In this technology assignment, you will find a quadratic function that passes through three of the points on each of the scatter plots you created in an earlier technology assignment. You will need the file you created that looks like the one below. Your file will look slightly different since you are working with a different dataset.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Years since 200	US Tuition and Fees at Two Year Colleges	US Tuition and Fees at Public Four Year									
2	6	2018	5666									
3	7	2061	5943									
4	8	2136	6312									
5	9	2285	6695									
6												
7												
8												
9	Your Name											
10	Date											
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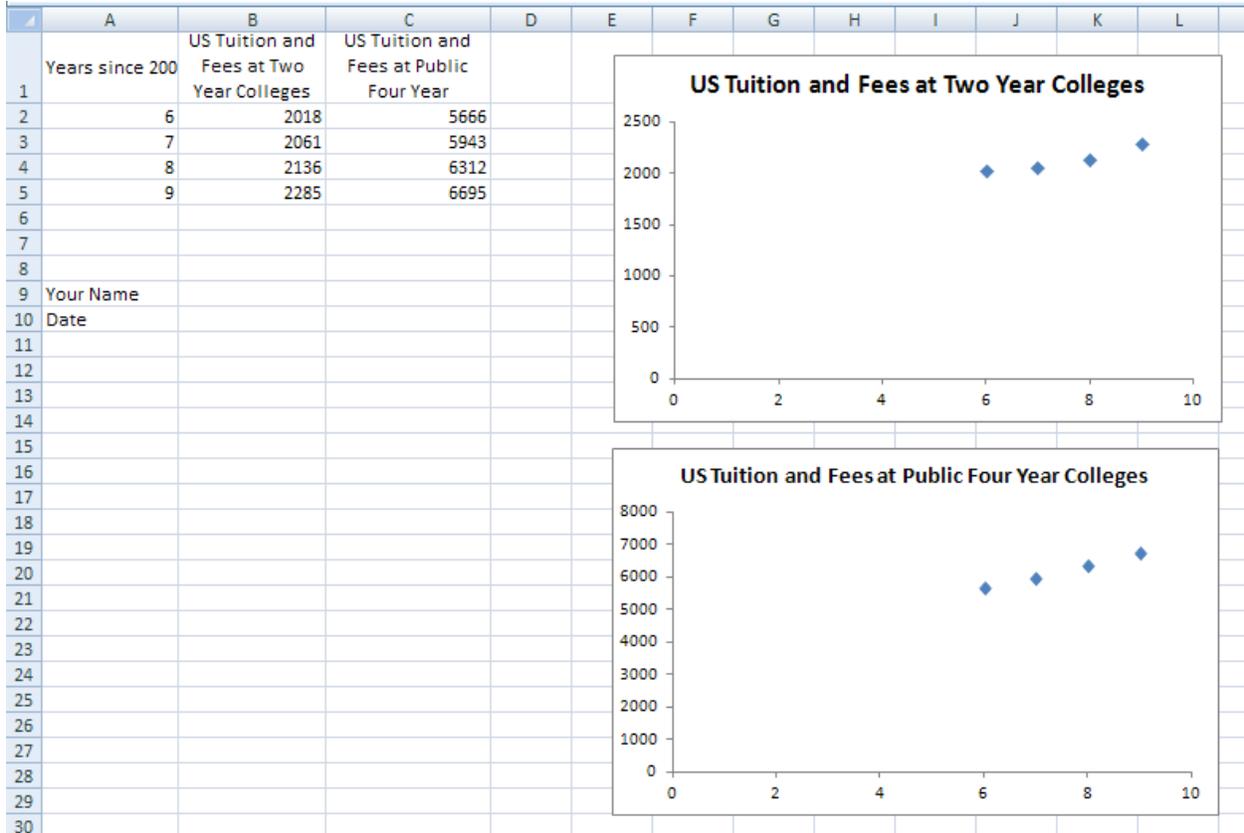
Before we can put the quadratic function that passes through three points on the scatter plot, we need to find the function by doing some mathematics. I'll show you how to do this math using the data for the US Tuition and Fees at two-year colleges. You should complete the same process for both sets of data for the state you are assigned.

Select the Points You'll Use

For this project, we'll find a quadratic function that passes close to the data for tuition and fees at two-year colleges and four-year colleges by making the parabola pass through three of the data points. There are many possibilities we could choose. We could pass through the first three points, the first, second and third, the first, third and fourth, the last three, or many other combinations of points.

Look at your data points. Visualize a parabola passing through any three points. Pick three of the points to create a parabola that appears to represent the data best. These are the points you'll use to find a quadratic function for your scatter plot.

Find the Equation of the Parabola

I will demonstrate how to find a line through a pair of points using the ordered pairs $(7, 2061)$, $(8, 2136)$ and $(9, 2285)$. With these ordered pairs, the x values represent the number of years since 2000 and the y values represent the tuition and fees at US two-year colleges.

The equation of a quadratic function is $f(x) = ax^2 + bx + c$. Since we are working with coordinates, we replace $f(x)$ with y,

$$y = ax^2 + bx + c$$

Substitute each of the ordered pairs we want the parabola to go through into this equation to give three equations,

$$2061 = a \cdot 49 + b \cdot 7 + c$$

$$2136 = a \cdot 64 + b \cdot 8 + c$$

$$2285 = a \cdot 81 + b \cdot 9 + c$$

If we can solve this system of equations for a, b, and c, we will have the constants in a quadratic function that passes through the three points. Rewrite the system to look like

$$49a + 7b + c = 2061$$

$$64a + 8b + c = 2136$$

$$81a + 9b + c = 2285$$

This system can be put into an augmented matrix,

$$\begin{bmatrix} 49 & 7 & 1 & \vdots & 2061 \\ 64 & 8 & 1 & \vdots & 2136 \\ 81 & 9 & 1 & \vdots & 2285 \end{bmatrix}$$

The reduced row echelon form for this matrix is

$$\begin{bmatrix} 1 & 0 & 0 & \vdots & 37 \\ 0 & 1 & 0 & \vdots & -480 \\ 0 & 0 & 1 & \vdots & 3608 \end{bmatrix}$$

This means that $a = 37$, $b = -480$, and $c = 3608$. The quadratic function that passes through the three points is

$$f(x) = 37x^2 - 480x + 3608$$

Our goal is to use Excel to create a graph like the one below for this quadratic function.
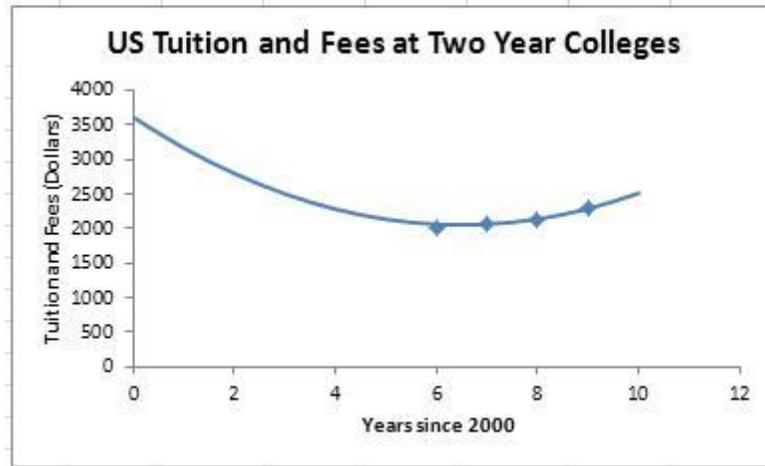
Once you have completed the process for your first scatter plot, you will need to find another parabola for the scatter plot for four-year colleges. This means you'll carry out the process above for three of the data points for four-year colleges in your state.

Before we start creating this graph, locate the earlier technology assignment where you created the scatter plots of two-year and four-year colleges. Copy this worksheet into a new workbook and name it something like p2_yourlastname.

Graph the Parabola on a Scatter Plot

1. To graph the quadratic function we found above, we must create a table of values for the parabola. Start by clicking on cell A12 and typing 0. Then click on the cell underneath it, A13, and type a 1. This is the start of the x values we'll use for the line. We will start at 0 and graph points at increments of 1.

2. To help us generate the x values, click on the cell A12. While holding the left mouse button down, drag the cursor to A13. This will select A12 and A13. Notice the dark black line surrounding the selection. In the lower right corner is a black box called the fill handle.

3. Click on the fill handle. The cursor will change to a cross. While holding down the left mouse button down, drag the cursor to cell A22. Use your mouse to grab the fill handle. While holding the left mouse button down, drag the mouse to cell A22. Release the mouse button to fill the rest of the table with y values.

As you drag the cursor, notice the small box that appears. This tells us what entries will be filled in the cell. When you release the mouse button at cell A22, those numbers will be filled in cells A14 through A22. The numbers filled in follow the pattern established in cells A12 and A13.

This leaves us with the numbers 0 through 10 in cells A12 through A22. If we had started with 0 and 2 in A12 and A13, the column would be filled 0, 2, 4, 6, ….

4. In cell B12, we want to put the equation of the line, $y = 37x^2 - 480x + 3608$. This is done by clicking on cell B12 and typing =37*A12^2-480*A12+3608. Any formula is always preceded by an = sign and the x value is replaced with the cell containing the corresponding x value. Instead of typing A12, you can click on the cell to paste its location into the formula.

5. Press **Enter** on the keyboard to calculate the y value.

6. To compute the rest of the y values, we'll use a fill. Click on cell B12 to select it.

7. Use your mouse to grab the fill handle. While holding the left mouse button down, drag the mouse to cell A22. Release the mouse button to fill the rest of the table with y values.

11		
12	0	3608
13	1	3165
14	2	2796
15	3	2501
16	4	2280
17	5	2133
18	6	2060
19	7	2061
20	8	2136
21	9	2285
22	10	2508

These are the values we'll use to make a parabola on the scatter plot. Did you notice that the three values at $x = 7, 8, 9$ match the desired data values? This is good because it means the parabola passes through the points.

8. To add the parabola to the scatter plot, right mouse click on one of the data points in the scatter plot. A menu will appear like the one to the right. Choose "Select Data" from this menu.

Delete

Reset to Match Style

Change Series Chart Type...

Select Data...

3-D Rotation...

Add Data Labels

Add Trendline...

Format Data Series...
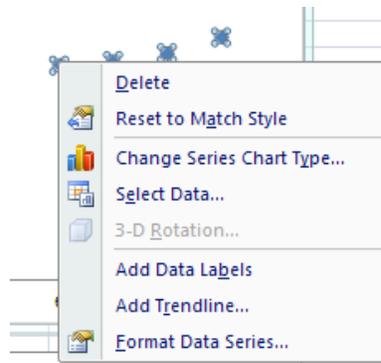
9. The Select Data Source box will appear. Under Legend Entries (Series), you'll see the title of the existing scatter plot. We want to add another dataset to this scatter plot. Click on **Add**.

Select Data Source

Chart data range: ='Tech 1'!$A$1:$B$5

Switch Row/Column

Legend Entries (Series)

Add   Edit   Remove

US Tuition and Fees at Two Year Colleges

Horizontal (Category) Axis Labels

Edit

6
7
8
9

Hidden and Empty Cells

OK   Cancel
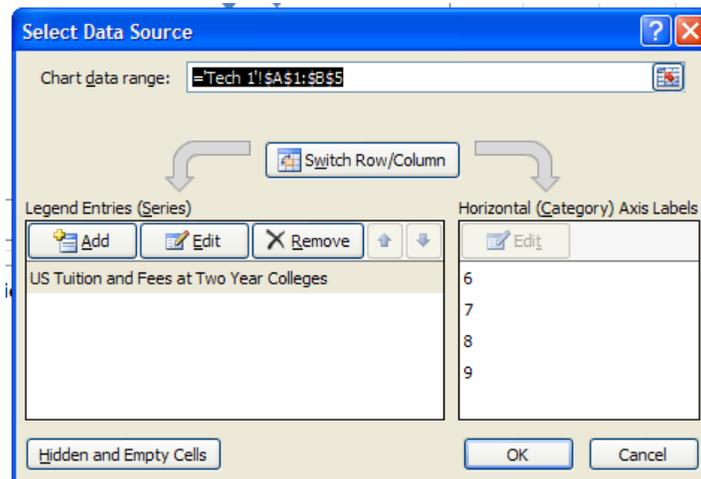
10. To put the parabola on the scatter plot, we need to enter the location of the parabola's points in the Edit Series box.
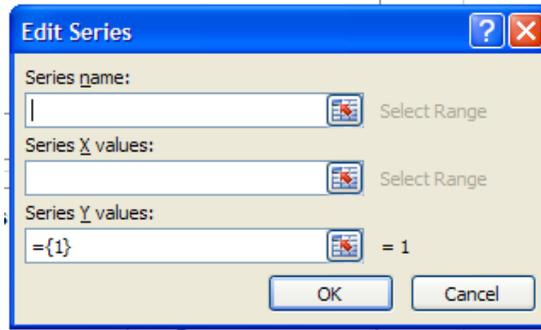
11. Click in the box under "Series X values" to place the insertion point in that box. Now click on cell A12 and drag select (hold the left mouse button) to cell A22. If your x values are not in cells A12 through A22, you may need to drag select a slightly different set of cells.
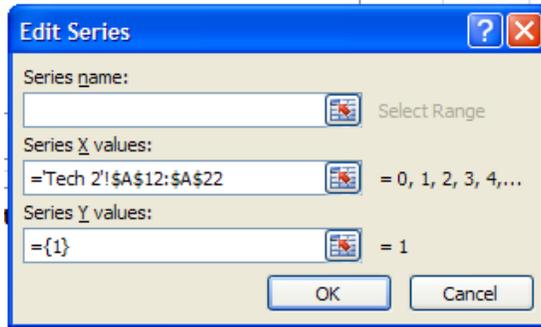
The location of the cells is pasted into "Series X values".

12. Put the insertion point in the box under "Series Y values". Delete any entry in that box. Now click on cell B12 and drag select (hold the left mouse button) to cell B22. If your x values are not in cells B12 through B22, you may need to drag select a slightly different set of cells.
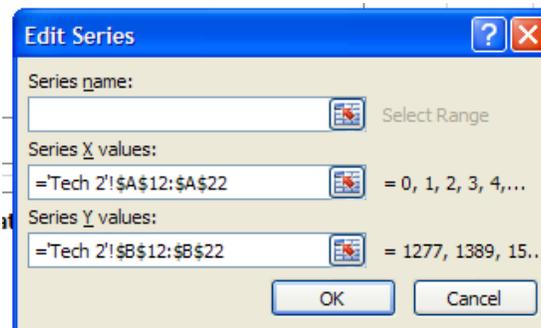
The location of the selected cells is pasted into "Series Y values". Click **OK**.

13. You'll return to the "Select Data Source" box.
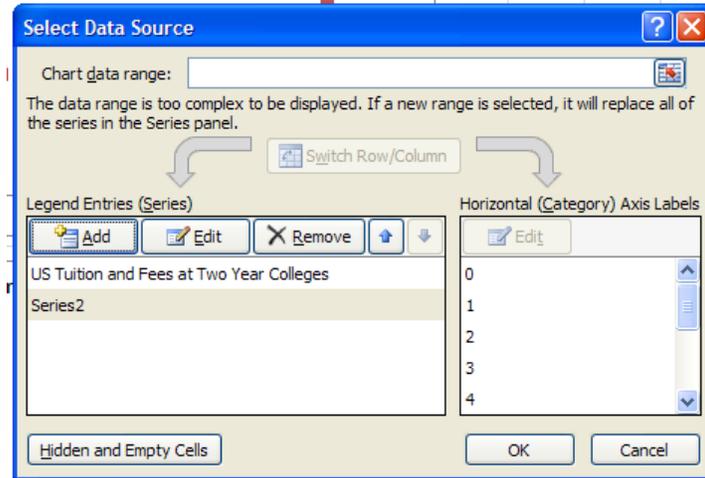
Click OK to see the new scatter plot.

14. By default, the parabola is graphed as a scatter plot and not as a line graph. We need to modify the red points so that we see a curve and not points on the parabola.
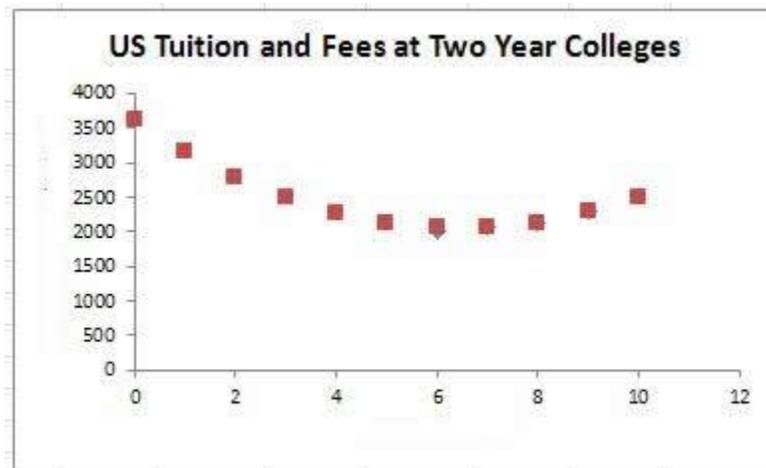

15. Right mouse click on one of the data points on the line. From the menu that appears, select "Change Series Chart Type…".
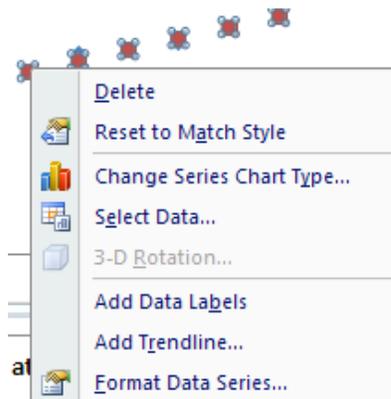
16. Select the line graph from "XY (Scatter)". Click **OK**.
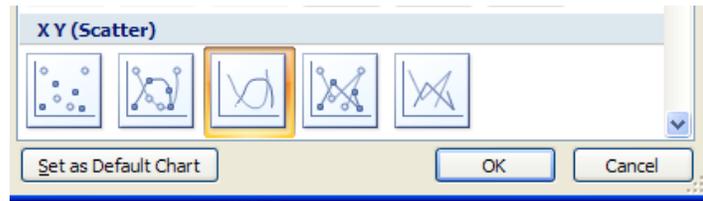


The points will change to a parabola on the scatter plot.
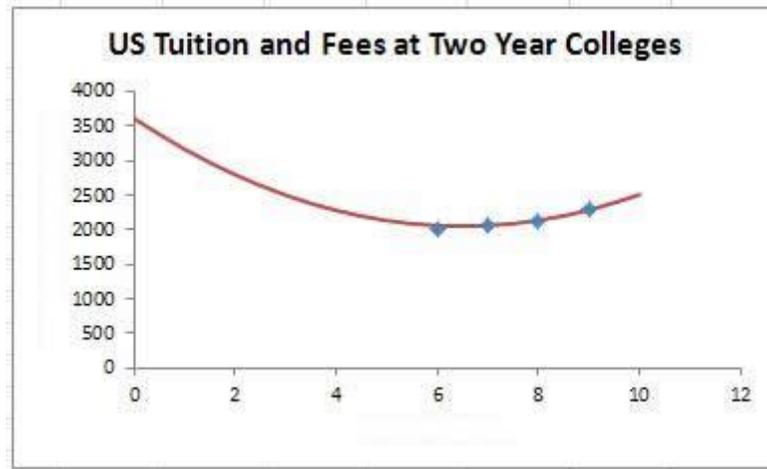
17. To finish the graph, we will add labels on each axis to describe what is being graphed. To begin doing this, click on the outside edge of the graph's window to select it. You'll see a double lined edge appear around the window. Along the top of Excel, you should see a series of tabs entitled "Chart Tools". Click on the "Layout" tab.
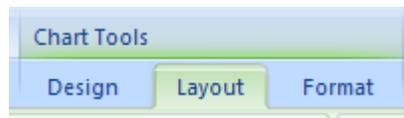

If you are using Excel 2013, click on the + on the right side to add axes titles. Then jump to step 20 to edit the axes titles.

18. Locate the "Labels" panel. Select "Axis Titles".

19. Now select "Primary Horizontal Axis Title" and "Title Below Axis".
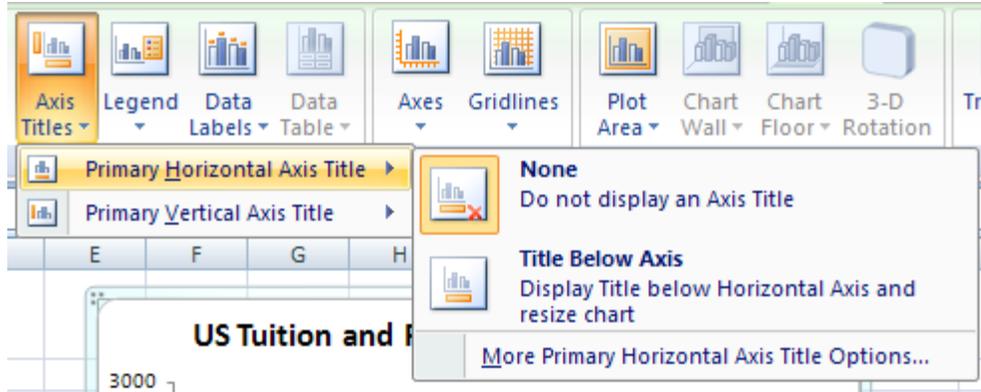
20. You'll see a label appear under the horizontal axis.
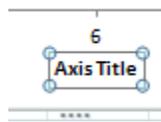
21. Since "Axis Title" is not very descriptive, select the text (or delete it).
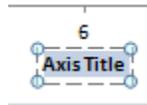
22. Change the text in the label to "Years since 2000".
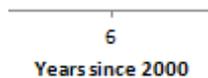

23. Let's follow the same process to add a label to the vertical axis. Make sure the graph is selected and choose "Axis Titles" from the Labels panel. In this case, select "Primary Vertical Axis Title" and "Rotated Title".
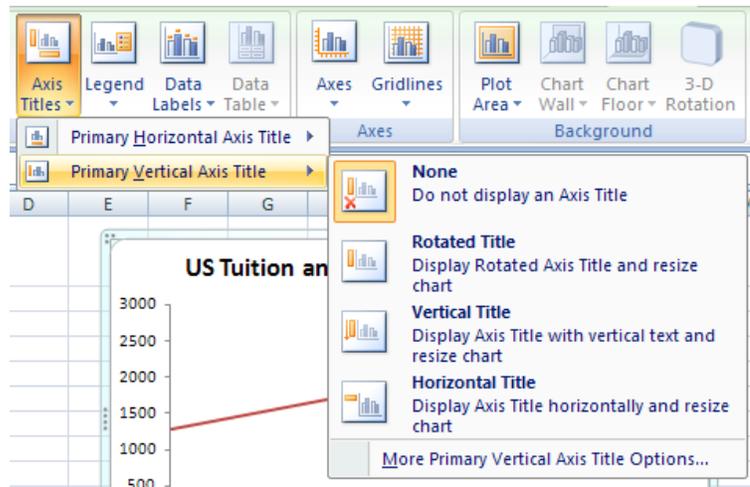

24. Edit the label that appears appropriately. Make sure you include the units, dollars, on the axis title.
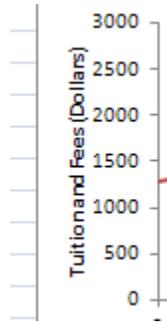
25. The new graph is shown below.

US Tuition and Fees at Two Year Colleges
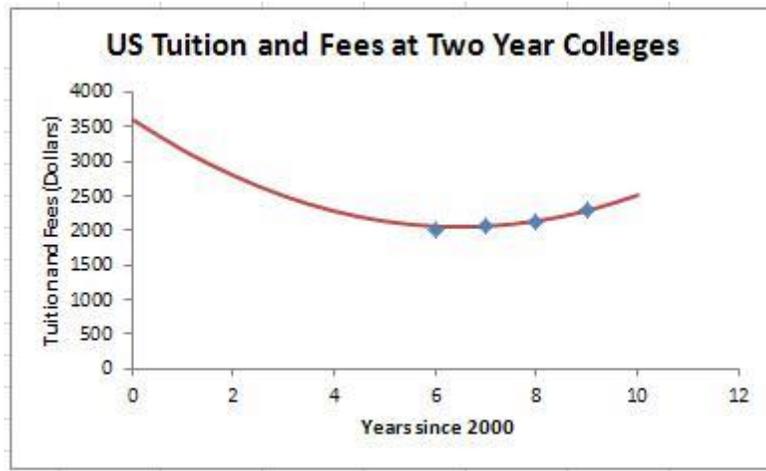
A good graph includes a title, horizontal axis title, vertical axis title, and appropriate scatter plots and/or line graphs.

26. To complete this assignment, repeat the steps you just completed to find a parabola for the scatter plot containing the four-year college data. Once you have a parabola on your scatter plot for four-year colleges, save your Excel file. This is the file you will submit (using the data from the state you are assigned) for this technology assignment.