Learning Quadratic Regression: A Step-by-Step Guide Using the TI-84 Calculator

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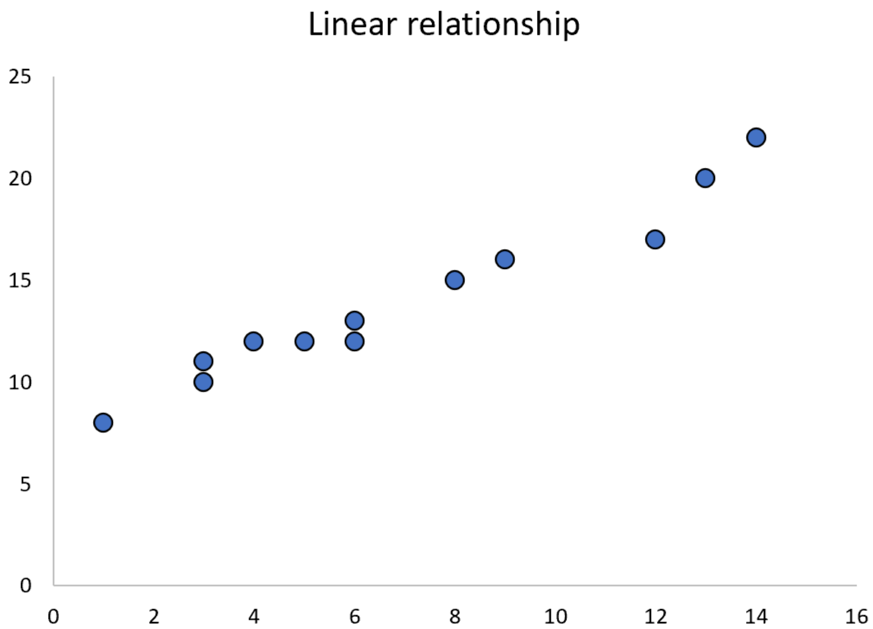
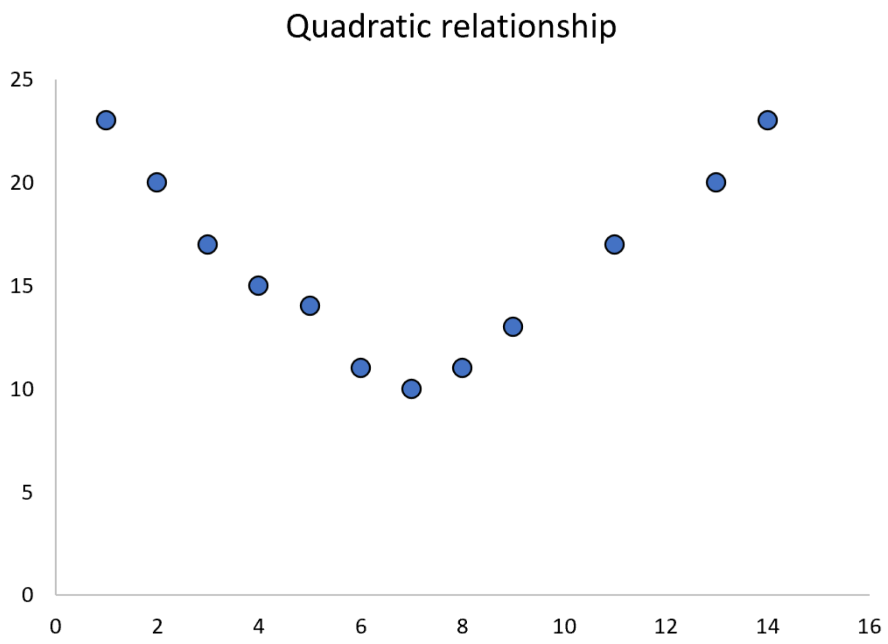
When statisticians analyze datasets, the initial goal is often to establish a quantifiable relationship between two variables. If this relationship demonstrates a consistent, straight-line association, the standard methodology employed is **linear regression**. This fundamental statistical technique allows analysts to accurately model the connection between variables and generate predictions, operating under the assumption that the observed data points cluster closely around a single straight line.



However, the complexity of real-world phenomena frequently dictates patterns that deviate significantly from linearity. When the relationship between two variables exhibits a distinct, predictable curve--typically resembling a parabola (either U-shaped or inverted U-shaped)--attempting to force a straight-line model will result in inaccurate and inadequate findings. In these crucial scenarios, we must shift our analytical approach and utilize **quadratic regression** to precisely quantify the underlying non-linear association, ensuring the statistical model accurately reflects the true nature of the data.



This comprehensive tutorial serves as a guide to mastering the methodology required for a full quadratic regression analysis. We will detail the step-by-step process specifically tailored for the **TI-84 Calculator**, a widely used tool in educational and professional environments. By following these instructions, users will be able to achieve accurate model fitting, efficiently calculate regression coefficients, and confidently interpret their non-linear results.

Understanding the Need for Non-Linear Modeling

Selecting the appropriate statistical model is arguably the most critical step in valid data analysis. While **linear regression** is favored for its simplicity and robustness, it remains applicable only when the data can be reasonably approximated by the linear formula $y = mx + b$. When preliminary data visualization reveals a clear curvature, persistence in fitting a straight line will inevitably lead to high residuals (the distance between the observed data points and the regression line) and a poor coefficient of determination. This outcome signifies that the model is statistically unsound and lacks reliable predictive power.

A **quadratic relationship** is mathematically defined by a parabolic curve, represented by the polynomial equation $y = ax^2 + bx + c$. This model is essential for fitting data that inherently involves an optimal point, which may manifest as either a peak (maximum) or a trough (minimum). For example, in fields like engineering or biology, relationships often follow this curved path. Economists frequently rely on this model because cost functions often demonstrate a quadratic shape, initially decreasing due to economies of scale but eventually increasing sharply due to diminishing returns or operational inefficiencies once production exceeds an optimal level.

The decision to employ **quadratic regression** must be strongly supported by preliminary investigation, primarily through examining a scatterplot of the variables. If the visual evidence confirms a strong curve rather than a straight line, transitioning from a linear model to a quadratic model is necessary. This switch will dramatically improve the model's accuracy and enhance the predictive capacity of the resulting equation. Fortunately, the **TI-84 Calculator** provides streamlined, built-in functions designed to efficiently calculate the coefficients (a, b, and c) required for this precise non-linear fit.

Case Study: Hours Worked vs. Happiness Level

To effectively demonstrate the mechanics of quadratic regression on the TI-84, we will utilize a hypothetical case study investigating a common psychological phenomenon: the relationship between the number of hours an individual works per week and their self-reported happiness level. Happiness is measured on a standardized index ranging from 0 (lowest happiness) to 100 (highest happiness). Our core hypothesis suggests a clear non-linear optimum: working too few hours (leading to financial stress or lack of purpose) may result in low happiness, while conversely, working excessive hours (leading to burnout and stress) will also reduce happiness. This implies an inverted U-shaped curve with an optimal level of work hours in the middle.

We have collected the following data points from a sample of 11 individuals, recording their typical hours worked per week and their corresponding happiness score. In this analysis, the hours worked serves as our **explanatory variable** (conventionally denoted as X), and the happiness score functions as our **response variable** (conventionally denoted as Y):

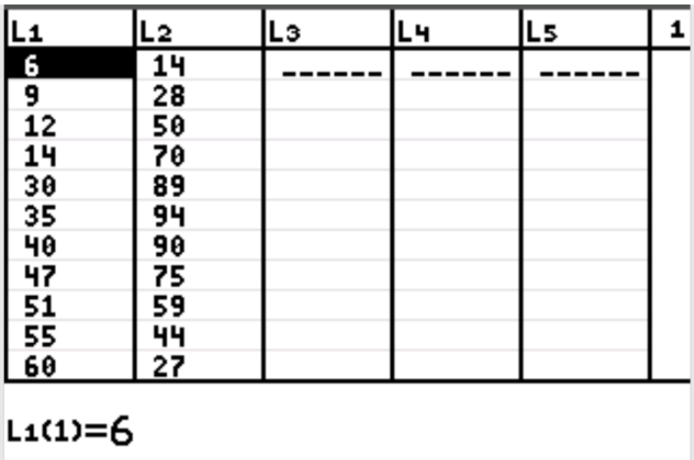
Hours	Happiness
6	14
9	28
12	50
14	70
30	89
35	94
40	90
47	75
51	59
55	44
60	27

Our primary objective is to leverage the computational power of the TI-84 to derive the quadratic equation that best models this relationship. Once established, this equation will allow us to accurately predict the happiness level associated with any given number of hours worked per week. We will now proceed through the necessary calculation steps on the calculator, starting with data input.

Step 1: Data Entry and Preliminary Checks

The initial and most fundamental step requires the accurate entry of the raw data into the statistical lists of the TI-84 calculator. This process ensures that the machine has the necessary input to execute both the visualization and the subsequent regression calculation. To begin, press the Stat key, navigate to the **EDIT** menu, and select option 1: `Edit...` to open the list editor interface.

Carefully input all values corresponding to the **explanatory variable** (Hours Worked) into column L1. It is crucial to double-check these entries to avoid transposition errors, as these errors directly invalidate the final model. Subsequently, input the values for the **response variable** (Happiness Level) into column L2. A critical validation point here is ensuring the alignment of data pairs: the i-th entry in L1 must precisely correspond to the i-th entry in L2, maintaining the integrity of the observations.

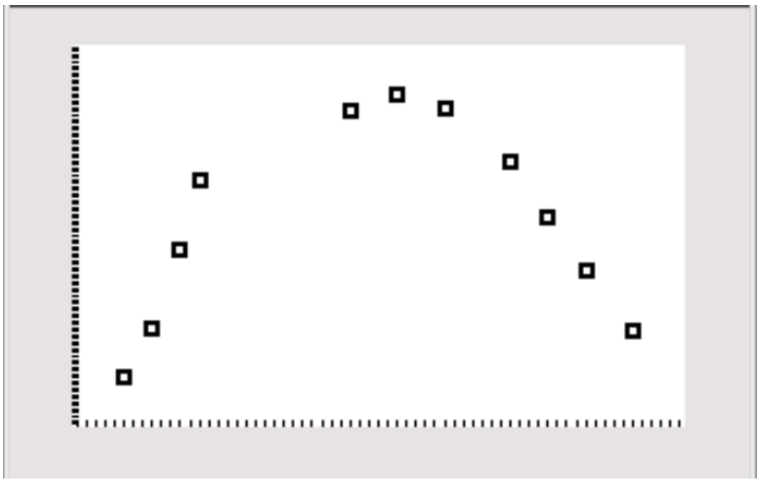


Once the data entry is finalized, confirm that both L1 and L2 contain an identical number of observations (11 data points in this case study). This preliminary dimensional check prevents the calculator from displaying a dimension mismatch error later during the regression analysis. After verifying the integrity and alignment of the dataset, we are ready to visualize the relationship.

Step 2: Generating the Scatterplot to Confirm the Model

Before committing to the regression calculation, a visual confirmation that the relationship between hours worked and happiness is indeed quadratic is mandatory. To access the statistical plot menu, press the 2nd key followed by the y= key (labeled STAT PLOT). Highlight Plot1 and press Enter. Configure the plot parameters as follows: ensure the plot is set to **On**, the Type is set to the first icon (the standard Scatter Plot), Xlist is set to L1, and Ylist is set to L2.

To visualize the scatterplot effectively, the calculator's viewing window must be calibrated to encompass the entire range of the data points. Instead of manually adjusting the window settings (Xmin, Xmax, Ymin, Ymax), the TI-84 offers a significant shortcut: press the zoom key and then select option 9:ZoomStat. This powerful function automatically scales the display window to perfectly fit all data currently stored in the designated lists (L1 and L2), eliminating the guesswork associated with manual window configuration.

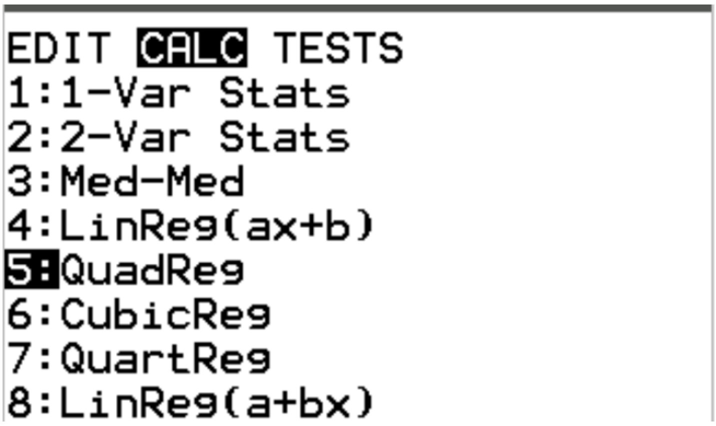


Upon observing the resulting scatterplot, we clearly confirm the inverted "U" shape, which aligns perfectly with our initial hypothesis that the relationship is non-linear and specifically parabolic. This visual confirmation is essential as it validates our decision to proceed with **quadratic regression**, discarding the simpler yet inadequate option of **linear regression**.

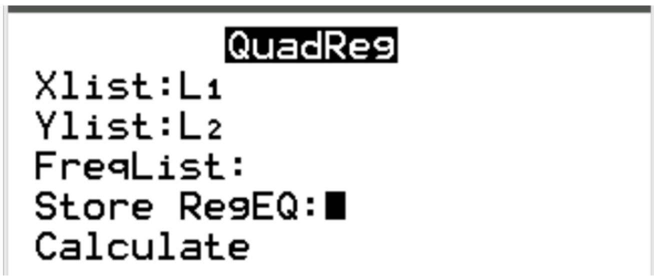
Step 3: Executing the Quadratic Regression Calculation

With the data accurately entered and the quadratic model visually confirmed, the final step involves instructing the calculator to perform the necessary statistical computations. Press the Stat key again, and then scroll horizontally using the arrow keys until you highlight the **CALC** menu. This menu aggregates all the available regression analysis options supported by the device.

Scroll down through the list of options until you locate **5: QuadReg** (Quadratic Regression) and press Enter. Depending on the specific model of your TI-84 (e.g., Plus CE or Silver Edition), you will encounter a menu prompt requiring parameter input. Confirm that the **Xlist** is correctly set to L1 and the **Ylist** is set to L2. The **FreqList** should be left blank, as frequency weights are not being used in this standard analysis.

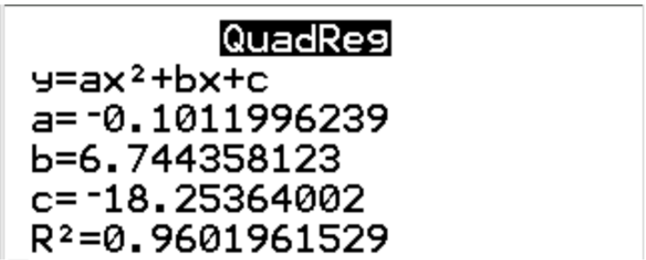


A highly recommended feature is the ability to store the regression equation directly into one of the calculator's graphing functions. If your model supports this, select Y1 under **Store RegEQ**. This action permits you to easily graph the resulting best-fit parabola directly over the scatterplot, allowing for an immediate visual assessment of the model's fit. Finally, scroll down to the **Calculate** command and press Enter. The calculator will then process the data in L1 and L2 and generate the numerical coefficients (a, b, and c) for the quadratic equation $y = ax^2 + bx + c$.



Step 4: Interpreting the Regression Output and Model Prediction

The final output screen displays the calculated coefficients that define the regression model, alongside critical statistics used to assess the model's goodness-of-fit. The following results should appear on the screen:



By substituting the calculated values for a, b, and c into the standard quadratic formula, we can construct the specific estimated regression equation for our case study:

happiness = -0.1012(hours)2 + 6.7444(hours) - 18.2536

This derived equation now functions as a robust predictive tool. It enables us to estimate the predicted happiness level for any individual based solely on their reported number of hours worked per week, providing insight into the optimal working balance.

To illustrate the model's predictive capability, consider an individual who works 60 hours per week. Substituting this value into the equation reveals the predicted happiness level:

happiness = -0.1012(60)2 + 6.7444(60) - 18.2536 = **22.09**

Conversely, considering an individual who works 30 hours per week, the predicted happiness level is significantly higher, aligning with our expected optimal range:

happiness = -0.1012(30)2 + 6.7444(30) - 18.2536 = **92.99**

Most importantly, the output also provides the **r-squared** (r^2) value for the model, which is $r^2 = **0.9602**$. The r^2 statistic is a critical measure representing the proportion of the total variance in the **response variable** (happiness) that is successfully accounted for or explained by the quadratic function of the explanatory variable (hours). A value of 0.9602 signifies that 96.02% of the variation observed in happiness levels can be attributed to the factors of $hours$ and $hours^2$. This extremely high value indicates an exceptionally strong and highly reliable fit for this specific quadratic regression model.