**Exploring the Parameters of**

Recall from Unit 4 that a **linear function** has the form

* + The parameter *m* represents the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + The parameter *b* represents the ­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Recall from Unit 7 that an **exponential function** has the form .

* + The parameter *a* represents the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + The parameter *b* represents the ­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Now we will study quadratic functions. In **standard form** these may be written as  
 . The parameters *a,* *b* and *c* may take on any values, with one exception:

*a* cannot be 0.

In this activity we will examine graphs of quadratic functions to study the roles of the parameters *a,* *b* and *c.*

**Section 1: Identifying Parameters**

1. For each quadratic function, identify *a,* *b* and *c.*
2. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
3. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
4. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
5. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
6. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
7. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
8. *a = \_\_\_\_\_ b = \_\_\_\_\_\_\_ c = \_\_\_\_\_\_\_\_\_*
9. Suppose for , that *a* = 0, *b* = 1 and *c =* –3. What type of function would you have? Explain.

**Section 2: Exploring Parameter *a***

To explore the role of *a*, let’s use 0 for both *b* and *c*. Then we will vary parameter *a* until we can explain its role in the graph of .

**Case 1: *a* ≥ 1 and *b* = *c* = 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –5, Ymax = 20.

1. Let *a* = 1, 2, and 3. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = *x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = 2*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = 3*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. The graphs you have drawn all have symmetry with respect to a vertical line.
2. What vertical line?
3. What is the equation of this line?
4. What point do all three graphs have in common?

**Case 2: 0 < *a* < 1 and 0 = *b* = *c***

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –5, Ymax = 20.

1. Let *a* = .5, .25, and .1. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = .5*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = .25*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = .1*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. The graphs you have drawn all have symmetry with respect to a vertical line.
2. What vertical line?
3. What is the equation of this line?
4. What point do all three graphs have in common?
5. Based on Case 1 and Case 2, how does the graph change as *a* gets larger?

**Case 3: *a* < 0 and *b* = *c* = 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –20, Ymax = 5.

1. Let *a* = –1, –2, and –3. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = –*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = –2*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = –3*x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. How do the graphs in case 3 differ from the graphs in cases 1 and 2?
2. What do all the graphs in cases 1, 2, and 3 have in common?
3. What would the graph of look like
4. In comparison with the graph of ?
5. In comparison with the graph of ?

**Section 3: Exploring Parameter *c***

Now that we have a good idea of how parameter *a* impacts the graph of the function

we wish to explore the role of parameter *c*. So, we will keep *a* and *b* constant and then vary parameter *c* until we can explain its impact.

**Case 1: *a* = 1 and *b* = 0 and *c* ≥ 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –5, Ymax = 20.

1. Let *c* = 0, 5, and 10. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = *x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 + 5** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 + 10** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. Identify the *y*-intercept for each graph. How is the *y*-intercept related to parameter *c*?
2. Based on this investigation where *a* = 1, *b* = 0 and *c* ≥ 1, how does the graph change as parameter *c* gets larger?

**Case 2: *a* = 1 and *b* = 0 and *c* < 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –20, Ymax = 5.

1. Let *c* = –5, –10, and –15. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = *x*2 – 5** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 – 10** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 – 15** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. Identify the *y*-intercept for each graph. How is the *y*-intercept related to parameter *c***?**
2. Based on this investigation where *a* = 1, *b* = 0 and *c* ≤ 1, how does the graph change as parameter *c* gets smaller?
3. Now summarize the role of parameter *c* when *c* > 0 or *c* < 0.

**Section 4: Exploring Parameter *b***

Now let’s keep parameters *a* and *c* constant and then vary parameter *b* until we can explain its impact.

**Case 1: *a* = 1 and *c* = 0 and *b* ≥ 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –4, Ymax = 4.

1. Let *b* = 0, 2, and 4. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = *x*2** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 + 2*x*** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 + 4*x*** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |



1. What can you say about the location of the vertex when *b* > 0?
2. What happens to the location of the vertex as *b* gets larger?
3. When *b* > 0, the graph should still have symmetry but the line of symmetry is now a different vertical line. Try to find the equation of each line of symmetry and write the equations here.

**Case 2: *a* = 1 and *c* = 0 and *b*  < 0**

Window settings: Xmin = –4.7, Xmax = 4.7, Ymin = –4, Ymax = 4.

1. Let *b* = –2, –3, and –4. Fill in the tables and draw all 3 functions on the same graph.

|  |  |
| --- | --- |
| ***y* = *x*2 – 2*x*** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 – 3*x*** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |

|  |  |
| --- | --- |
| ***y* = *x*2 – 4*x*** | |
| ***x*** | ***y*** |
| –2 |  |
| –1 |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |



1. What can you say about the location of the vertex when *b* < 0?
2. What happens to the location of the vertex as *b* gets smaller?
3. Try to find the equation of each line of symmetry and write the equations here.

**Section 5: Exploring the Graph of**

You will be given two quadratic functions. From what you have learned about the parameters *a*, *b* and *c,* you should be able to tell how their graphs are similar and how they are different.

|  |  |  |  |
| --- | --- | --- | --- |
| ***f*(*x*)** | ***g*(*x*)** | **How are the graphs similar?** | **How are the graphs different?** |
| *f*(*x*) = *x*2 + 2*x* | *g*(*x*) = *x*2 + 2 *x* + 3 |  |  |
| *f*(*x*) = *x*2 + 3 | *g*(*x*) = –*x*2 + 3 |  |  |
| *f*(*x*) = *x*2 + 4*x* + 4 | *g*(*x*) = 2*x*2 + 4*x* + 4 |  |  |
| *f*(*x*) = *x*2 + 1 | *g*(*x*) = *x*2 – 4*x* + 1 |  |  |

**Section 6: Summary**

If one were asked to summarize the role of parameter *a i*n the equation where parameter *a* > 0, here is what a response might look like: “When *a* is greater than 0, the graph of decreases as we move from left to right until we reach the vertex. Then the graph increases as we move from left to right.

1. Continue with this response, but now summarize the role of parameter *a* when it’s negative.
2. You never set *a* = 0. Why can’t *a* = 0?
3. Summarize what you have learned about the role of parameter *c* where *c* may be any number, in the equation . Include in your response the relationship between the

*y-*intercept and the parameter *c*, if any.

1. Summarize what you have learned about the role of parameter *b* where *b* may be any number. Include in your summary how the graph changes when *b* is negative or positive, and the impact on the graph when *b* is 0.