2.3a (Optional): GRAPH QUADRATIC FUNCTIONS USING TECHNOLOGY

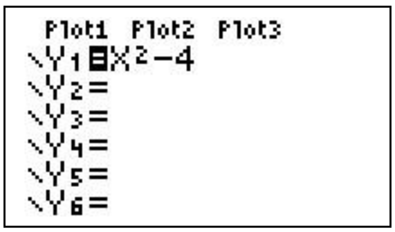
"I Can…" Statements:

- I can use technology to model quadratic functions.

Example #1

Graph $f(x) = x^2 - 4$ and complete the table using a graphing calculator.

Press the **Y =** key. Enter the equation $y = x^2 - 4$. The ***x,t, ,n*** key should be used to enter the variable x. The **x^2** key should be used for the exponent.

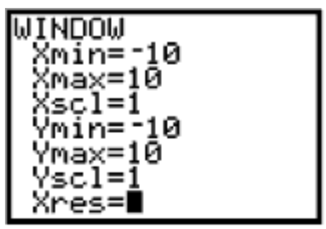


If Plot1, Plot2 or Plot3 are highlighted it will not graph.

To turn off STAT PLOTS before you graph a function, press 2nd [STATPLOT]. Select 4:PlotsOff.

Students may use the (-) negative key instead of the subtract key when entering equations. This will cause an ERROR.

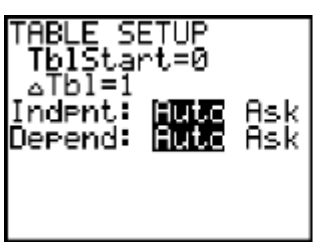
Check the window by pushing the **WINDOW** key.
The standard window should be:



- Xmin and Xmax set the boundaries for the x–axis
- Ymin and Ymax set the boundaries for the y–axis
- Xscl and Yscl settings determine the increment by which the axes are marked

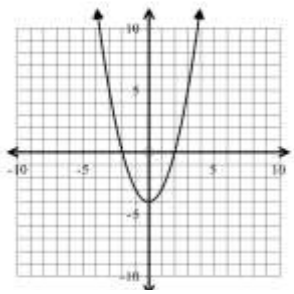
If necessary, press the **2nd** **WINDOW** [TBLSET] key to access the Table Set menu.

Make sure the Independent variable (x-value) is on "Auto" and the Dependent variable (y-value) is on "Auto" so the calculator will automatically give you the x-value and y-value. (Use the arrows and the enter key to change the values if necessary.)



Students can also use **ZOOM** 6: ZStandard for the window.

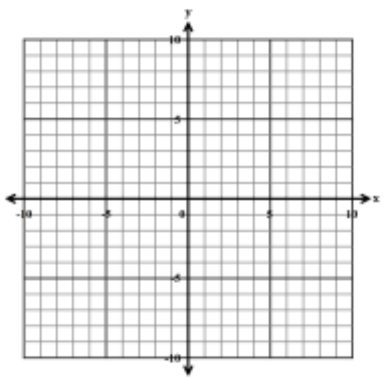
Press the **GRAPH** key. Press **2nd** **GRAPH** [TABLE].
Use the arrows to scroll.



x	*f (x)*
-3	5
-2	0
-1	-3
0	-4
1	-3
2	0
3	5

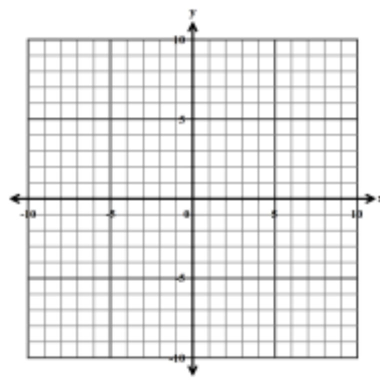
Practice Exercises
Graph each equation using a graphing calculator. Fill in the table of values.

1. $f(x) = x^2 - 1$



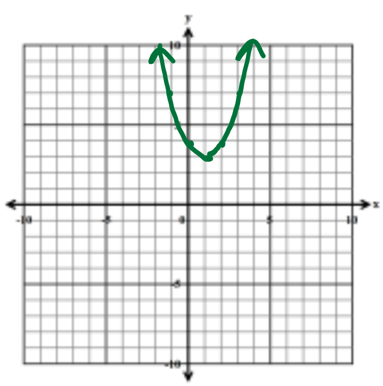
x	***f(x)***
-3	
-2	
-1	
0	
1	
2	
3	

2. $f(x) = x^2 + 1$



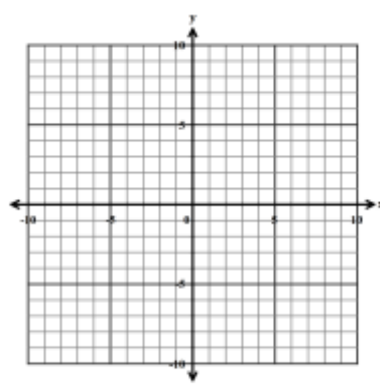
x	***f(x)***
-3	
-2	
-1	
0	
1	
2	
3	

3. $f(x) = (x-1)^2 + 3$



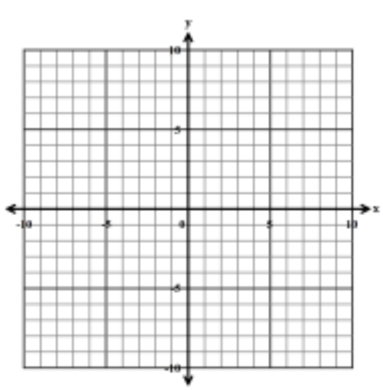
x	***f(x)***
-1	7
0	4
1	3
2	4
3	7

4. $f(x) = -(x+1)^2$



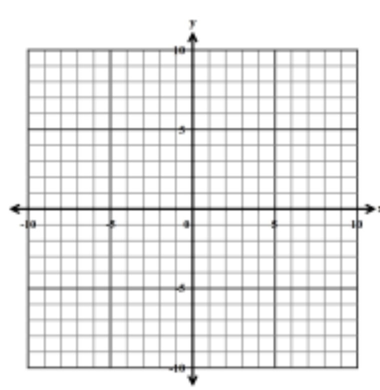
x	***f(x)***
-4	
-3	
-2	
-1	
0	
1	
2	

5. $f(x) = x^2 - 4$



x	***f(x)***
-3	
-2	
-1	
0	
1	
2	
3	

6. $f(x) = -x^2 + 2x + 1$



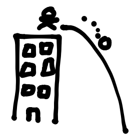
x	***f(x)***
-2	
-1	
0	
1	
2	
3	
4	

2.3: MODEL QUADRATIC FUNCTIONS USING TECHNOLOGY

"I Can…" Statements:

- I can use technology to model quadratic equations.

Example #1
Fred drops an egg from the top of a building 500 feet tall. The vertical distance fallen by a free-falling object is represented by the function $h(t) = -16t^2 + 500$ where $h(t)$ is the height of the egg, in feet, and t is the time, in seconds.
How long does it take for the egg to touch the ground?



1. Press **Y =** and next to Y_1 enter $-16x^2 + 500$

   (remember to use the negative (-) *key, not the* - *subtract key.)*

   Use the **x,t, ,n** to enter the variable x.

2. Press **2nd** **GRAPH** [TABLE] to view values generated by the function.

Use the values in the table to adjust the window size for the specific problem.
You should see the following values in your table.

X	Y_1	
0	500	
1	484	
2	436	
3	356	
4	244	
5	100	
6	-76	

X=0

When choosing values for your window setting, be sure to keep the original problem in mind. The x-axis represents *time*, therefore an appropriate minimum value on the x-axis would be *0*. At $x = 0$ the egg is dropped.

Another thing to keep in mind, the y-axis represents the *height*, therefore an appropriate minimum value on the y-axis would be 0.
Notice the Y_1 values change from positive values to negative values between the X values of 5 and 6. Therefore, you can choose 6 or 7 for the Xmax.

The largest value in the Y_1 column is 500. Therefore, you should choose a value larger than 500 for the Ymax. Values such as 550 or 600 are reasonable.

X	Y_1	
0	500	
1	484	
2	436	
3	356	
4	244	
5	100	
6	-76	

X=0

WINDOW
Xmin=0
Xmax=7
Xscl=1
Ymin=0
Ymax=600
Yscl=100
Xres=

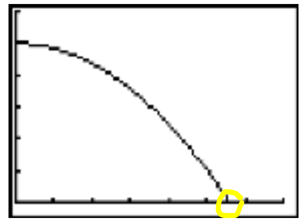
*X*scl represents the number of tick marks on the graph along the *x*-axis.

*Y*scl represents the number of tick marks on the graph along the *y*-axis.

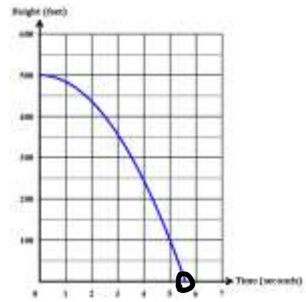
3. Press **WINDOW** and adjust the values to fit your graph.

(remember to use the negative (-) *key, not the* - *subtract key.)*

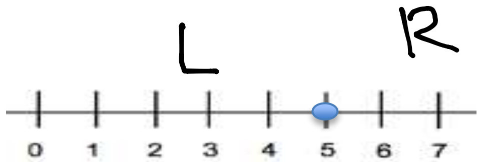
4. Press **GRAPH**, you should see the following graph.



The same graph with more detail would look like:

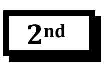


SIDE NOTE:



5. Calculate the *x*-intercept.

Notice the graph touches the *x*-axis between the values of **5** and **6**. This tells us the egg is at a height of *zero* between **5** and **6** seconds, but we want a *more accurate estimate* of the time when the egg hits the ground.

Press  **TRACE** [CALC] to calculate the *x*-intercept. Choose **2: zero.**

"zero" and "x-intercept" are interchangeable.

Left Bound? appears in the lower left corner.

Type a value just to the left of the *x*-intercept, in this case **5**, and press **ENTER**.

Right Bound? appears in the lower left corner.

Type a value just to the right of the *x*-intercept, in this case **6**, and press **ENTER**.

Guess? appears in the lower left corner. Press **ENTER**.

The *x*-intercept is $x = 5.59$

How long does it take for the egg to touch the ground?

It takes the egg approximately 5.59 seconds to touch the ground.

Example #3

Fred jumps feet first from a diving board, springing up into the air and then dropping feet-first. The distance *d* in feet from his feet to the pool's surface *t* seconds after he jumps is $d(t) = -16t^2 + 18t + 2$.

a) What is the maximum height of Fred's feet during this jump?
b) When does the maximum height occur?
c) When do Fred's feet hit the water?
d) What does the constant term ***2*** in the equation tell you about Fred's jump?

1. Type the function into the calculator.

2. Use the TABLE to find appropriate values for your window.

X	Y_1
0	2
1	4
2	-26

WINDOW
*X*min= 0
*X*max= 2
*X*scl= 0.25
*Y*min= 0
*Y*max= 8
*Y*scl= 1

It may take a few adjustments to find a complete graph.

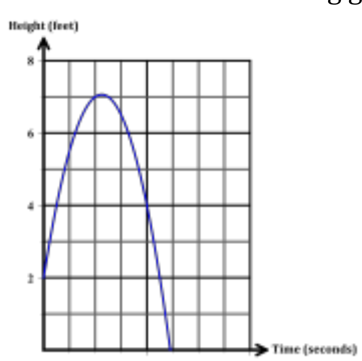
There are not exact values to choose for the window, but you must choose reasonable values to see a complete graph.

Notice the Y_1 values change from positive values to negative values between the *X* values of 1 and 2. Therefore, you can choose 2 for the *X*max.

The largest value in the Y_1 column is 4. Although, it is possible someone jumping on a diving board may bounce higher. Therefore, you should choose a value larger than 4 for the *Y*max. Values such as 8 or 10 are reasonable.

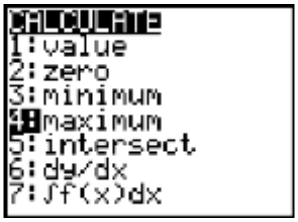
3. Press **WINDOW** and adjust the values to fit your graph.

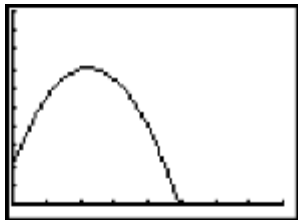
4. Press **GRAPH**, you should see the following graph.



5. Calculate the maximum point.

Press **2nd** **TRACE** [CALC] to calculate the maximum value.
Choose **4: maximum.**





Left Bound? appears in the lower left corner.

Type a value to the <u>left of the *maximum*</u> in this case **0**, and press **ENTER**.

Right Bound? appears in the lower left corner.

Type a value to the <u>right of the *x*-intercept</u>, in this case **1**, and press **ENTER**.

Guess? appears in the lower left corner. Press **ENTER**.

a) What is the maximum height of Fred's feet during this jump?

Fred's feet reach a height of 5.6 feet.

b) When does the maximum height occur?

The maximum height occurs at 0.56 seconds.

6. Calculate the *x*-intercept.

Press **2nd** **TRACE** [CALC] to calculate the *x*-intercept.
Choose **2: zero.**

Left Bound? appears in the lower left corner.

Type a value to the <u>left of the *x*-intercept</u>, in this case **1**, and press **ENTER**.

Right Bound? appears in the lower left corner.

Type a value just to the <u>right of the *x*-intercept</u>, in this case **1.7**, and press **ENTER**.

Guess? appears in the lower left corner. Press **ENTER**.

c) When do Fred's feet hit the water?

Fred's feet hit the water at approximately 1.2 seconds.

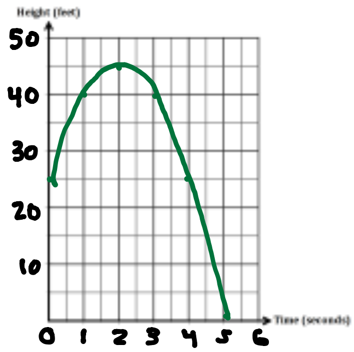
d) What does the constant term ***2*** in the equation tell you about Fred's jump?

He jumps from a diving board 2-feet from the surface of the water

Practice Exercises A

1. A ball is thrown from the top of a hill. The height, in feet, of a ball t seconds after being thrown is modeled by the function $h(t) = -4.9(t - 2)^2 + 45$. Use a graphing calculator to graph the function and answer the questions below.

WINDOW
Xmin= 0
Xmax= 7
Xscl= 1
Ymin= 0
Ymax= 50
Yscl= 10



y-value

a) *What* height is the ball thrown? 25 feet

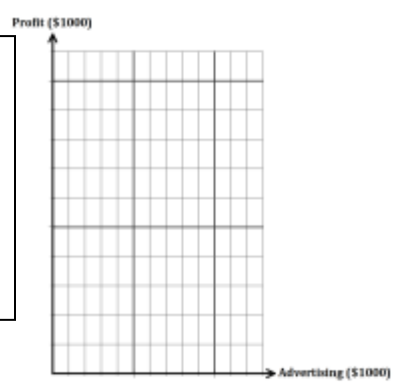
b) *What* is the maximum height of the ball? 45 feet

c) *When* does the ball reach the maximum height? 2 seconds

d) How long it takes the ball to hit the ground.
It takes the ball approximately 5.03 seconds to hit the ground.

2. Each year, a sporting goods store has a budget for advertising to generate more sales and thus profit. Analysis has found that the profit can be modeled by the function $P(x) = -2x^2 + 20x + 50$ where x is the advertising budget and $P(x)$ is the profit, both in thousands of dollars.

WINDOW
Xmin=
Xmax=
Xscl=
Ymin=
Ymax=
Yscl=

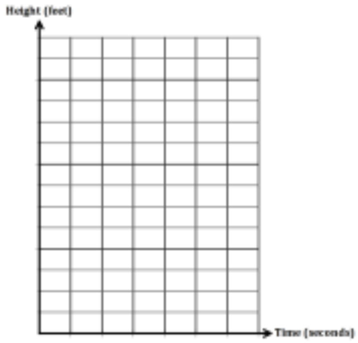


a) What amount of advertising will produce the maximum profit?

b) What is the maximum profit?

3. From the top of a 48 foot tall building, a ball is thrown straight up with an initial velocity of 32 feet per second as represented by the function $h(t) = -16t^2 + 32t + 48$.

WINDOW
Xmin=
Xmax=
Xscl=
Ymin=
Ymax=
Yscl=



a) *What* height is the ball thrown?

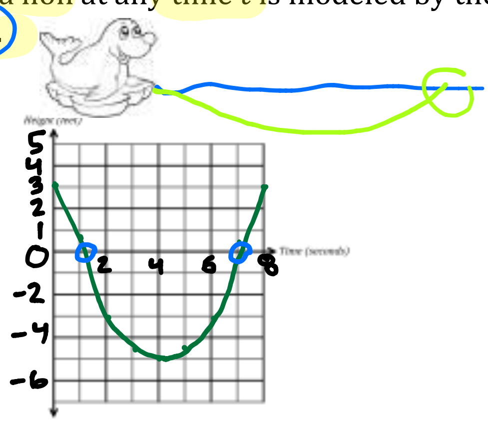
b) *What* is the maximum height of the ball?

c) *When* does the ball reach the maximum height?

d) How long does it take the ball to land?
It takes the ball to hit the ground.

4. From the top of a 3-foot podium a sea lion jumps into a large tank of water. The height of the sea lion at any time *t* is modeled by the function $h(t) = 0.5t^2 - 4t + 3$.

WINDOW
Xmin= 0
Xmax= 8
Xscl= 1
Ymin= -6
Ymax= 4
Yscl= 1



a) *What* is the height the sea lion jumps from the podium? 3 feet

b) *What is* the minimum height the sea lion reaches? -5 feet

c) *When* does the sea lion reach the minimum height? 4 seconds

d) *When* is the seal lion at the surface of the water?
The sea lion is at the surface of the water at 0.84 seconds and again at 7.16 seconds