

$$g(x) = af(x - c) + d$$

**Note:** the transformations caused by parameters  $d$ ,  $a$ , and  $c$  are as follows:

Parameter  $d$  **causes a vertical shift**. If  $d > 0$ , then there is a shift up. If  $d < 0$  then there is a shift down.

Parameter  $a$  **causes a vertical stretch or compression**. If  $|a| > 0$ , then there is a vertical stretch. If  $0 < |a| < 1$ , then there is a vertical compression.

Parameter  $a$  **causes a vertical reflection** if  $a$  is negative.

Parameter  $c$  **causes a horizontal shift**. If  $c > 0$ , then the shift is to the right. If  $c < 0$ , then the shift is to the left.

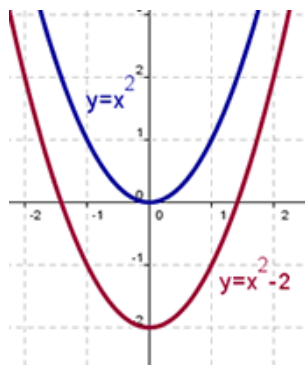
### Vertical shift

The blue function is the original function.

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

The red function is the result of vertically shifting the blue function down by 2.

$$g(x) = f(x) - 2 \text{ or } g(x) = x^2 - 2$$



x	f(x)	f(x)-2	g(x)
-2	4	4-2	2
-1	1	1-2	-1
0	0	0-2	-2
1	1	1-2	-1
2	4	4-2	2

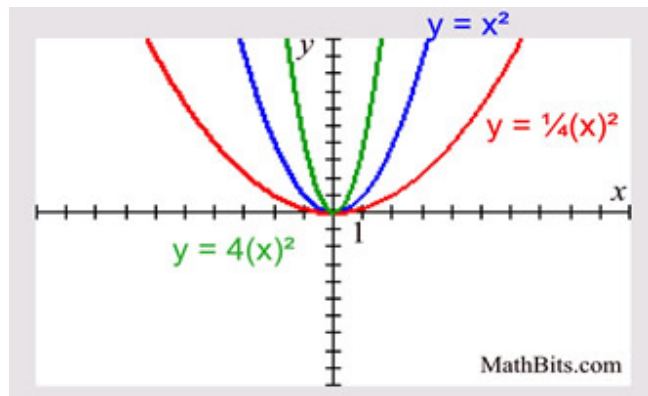
### Vertical compression

The blue function is the original function.

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

The red function is the result of vertically compressing the blue function by a factor of 1/4.

$$g(x) = \frac{1}{4}(f(x)) \text{ or } g(x) = \frac{1}{4}x^2$$



x	f(x)	$\frac{1}{4}f(x)$	g(x)
-2	4	$\frac{1}{4} * 4$	1
-1	1	$\frac{1}{4} * 1$	$\frac{1}{4}$
0	0	$\frac{1}{4} * 0$	0
1	1	$\frac{1}{4} * 1$	$\frac{1}{4}$
2	4	$\frac{1}{4} * 4$	1

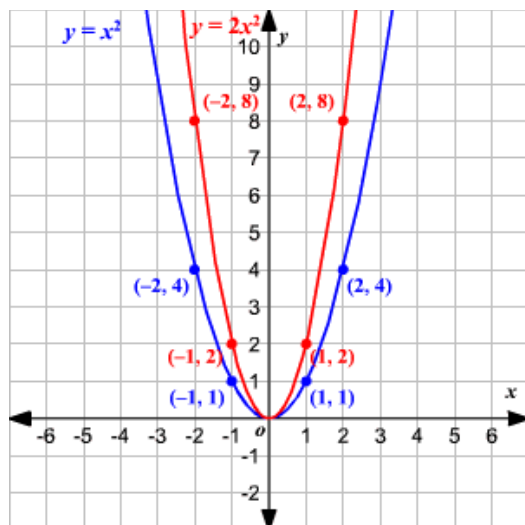
## Vertical stretch

The blue function is the original function.

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

The red function is the result of vertically stretching the blue function by a factor of 2.

$$g(x) = 2(f(x)) \text{ or } g(x) = 2x^2$$



x	f(x)	2f(x)	g(x)
-2	4	2*4	8
-1	1	2*1	2
0	0	2*0	0
1	1	2*1	2
2	4	2*4	8

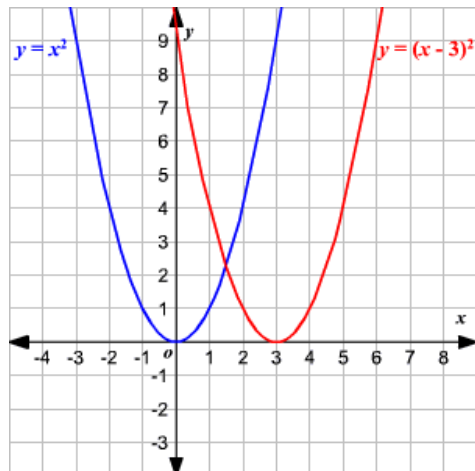
## Horizontal shift

The blue function is the original function.

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

The red function is the result of horizontally shifting the blue function right by 3.

$$g(x) = f(x - 3) \text{ or } g(x) = (x - 3)^2$$



x	$x^2$	f(x)	x - 3	$(x - 3)^2$	g(x)
-2	$(-2)^2$	4	-2 - 3	$(-5)^2$	25
-1	$(-1)^2$	1	-1 - 3	$(-4)^2$	16
0	$(0)^2$	0	0 - 3	$(-3)^2$	9
1	$(1)^2$	1	1 - 3	$(-2)^2$	4
2	$(2)^2$	4	2 - 3	$(-1)^2$	1
3	$(3)^2$	9	3 - 3	$(0)^2$	0
4	$(4)^2$	16	4 - 3	$(1)^2$	1