Because $\left|a\right|$ > 1, the graph of *y* = 2$x^{2}$ is the graph of *y* = $x^{2}$ that is stretched vertically.

**b. *g*(*x*) = –** $\frac{1}{2}x^{2}$ **– 3**

The negative sign causes a reflection across the *x*-axis. Then a dilation occurs in which *a* = $\frac{1}{2}$ and a translation in which *k* = –3. So the graph of *g*(*x*) = – $\frac{1}{2}x^{2}$ – 3 is reflected across the *x*-axis, dilated wider than the graph of *f*(*x*) = $x^{2}$, and translated down 3 units.

**Exercises**

**Describe how the graph of each function is related to the graph of *f*(*x*) =** $x^{2}$**.**

 **1.** *g*(*x*) = –5$x^{2}$ **2.** *g*(*x*) = – $(x+1)^{2}$ **3.** *g*(*x*) = – $\frac{1}{4}x^{2}$ – 1