(Warm-Up) Task B: The Basic Parabola $y = x^2$
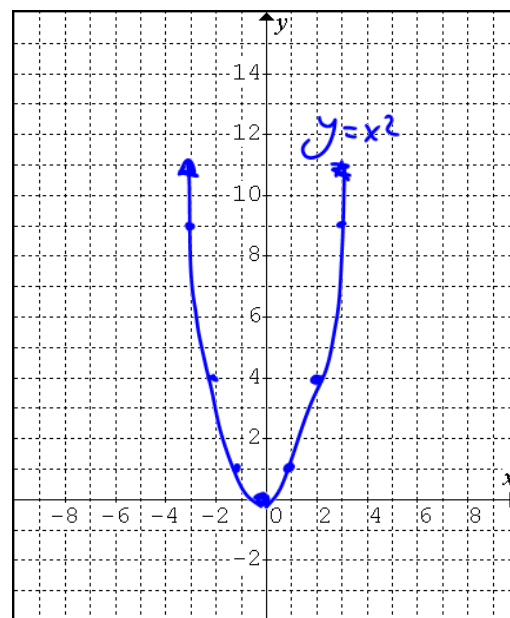
1. Complete the table of values, including the first differences.

2. Graph the parabola.

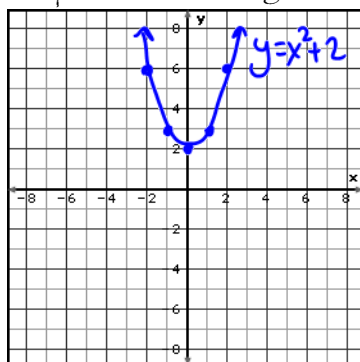| x	$y = x^2$	first differences
-4	16	
-3	9	$9-16=-7$
-2	4	$4-9=-5$
-1	1	$1-4=-3$
0	0	$0-1=-1$
1	1	$1-0=1$
2	4	$4-1=3$
3	9	$9-4=5$
4	16	$16-9=7$

*These are also referred to as the '**step pattern**'.* ↑

$1, 3, 5, 7$

- Go to DESMOS and type $y = (x - h)^2 + k$. Then click all to add slider. Set h and k to 0. Does this graph match the one you drew above?

Task k: What happens when you graph $y = x^2 + k$?

- Change the slider for **k** to 2. What equation does that produce? $y = x^2 + 2$

3. Describe the effect this had on the graph.

It shifted the graph 2 units UP.

4. Complete the following information.

x	$y = x^2 + 2$	first diff.
-3	$(-3)^2 + 2 = 11$	-5
-2	$(-2)^2 + 2 = 6$	-3
-1	$(-1)^2 + 2 = 3$	-1
0	$(0)^2 + 2 = 2$	1
1	$(1)^2 + 2 = 3$	3
2	$(2)^2 + 2 = 6$	5
3	$(3)^2 + 2 = 11$	

vertex = $(0, 2)$

axis of symmetry = $x = 0$

direction of opening = UP
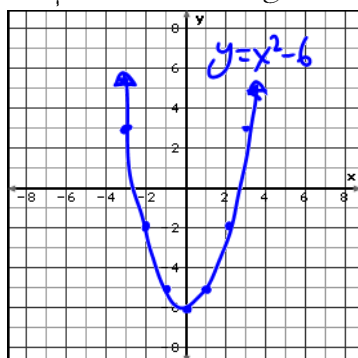
step pattern =

$1 \quad 3 \quad 5 \quad 7$

steps

- Change the slider for *k* to -6. What equation does that produce? $y = x^2 - 6$

5. Describe the effect this had on the graph.

   It shifted/translated 6 units Down

6. Complete the following information.

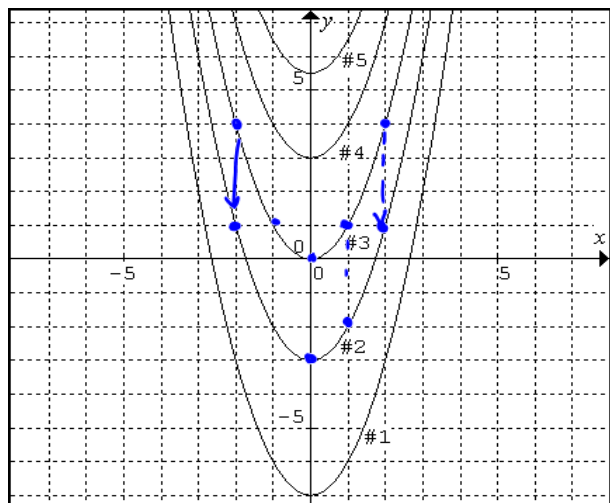| x	$y = x^2 - 6$	first diff.
-3	$(-3)^2 - 6 = 3$	-5
-2	$(-2)^2 - 6 = -2$	-3
-1	$(-1)^2 - 6 = -5$	-1
0	$(0)^2 - 6 = -6$	1
1	$(1)^2 - 6 = -5$	3
2	$(2)^2 - 6 = -2$	5
3	$(3)^2 - 6 = 3$	

vertex = $(0, -6)$

axis of symmetry = $x = 0$

direction of opening = UP

step pattern =

   1 3 5

7. State the equation of each graph.

#1: $y = x^2 - 7$

#2: $y = x^2 - 3$

#3: $y = x^2$

#4: $y = x^2 + 3$

#5: $y = x^2 + 5.5$

The Effect of k

The graph of $\underline{y = x^2 + k}$ produces a **vertical translation (or shift)**.

- the parabola will shift **up** if $k > 0$ (i.e: $y = x^2 + k$)

- the parabola will shift **down** if $k < 0$ (i.e: $y = x^2 - k$)

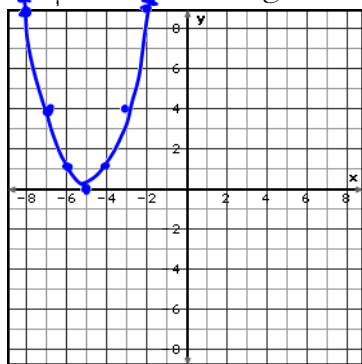## Task H: What happens when you graph y = (x − h)²?

- Back in DESMOS; change the slider for **k** back to 0.
- Change the slider for **h** to -5. What equation does that produce in <u>vertex form</u>? (HINT: Sub -5 for h)

$$y = (x+5)$$

8. Describe the effect this had on the graph.

The graph shifted/translated 5 units left

9. Complete the following information:

x	y = (x + 5)²	first differences
-8	$(-8+5)^2 = 9$	
		-5
-7	$(-7+5)^2 = 4$	
		-3
-6	$(-6+5)^2 = 1$	
		-1
-5	$(-5+5)^2 = 0$	
		1
-4	$(-4+5)^2 = 1$	
		3
-3	$(-3+5)^2 = 4$	
		5
-2	$(-2+5)^2 = 9$	

vertex = (5, 0)

axis of symmetry = $x = -5$

direction of opening = up
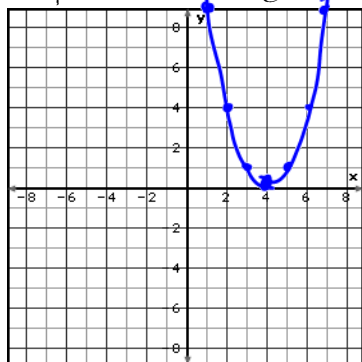
step pattern =

1   3   5

- Back in DESMOS; change the slider for **h** to 4.

What equation does that produce in <u>vertex form</u>? $y = (x-4)$

10. Describe the effect this had on the graph.

It shifted/translated 4 units RIGHT

11. Complete the following information:

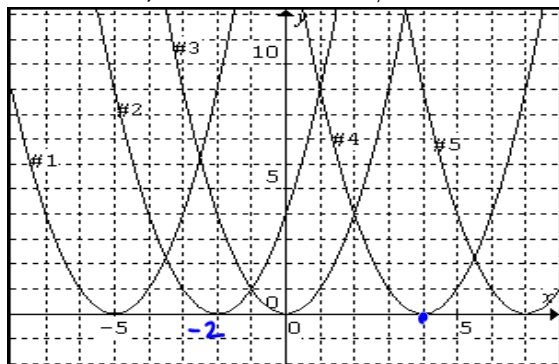| x	y = (x − 4)²	first differences
1	$(1-4)^2 = 9$	
		-5
2	$(2-4)^2 = 4$	
		-3
3	$(3-4)^2 = 1$	
		-1
4	$(4-4)^2 = 0$	
		1
5	$(5-4)^2 = 1$	
		3
6	$(6-4)^2 = 4$	
		5
7	$(7-4)^2 = 9$	

vertex = (4, 0)

axis of symmetry = $x = 4$

direction of opening = up

step pattern =

1   3   5

12. State the equation of each graph.

#1: $y = (x+5)^2$

#2: $y = (x+2)^2$

#3: $y = x^2$

#4: $y = (x-4)^2$

#5: $y = (x-7)^2$

The Effect of h

The graph of $y = (x - h)^2$ produces a horizontal translation (or shift).

the parabola will shift **R I G H T** if $h > 0$ (i.e: $y = (x - {}^+h)^2$ or $y = (x - h)^2$)

- the parabola will shift **L E F T** if $h < 0$ (i.e: $y = (x - {}^-h)^2$ or $y = (x + h)^2$)

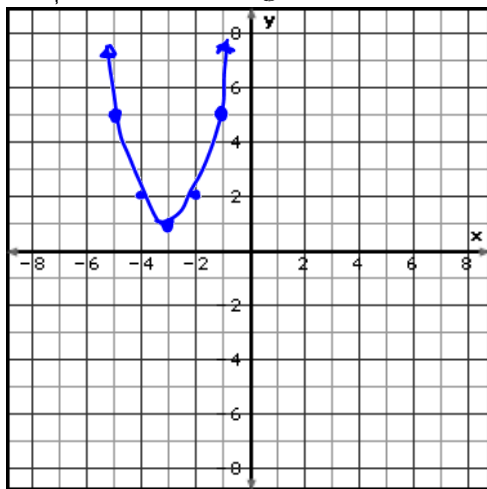## Task T: What happens when they're together $y = (x - h)^2 + k$?

- Back in DESMOS, change the slider for k to 1 and for h to -3.

  What equation does that produce in **vertex form**? $y = (x + 3)^2 + 1$

13. Describe the effect this had on the graph.
    It shifted / translated 3 units left and 1 unit up.

14. Complete the following information:
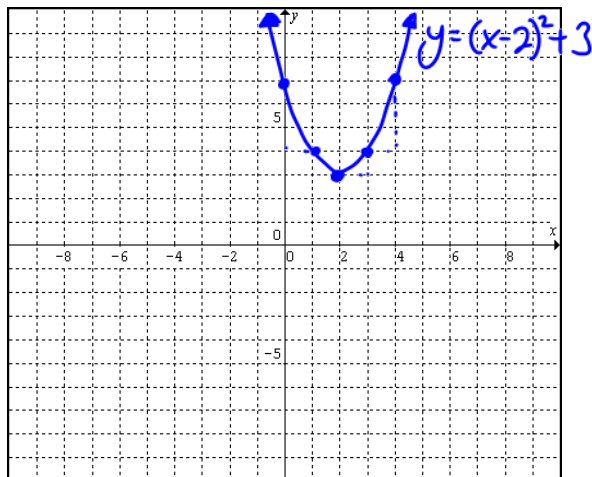

    vertex = $(-3, 1)$

    axis of symmetry = $x = -3$

    direction of opening = up

    step pattern = 1 3 5 7

15. Graph the equation $y = (x - 2)^2 + 3$ using the step pattern. Vertex $(2, 3)$

    $y = (x - 2)^2 + 3$

    Graphing: Step Pattern
    1) State the step pattern:
    2) Plot the vertex
    3) From vertex, move 1 unit right, then 1 unit up. Plot the point. (This is your first step)
    4) From the last point, move 1 unit right, then 3 units up. Plot the point. (This is your second step)
    5) If there is any space left in the Cartesian plane, continue with this pattern.

==Task P: Practice!==

15. Complete the following table.

Equation	Vertex	Axis of Symmetry	Step Pattern From Vertex	Direction of Opening
1) $y = x^2 + 1$	(0, 1)	x = 0	1, 3, 5	UP
2) $y = x^2 - 6$	(0, -6)	x = 0	1, 3, 5	UP
3) $y = (x - 4)^2$	(4, 0)	x = 4	1, 3, 5	UP
4) $y = (x + 7)^2$	(-7, 0)	x = -7	1, 3, 5	UP
5) $y = (x + 4)^2 - 2$	(-4, -2)	x = -4	1, 3, 5	UP
6) $y = (x - 1)^2 - 3$	(1, -3)	x = 1	1, 3, 5, 7	UP

16. Graph each parabola from the table.

1) $y = x^2 + 1$ $y = x^2 + 1$

2) $y = x^2 - 6$

3) $y = (x - 4)^2$

4) $y = (x + 7)^2$

5) $y = (x + 4)^2 - 2$ V(-4, -2)

6) $y = (x - 1)^2 - 3$ V(1, -3)