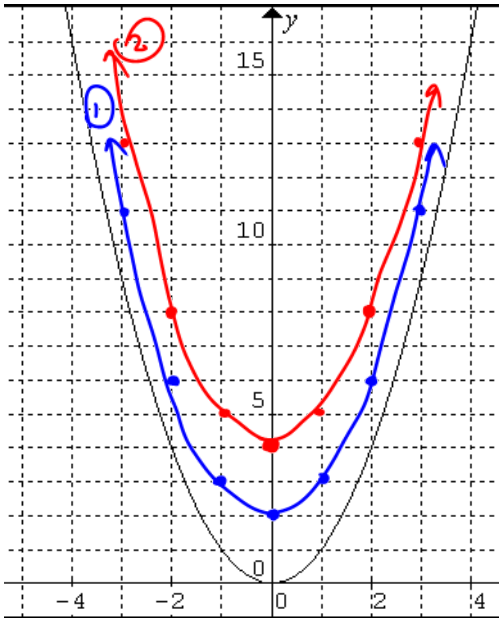
The Quadratic Relation $y = x^2 + k$

***INVESTIGATION 1:* Graphing $y = x^2 + k$, when 'k' is positive**

Complete the table of values. Use a different colour to sketch the graph of each parabola on the axes.

① $y = x^2 + 2$	
x	(x , y)
-4	$(-4)^2+2=18$
-3	$(-3)^2+2=11$
-2	$(-2)^2+2=6$
-1	$(-1)^2+2=3$
0	$(0)^2+2=2$
1	3
2	6
3	11
4	18

② $y = x^2 + 4$	
x	(x , y)
-4	$(-4)^2+4=20$
-3	$(-3)^2+4=13$
-2	$(-2)^2+4=8$
-1	$(-1)^2+4=5$
0	4
1	5
2	8
3	13
4	20



Observation – How do the graphs of $y = x^2 + 2$ *and* $y = x^2 + 4$ *differ from the standard graph?*

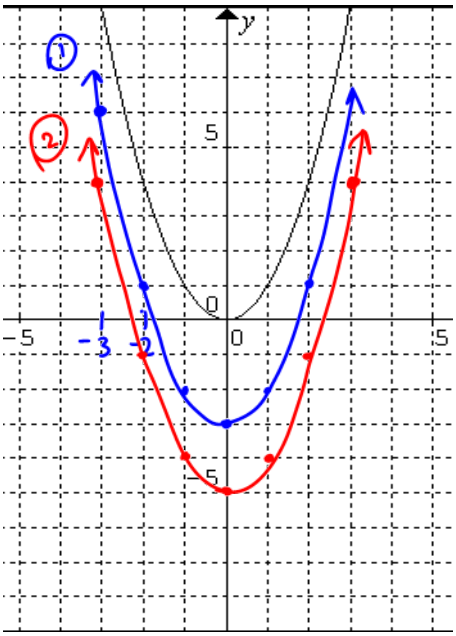
they're shifted up

***INVESTIGATION 2:* Graphing $y = x^2$, when 'k' is negative.**

Complete the table of values. Use a different colour to sketch a graph of each parabola on the axes.

① $y = x^2 - 3$	
x	(x , y)
-4	$(-4)^2-3=13$
-3	$(-3)^2-3=6$
-2	$(-2)^2-3=1$
-1	$(-1)^2-3=-2$
0	-3
1	-2
2	1
3	6
4	13

② $y = x^2 - 5$	
x	(x , y)
-4	$(-4)^2-5=11$
-3	$(-3)^2-5=4$
-2	$(-2)^2-5=-1$
-1	$(-1)^2-5=-4$
0	-5
1	-4
2	-1
3	4
4	11



Observation – How do the graphs of $y = x^2 - 3$ *and* $y = x^2 - 5$ *differ from the standard graph?*

They're shifted Down

***Conclusion :* The value of 'k' determines the** vertical position **of the parabola.**
if 'k' is positive, the parabola SHIFTS UP ***'k' units ,***
if 'k' is negative, the parabola SHIFTS DOWN ***'k' units .***

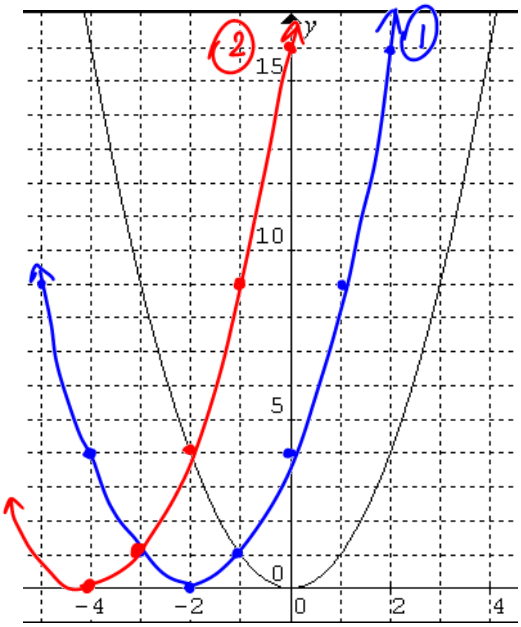
The Quadratic Relation $y=(x-h)^2$

INVESTIGATION 1: **Graphing $y = (x-h)^2$, when 'h' is positive**

Complete the table of values. Use a different colour to sketch the graph of each parabola on the axes.

① $y = (x + 2)^2$	
x	(x , y)
-4	$(-4+2)^2 = 4$
-3	$(-3+2)^2 = 1$
-2	$(-2+2)^2 = 0$
-1	$(-1+2)^2 = 1$
0	$(0+2)^2 = 4$
1	$(1+2)^2 = 9$
2	$(2+2)^2 = 16$
3	$(3+2)^2 = 25$
4	$(4+2)^2 = 36$

$y = (x + 4)^2$	
x	(x , y)
-4	$(-4+4)^2 = 0$
-3	$(-3+4)^2 = 1$
-2	$(-2+4)^2 = 4$
-1	$(-1+4)^2 = 9$
0	$(0+4)^2 = 16$
1	$(1+4)^2 = 25$
2	$(2+4)^2 = 36$
3	
4	



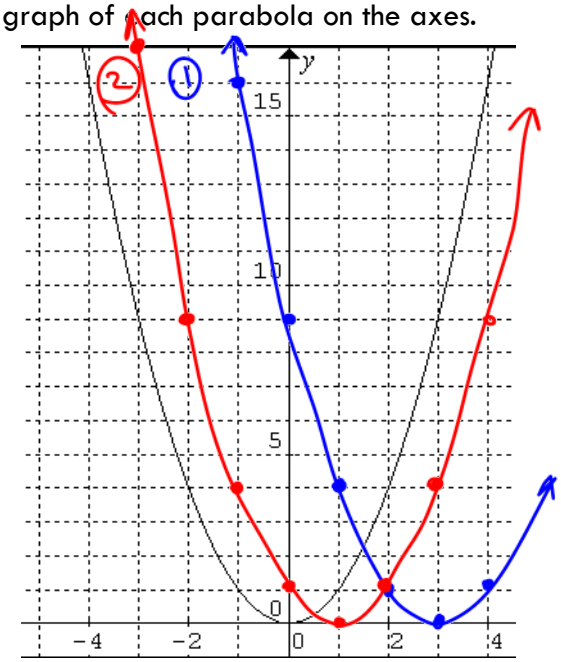
Observation – How do the graphs of $y = (x + 2)^2$ and $y = (x + 4)^2$ differ from the standard graph?
Same graphs but shifted left horizontally

INVESTIGATION 2: **Graphing $y = (x-h)^2$, when 'h' is negative.**

Complete the table of values. Use a different colour to sketch a graph of each parabola on the axes.

① $y = (x - 3)^2$	
x	(x , y)
-4	$(-4-3)^2 = 49$
-3	$(-3-3)^2 = 36$
-2	$(-2-3)^2 = 25$
-1	$(-1-3)^2 = 16$
0	$(-3)^2 = 9$
1	$(1-3)^2 = 4$
2	$(2-3)^2 = 1$
3	$(3-3)^2 = 0$
4	$(4-3)^2 = 1$

② $y = (x - 1)^2$	
x	(x , y)
-4	$(-4-1)^2 = 25$
-3	$(-3-1)^2 = 16$
-2	$(-2-1)^2 = 9$
-1	$(-1-1)^2 = 4$
0	$(-1)^2 = 1$
1	$(0)^2 = 0$
2	$(2-1)^2 = 1$
3	$(3-1)^2 = 4$
4	$(4-1)^2 = 9$



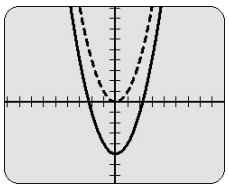
Observation – How do the graphs of $y = (x - 3)^2$ and $y = (x - 1)^2$ differ from the standard graph?
Same graphs but shifted right

Conclusion : ***The value of 'h' determines the*** horizontal ***of the parabola.***
if 'h' is positive, the parabola SHIFTS RIGHT ***'h' units.***
if 'h' is negative, the parabola SHIFTS LEFT ***'h' units.***

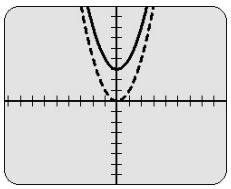
Quadratic $y = x^2 + k$ Practice

1. In each picture, the graph of $y = x^2$ is shown as a dotted parabola (standard position). The solid parabola is the graph of a quadratic relation of the form $y = x^2 + k$.

For each solid parabola, is the value of k positive or negative? Explain your answer.

a) 

$k < 0$ (negative)

b) 

$k > 0$ (negative)

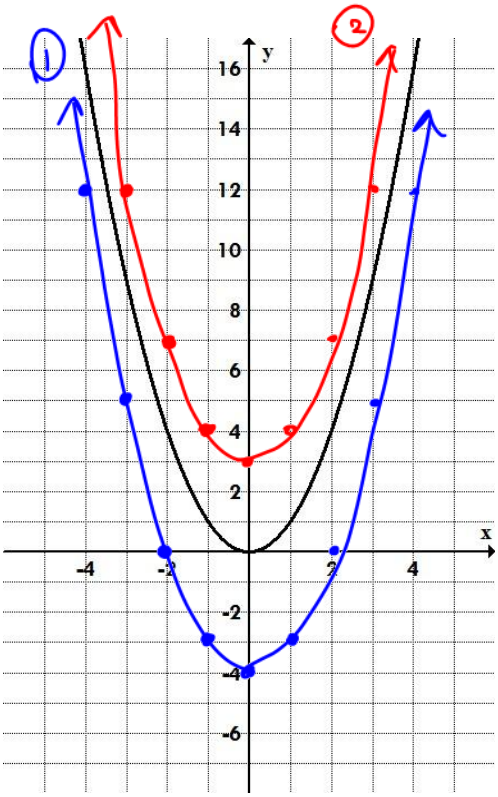
2. On the same axis, graph the following functions and identify the vertex for each:

① $y = x^2 - 4$	
x	(x , y)
-4	$(-4)^2 - 4 = 12$
-3	$(-3)^2 - 4 = 5$
-2	$(-2)^2 - 4 = 0$
-1	$(-1)^2 - 4 = -3$
0	$(0)^2 - 4 = -4$
1	$(1)^2 - 4 = -3$
2	$(2)^2 - 4 = 0$
3	$(3)^2 - 4 = 5$
4	$(4)^2 - 4 = 12$

Vertex (0 , -4)

② $y = x^2 + 3$	
x	(x , y)
-4	$(-4)^2 + 3 = 19$
-3	$(-3)^2 + 3 = 12$
-2	$(-2)^2 + 3 = 7$
-1	$(-1)^2 + 3 = 4$
0	$(0)^2 + 3 = 3$
1	$(1)^2 + 3 = 4$
2	7
3	12
4	19

Vertex (0 , 3)



3. Match each relation with its corresponding graph.

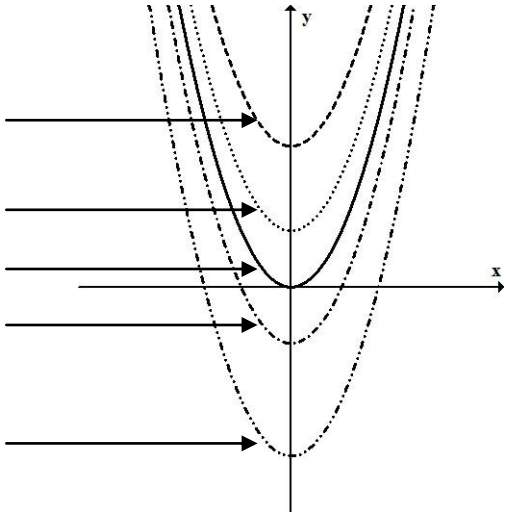
a) $y = x^2$ — a

b) $y = x^2 - 2$ — b

c) $y = x^2 + 2$ — c

d) $y = x^2 - 6$

e) $y = x^2 + 6$ — e



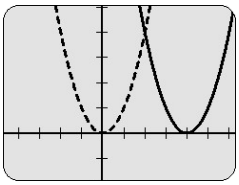
4. In general, what are the coordinates of the vertex of a parabola of the form $y = x^2 + k$?

V(0, k)

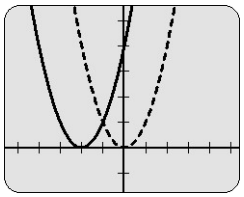
Quadratic $y=(x-h)^2$ Practice

5. In each picture, the graph of $y = x^2$ is shown as a dotted parabola (standard position). The solid parabola is the graph of a quadratic relation of the form $y = (x - h)^2$.

For each solid parabola, is the value of '***h***' positive or negative? Explain your answer.

b) 

$h>0$ positive

b) 

$h<0$ negative

6. On the same axis, graph the following functions and identify the vertex for each:

① $y=(x+1)^2$	
x	(x, y)
-4	$(-4+1)^2=9$
-3	$(-3+1)^2=4$
-2	$(-2+1)^2=1$
-1	$(-1+1)^2=0$
0	$(0+1)^2=1$
1	$(1+1)^2=4$
2	$(2+1)^2=9$
3	$(3+1)^2=16$
4	$(4+1)^2=25$

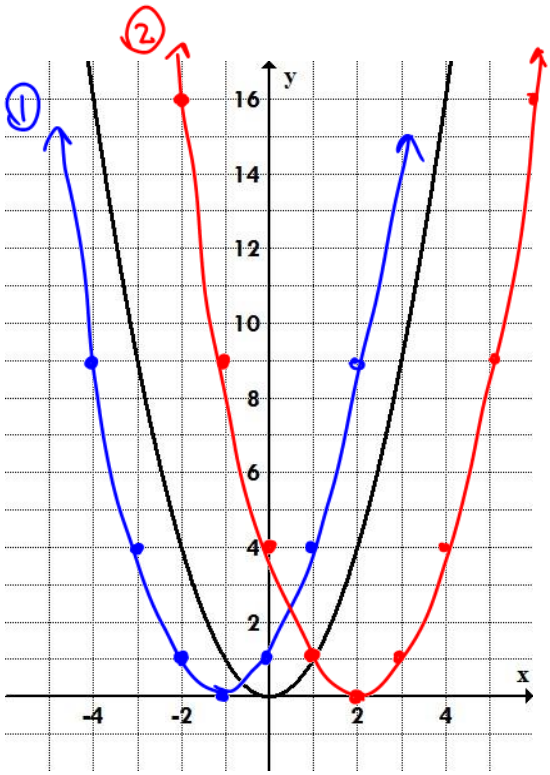
$h=-1$

Vertex $(-1, 0)$

② $y=(x-2)^2$	
x	(x, y)
-4	$(-4-2)^2=36$
-3	$(-3-2)^2=25$
-2	$(-2-2)^2=16$
-1	$(-1-2)^2=9$
0	$(0-2)^2=4$
1	$(1-2)^2=1$
2	$(2-2)^2=0$
3	$(3-2)^2=1$
4	$(4-2)^2=4$

$h=2$

Vertex $(2, 0)$



7. Match each relation with its corresponding graph.

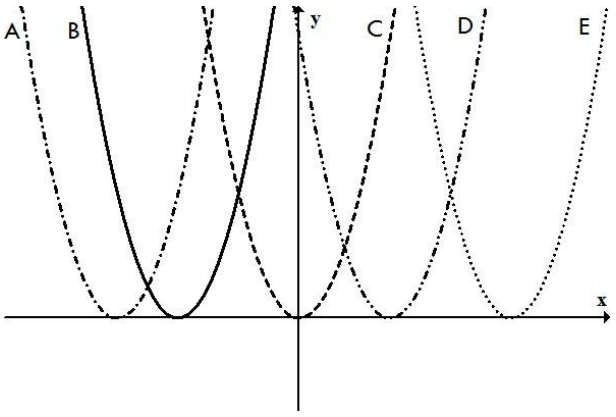
f) $y=x^2$ $h=0$ C

g) $y=(x+4)^2$ B $h=-4$

h) $y=(x-7)^2$ E $h=7$

i) $y=(x-3)^2$ D $h=3$

j) $y=(x+6)^2$ A $h=-6$



8. In general, what are the coordinates of the vertex of a parabola of the form $y=(x-h)^2$?

$V(h, 0)$