Quadratic (and higher order) regression on your calculator (TI-82, 83, or 84)

NAME:

Notice the points on the scatter plot below have a curved pattern. We will find the quadratic, cubic, and quartic functions that best fit the data.

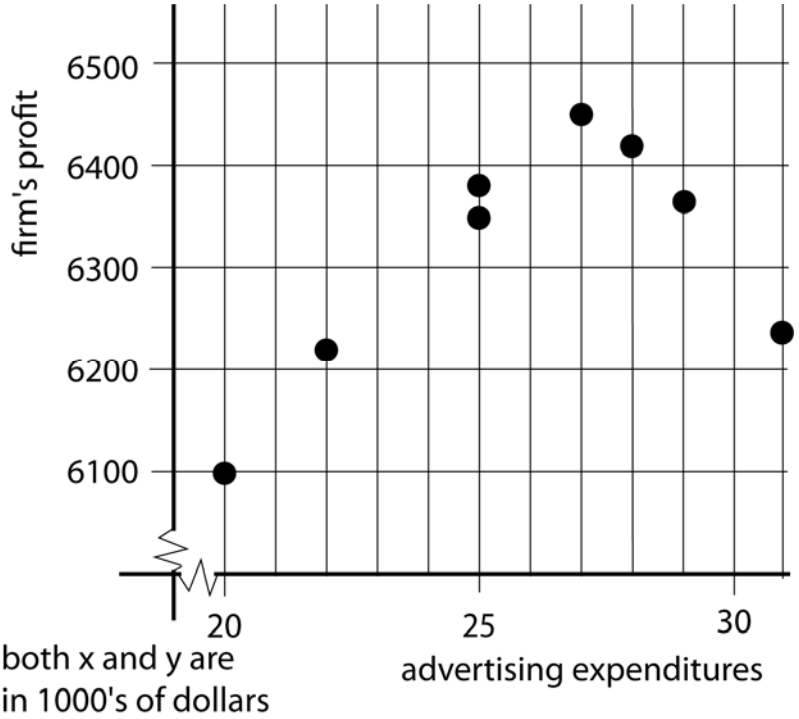
A quadratic function will be of the form $y = ax^2 + bx + c$.

A cubic function will be of the form $y = ax^3 + bx^2 + cx + d$.

A quartic function will be of the form $y = ax^4 + bx^3 + cx^2 + dx + e$.

We will *not* try to fit this data with a linear function. Why not?

The following graph shows the relationship between the money spent on advertising and the profit of a certain firm. **Roughly draw in a curve that mimics the pattern of the points.** We will use our calculator to find the one (quadratic, cubic, or quartic) function that fits the pattern best.



We'll need to enter the data into our calculator, draw a scatter plot and look at its pattern, and then find the regression equation that fits the data best. We'll follow up by graphing both the scatter plot and the regression functions together. Lastly, we'll use the regression equation to make a prediction.

The worksheet "Linear regression on your calculator" describes in more detail the menus we will use.

1. *Let's enter the data.* Remember we need the **STAT** menu.

The **STAT** button is to the left of the arrows, beneath the **DEL** key.

The table below shows the coordinates of the points from the scatter plot.
Select **1:Edit** under the **EDIT** heading and enter the data in the columns labeled **L1** and **L2**. (Remember x and y are in thousands of dollars but do *not* worry about that yet.)

If your first two columns are *not* labeled **L1** and **L2**, exit back out. Then re-enter the **STAT** menu and select **5:SetUpEditor**. Press **ENTER** back on the home screen and it will say "Done". When you return to the **STAT** editor, you should see it set up correctly.

Remember you can clear out a whole column of previous data by arrowing up to the column heading and pressing **CLEAR**. When you arrow back down, the column should be cleared.

***x* (advertising expenditures in thousands of dollars)**	***y* (firm's profit in thousands of dollars)**
20	6,101
22	6,222
25	6,350
25	6,378
27	6,453
28	6,423
29	6,360
31	6,231

2. *Let's draw a scatter plot on the calculator.* Exit out of the data entry screen. I do this by pressing **2nd MODE** (second function **QUIT**).

Select **STATPLOT**. It's the second function of the **y=** button. Highlight **Plot1** and press **ENTER**. Turn it **On,** make sure the first little graph (that looks like a scatter plot) is highlighted and it has **L1** and **L2** selected for **Xlist** and **Ylist**. Go to the **ZOOM** menu and select **ZoomStat**. You'll have to arrow down the list to get to **ZoomStat**.

Check out how the scatter plot looks rather curved in shape.

3. *We will now calculate the quadratic regression equation.*
Press the **STAT** button to enter the **STAT** menu, and arrow over to **CALC**. Select **QuadReg** from the list. This puts the expression **QuadReg** on the home screen. Press **ENTER** to have it calculate it. (If your calculator does not immediately calculate the equation, see the note below.) **Round your coefficients to two decimal places. What is the regression equation? (Write the equation in quadratic form in the space provided, *not* just a list of the coefficients.) Also, record the value given for R^2, rounded to four decimal places.** If it did not give a value for R^2, see the blurb at the top of the next page.

Note: Some newer calculators have an intermediate screen where you check the settings and then arrow down to select **Calculate** at the bottom. You can also at that step, tell it to graph the regression equation over the scatterplot, which is the next step on this worksheet. You do this by entering **Y1** in the line reading "**Store Reg EQ:**". Do this by going to that line and pressing **VARS**, arrow over to **Y-VARS,** select **1: Function**, and then select **Y1**. (By the way, the next instruction for graphing the equation may *not* work on your newer calculators.)

Quadratic Regression Equation:

Value of R^2:

4. *Let's graph the regression function on top of our scatter plot to see how well it mimics the pattern.* Get to the **y=** editor. Place your cursor in the space for **y1**.

Press the **VARS** button. Select **Statistics** from the **VARS** menu. Arrow over to **EQ** and select **RegEQ**. Then press **GRAPH**. (This may *not* work on newer calculators.)

5. *The regression equation does fit the data but could we do better? Let's investigate that.*
Did your calculator display a value for R^2 when it calculated the regression equation? This is called the **coefficient of determination**. Make sure you recorded it above with your quadratic regression equation.

We want to try different types of regression (namely cubic and quartic), or rather try to fit other types of functions to the data, and see which one is best. The regression equation that gives us a coefficient of determination closest to 1 will be our winner.

6. *If your calculator did not display the R^2 value, do the following to turn on what is called Diagnostics.*
Press **2nd** and then the **0** button. (The second function of **0** is **CATALOG**.) Arrow down until you get to **DiagnosticOn**. Select it and it puts that on the home screen. Then press **ENTER** again and it will say "Done". Now, when you run regressions, it will display R and R^2 values when appropriate.

7. *Let's try cubic regression now.*
Press the **STAT** button to enter the **STAT** menu, and arrow over to **CALC**. Select **CubicReg** from the list. This puts the expression **CubicReg** on the home screen. Press **ENTER** to have it calculate it. **Round your coefficients to two decimal places. What is the regression equation? (Write the equation in cubic form, *not* just a list of the coefficients.) Also, record the value given for R^2, rounded to four decimal places.**

Cubic Regression Equation:

Value of R^2:

Notice how the **R^2** value for this cubic regression is closer to 1 than the one given for the quadratic equation. That means this second regression equation matches the pattern of the points better. But can we do better?

8. Let's try quartic regression now.
Press the **STAT** button to enter the **STAT** menu, and arrow over to **CALC**. Select **QuartReg** from the list. This puts the expression **QuartReg** on the home screen. Press **ENTER** to have it calculate it. **Round your coefficients to two decimal places. What is the regression equation? (Write the equation in quartic form, *not* just a list of the coefficients.) Also, record the value given for R^2, rounded to four decimal places.** It is quite likely that the whole result will *not* fit on the screen and you will see an arrow on the left of the bottom line. Arrow down to see all of the output.

Quartic Regression Equation:

Value of R^2:

9. Notice how the $\mathbf{R^2}$ value for this quartic regression is closer to 1 than either previous value. That means this quartic regression equation best matches the pattern of the points.

Let's see that on the graph. Get to the **y=** editor. Clear out the function in **y1** and replace it with this new regression function.

Press the **VARS** button. Select **Statistics** from the **VARS** menu. Arrow over to **EQ** and select **RegEQ**. Then press **GRAPH**. (As mentioned earlier, newer calculators may have issues with this and you will enter **Y1** into the "**Store Reg EQ:**" line as directed on page 3 instead.)

Does this function mimic the pattern of points well?

10. Why do regression at all?
Now we have the relationship between this firm's advertising expenditures and profit. So what profit should the company expect if they spend $23,500 on ads?

Use your *quartic* regression equation. Now that the regression equation is plotted as **Y1**, it might be easiest to use the **1:value** function under the **Calculate** menu, the **second** function of the **TRACE** button. Give it the *x*-value and it will calculate the *y*-value for you. (Be careful! What is the *x*-value? Think about the kinds of numbers and their units we entered in the **L1** column.) Be sure to give proper units in the answer, completing the sentences below.

The value I entered for *x* is _____.

This firm should expect a profit of _____ if they spend $23,500 on advertising.

(If you used rounded coefficients instead of using the exact regression equation (via the **Value** function as suggested above), your answer may vary dramatically from mine. Do *not* worry but **please indicate if you did that**.)