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Using Linear and Absolute Value Functions

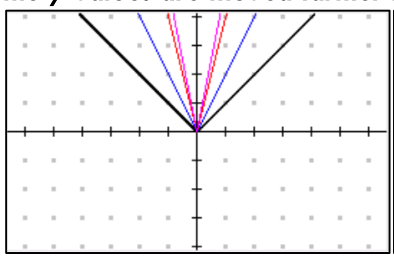
Elaborate – Answer Key

Directions: The absolute value parent function is $y = |x|$. The parameters *a*, *b*, *c*, and *d*, which represent real numbers can be used to transform the absolute value parent function: $y = a|x|$, $y = |bx|$, $y = |x - c|$, and $y = |x| + d$. Use your graphing calculator to graph the four functions shown in each box on the same screen. Graph the first function, *Y*1, in bold or a different color. Use the graphs and tables of values on the graphing calculator to answer the questions next to the box.

Part 1: Investigating *a*

- $Y1 = |x|$
- $Y2 = 2|x|$
- $Y3 = 4|x|$
- $Y4 = 5|x|$

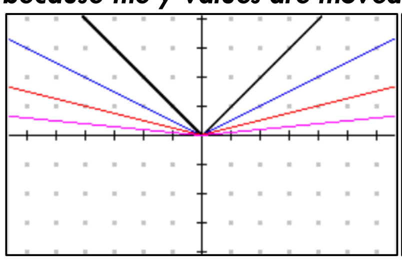
1. What happens to the graph of $y = a|x|$ when the value of *a* increases?
As a increases, the graph becomes vertically stretched because the y-values are moved farther from the x-axis.



X	Y1	Y2	Y3	Y4
-5	5	10	20	25
-4	4	8	16	20
-3	3	6	12	15
-2	2	4	8	10
-1	1	2	4	5
0	0	0	0	0
1	1	2	4	5
2	2	4	8	10
3	3	6	12	15
4	4	8	16	20
5	5	10	20	25

- $Y1 = |x|$
- $Y2 = 0.5|x|$
- $Y3 = 0.25|x|$
- $Y4 = 0.1|x|$

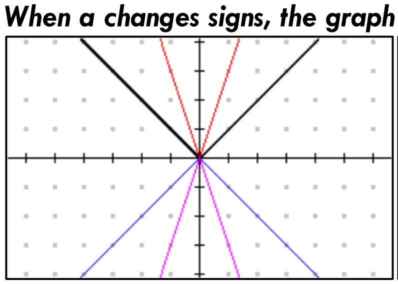
2. What happens to the graph of $y = a|x|$ when the value of *a* decreases?
As a decreases, the graph becomes more vertically compressed because the y-values are moved closer to the x-axis.



X	Y1	Y2	Y3	Y4
-5	5	2.5	1.25	.5
-4	4	2	1	.4
-3	3	1.5	.75	.3
-2	2	1	.5	.2
-1	1	.5	.25	.1
0	0	0	0	0
1	1	.5	.25	.1
2	2	1	.5	.2
3	3	1.5	.75	.3
4	4	2	1	.4
5	5	2.5	1.25	.5

- $Y1 = |x|$
- $Y2 = -|x|$
- $Y3 = 3|x|$
- $Y4 = -3|x|$

3. What happens to the graph of $y = a|x|$ when the value of *a* changes signs from positive to negative?
When a changes signs, the graph is reflected across the x-axis.



X	Y1	Y2	Y3	Y4
-5	5	-5	15	-15
-4	4	-4	12	-12
-3	3	-3	9	-9
-2	2	-2	6	-6
-1	1	-1	3	-3
0	0	0	0	0
1	1	-1	3	-3
2	2	-2	6	-6
3	3	-3	9	-9
4	4	-4	12	-12
5	5	-5	15	-15

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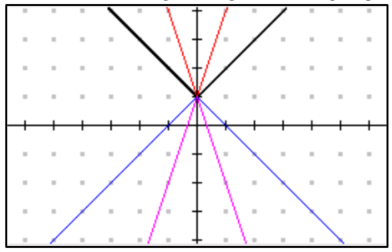
- $Y1 = |x| + 1$
- $Y2 = -|x| + 1$
- $Y3 = 3|x| + 1$
- $Y4 = -3|x| + 1$

4. What happens to the graph of $y = a|x| + 1$ when the value of a changes signs from positive to negative?
When a changes signs, the graph is reflected across the line y = 1.

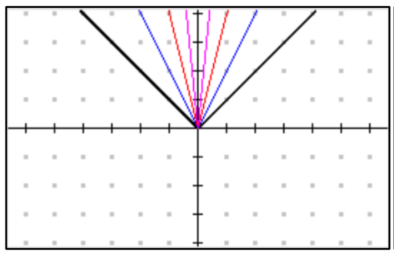


X	Y1	Y2	Y3	Y4
-5	6	-4	16	-14
-4	5	-3	13	-11
-3	4	-2	10	-8
-2	3	-1	7	-5
-1	2	0	4	-2
0	1	1	1	1
1	2	0	4	-2
2	3	-1	7	-5
3	4	-2	10	-8
4	5	-3	13	-11
5	6	-4	16	-14

Part 2: Investigating *b*

- $Y1 = |x|$
- $Y2 = |2x|$
- $Y3 = |4x|$
- $Y4 = |10x|$

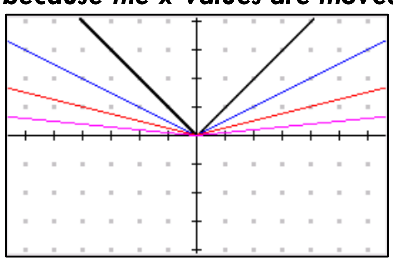
5. What happens to the graph of $y = |bx|$ when the value of b increases?
As b increases, the graph becomes more horizontally compressed because the x-values are moved closer to the y-axis.



X	Y1	Y2	Y3	Y4
-5	5	10	20	50
-4	4	8	16	40
-3	3	6	12	30
-2	2	4	8	20
-1	1	2	4	10
0	0	0	0	0
1	1	2	4	10
2	2	4	8	20
3	3	6	12	30
4	4	8	16	40
5	5	10	20	50

- $Y1 = |x|$
- $Y2 = |0.5x|$
- $Y3 = |0.25x|$
- $Y4 = |0.1x|$

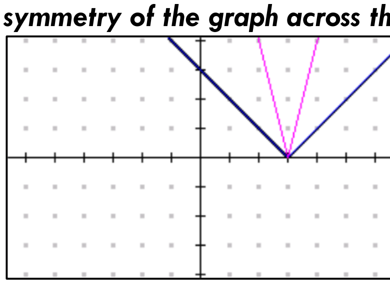
6. What happens to the graph of $y = |bx|$ when the value of b decreases?
As b decreases, the graph becomes more horizontally stretched because the x-values are moved farther from the y-axis.



X	Y1	Y2	Y3	Y4
-5	5	2.5	1.25	.5
-4	4	2	1	.4
-3	3	1.5	.75	.3
-2	2	1	.5	.2
-1	1	.5	.25	.1
0	0	0	0	0
1	1	.5	.25	.1
2	2	1	.5	.2
3	3	1.5	.75	.3
4	4	2	1	.4
5	5	2.5	1.25	.5

- $Y1 = |x - 3|$
- $Y2 = |-(x - 3)|$
- $Y3 = |4(x - 3)|$
- $Y4 = |-4(x - 3)|$

7. What happens to the graph of $y = |b(x - 3)|$ when the value of b changes signs from positive to negative?
When b changes signs, the graph is reflected across the line y = c. However, the pattern is not noticeable in the graph because of the symmetry of the graph across the line y = c.



X	Y1	Y2	Y3	Y4
-5	8	8	32	32
-4	7	7	28	28
-3	6	6	24	24
-2	5	5	20	20
-1	4	4	16	16
0	3	3	12	12
1	2	2	8	8
2	1	1	4	4
3	0	0	0	0
4	1	1	4	4
5	2	2	8	8

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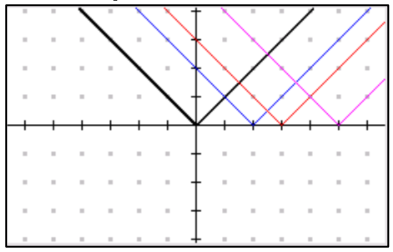
Part 3: Investigating c

- *Y*1 = |*x*|
- *Y*2 = |*x* – 2|
- *Y*3 = |*x* – 3|
- *Y*4 = |*x* – 5|

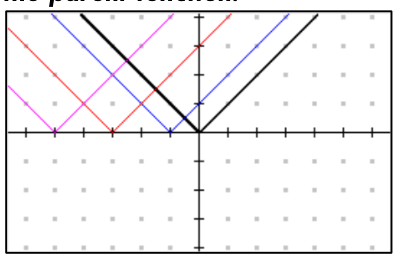
8. What happens to the graph of *y* = | x – c | when the value of c increases?
As c increases, the graph shifts or translates c units to the right from the parent function.



X	Y1	Y2	Y3	Y4
-5	5	7	8	10
-4	4	6	7	9
-3	3	5	6	8
-2	2	4	5	7
-1	1	3	4	6
0	0	2	3	5
1	1	1	2	4
2	2	0	1	3
3	3	1	0	2
4	4	2	1	1
5	5	3	2	0

- *Y*1 = |*x*|
- *Y*2 = |*x* + 1|
- *Y*3 = |*x* + 3|
- *Y*4 = |*x* + 5|

9. What happens to the graph of *y* = | x – c | when the value of c is negative and decreases?
As c decreases, the graph shifts or translates c units to the left of the parent function.

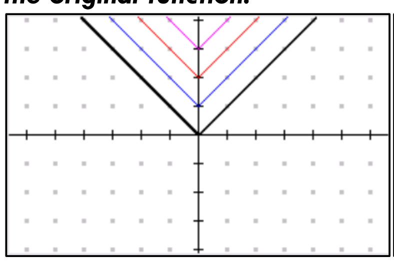


X	Y1	Y2	Y3	Y4
-5	5	4	2	0
-4	4	3	1	1
-3	3	2	0	2
-2	2	1	1	3
-1	1	0	2	4
0	0	1	3	5
1	1	2	4	6
2	2	3	5	7
3	3	4	6	8
4	4	5	7	9
5	5	6	8	10

Part 4: Investigating *d*

- *Y*1 = |*x*|
- *Y*2 = |*x*| + 1
- *Y*3 = |*x*| + 2
- *Y*4 = |*x*| + 3

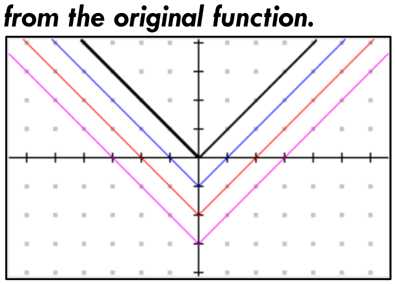
10. What happens to the graph of *y* = | *x* | + *d* when the value of *d* increases?
As d increases, the graph shifts or translates d units upward from the original function.



X	Y1	Y2	Y3	Y4
-5	5	6	7	8
-4	4	5	6	7
-3	3	4	5	6
-2	2	3	4	5
-1	1	2	3	4
0	0	1	2	3
1	1	2	3	4
2	2	3	4	5
3	3	4	5	6
4	4	5	6	7
5	5	6	7	8

- *Y*1 = |*x*|
- *Y*2 = |*x*| – 1
- *Y*3 = |*x*| – 2
- *Y*4 = |*x*| – 3

11. What happens to the graph of *y* = | *x* | + *d* when the value of *d* is negative and decreases?
As d decreases, the graph shifts or translates d units downward from the original function.



X	Y1	Y2	Y3	Y4
-5	5	4	3	2
-4	4	3	2	1
-3	3	2	1	0
-2	2	1	0	-1
-1	1	0	-1	-2
0	0	-1	-2	-3
1	1	0	-1	-2
2	2	1	0	-1
3	3	2	1	0
4	4	3	2	1
5	5	4	3	2

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Debriefing Questions

1. In general, how does the parameter *a* affect the graph of *f*(*x*) when it is changed to $a \cdot f(x)$?
   The parameter a generates a vertical dilation or reflection. If a > 1, then the graph of f(x) is vertically dilated by a factor of a. If 0 < a < 1, then the graph of f(x) is vertically compressed by a factor of a. If a < 1, then the graph of f(x) is reflected across the horizontal line containing the vertex of the absolute value graph.

2. In general, how does the parameter *b* affect the graph of *f*(*x*) when it is changed to *f*(*bx*)?
   The parameter b generates a horizontal dilation or reflection. If b > 1, then the graph of f(x) is horizontally compressed by a factor of $\frac{1}{b}$***. If 0 < b < 1, then the graph of f(x) is horizontally stretched by a factor of*** $\frac{1}{b}$***. If b < 1, then the graph of f(x) is reflected across the vertical line containing the vertex of the absolute value graph.***

3. In general, how does the parameter c affect the graph of *f*(*x*) when it is changed to *f*(*x* − c)?
   The parameter c generates a horizontal translation. If c > 0, then the graph is translated c units to the right. If c < 0, then the graph is translated c units to the left.

4. In general, how does the parameter *d* affect the graph of *f*(*x*) when it is changed to *f*(*x*) + *d*?
   The parameter d generates a vertical translation. If d > 0, then the graph is translated d units up. If d < 0, then the graph is translated d units down.