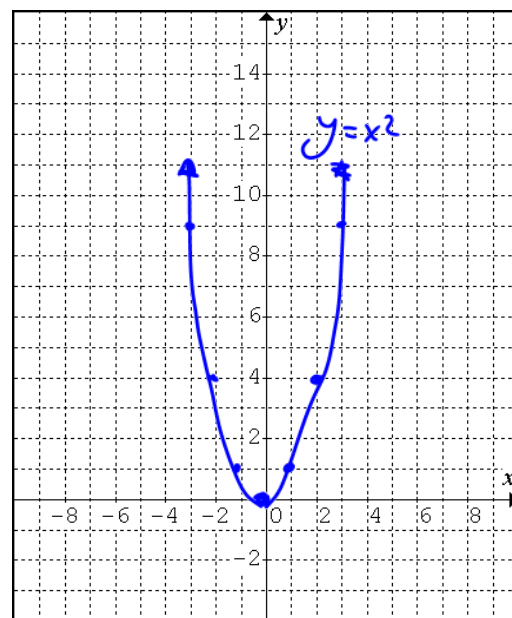


**(Warm-Up) Task B: The Basic Parabola  $y = x^2$**

- Complete the table of values, including the first differences.
- 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	$16 - 9 = 7$



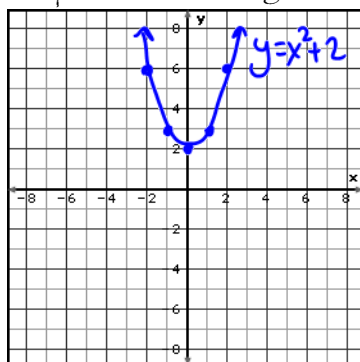
These are also referred to as the **'step pattern'**.

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?  $y = x^2 + 2$
- Describe the effect this had on the graph.  
It shifted the graph 2 units UP.
- Complete the following information.



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

vertex = (0, 2)

axis of symmetry =  $x = 0$

direction of opening = UP

step pattern =

1 3 5 7

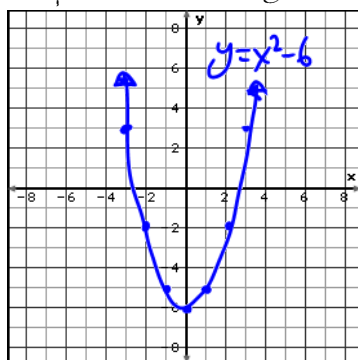
steps

• 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	$(3)^2 - 6 = 3$	

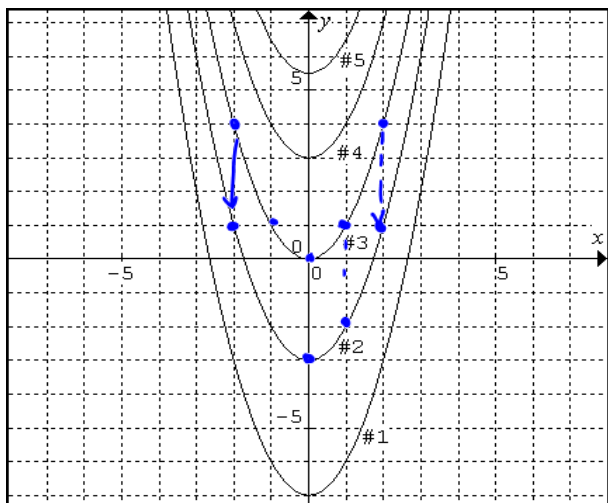
vertex =  $(0, -6)$

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  $y = x^2 + k$  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  $y = (x - h)^2$ ?**

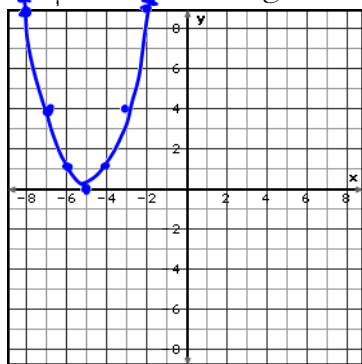
- Back in DESMOS; change the slider for  $k$  back to 0.
- Change the slider for  $h$  to -5. What equation does that produce in vertex form? (HINT: Sub -5 for h)

$y = (x + 5)^2$

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 =

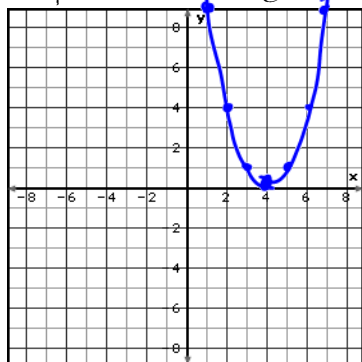
1 3 5

- Back in DESMOS; change the slider for  $h$  to 4.  
What equation does that produce in vertex form?  $y = (x - 4)^2$

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	$(1-4)^2 = 9$	-3
2	$(2-4)^2 = 4$	-1
3	$(3-4)^2 = 1$	1
4	$(4-4)^2 = 0$	3
5	$(5-4)^2 = 1$	5
6	$(6-4)^2 = 4$	
7	$(7-4)^2 = 9$	

vertex =  $(4, 0)$

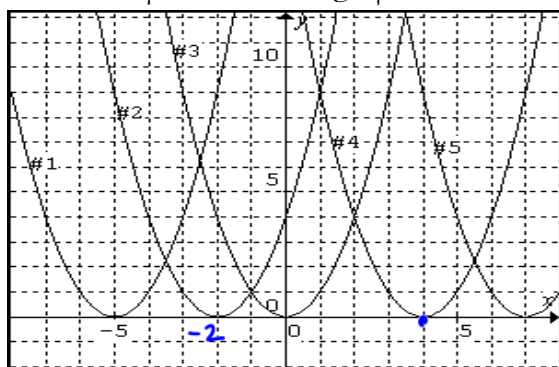
axis of symmetry =  $x = 4$

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  $y = (x-h)^2 + k$ ?**

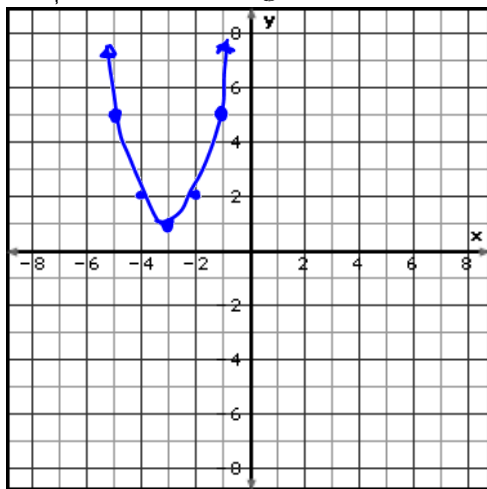
- Back in DESMOS, change the slider for  $k$  to 1 and for  $h$  to -3.

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:



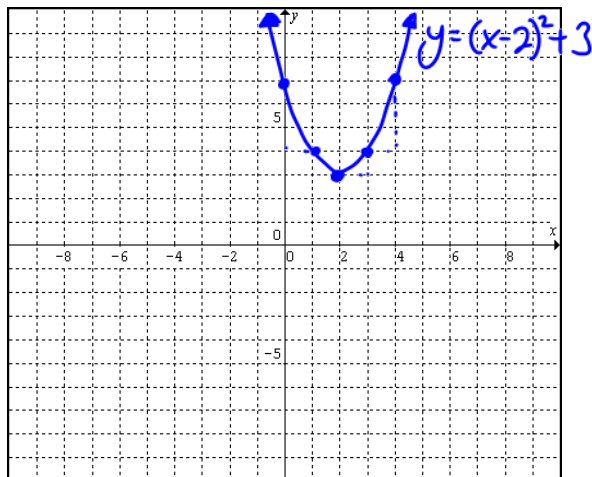
vertex =  $(-3, 1)$

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)



**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.

