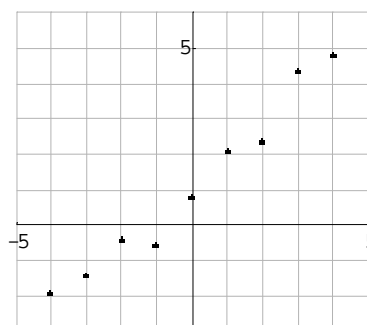


4.2 Fitting Functions Using the TI-89 Calculator

In the previous calculator lessons you have learned how to enter data, how to graph it, and how to perform numerical tests for determining which function type may fit the data. We will now see how we can use the TI-89 to actually find the best fitting function of a given type. As an example of the procedure we will use the data given in Section 4.1, to which we want to fit a straight line.

x	y
-4	-1.932
-3	-1.442
-2	-0.408
-1	-0.566
0	0.772
1	2.080
2	2.382
3	4.361
4	4.768



- We start by entering the data. Press **[APPS]** 6 3 and select
 Type: Data →
 Folder: main →
 Variable: lsfit →



(As this is a new set of data, you have to type in the name lsfit using **[2nd]**[a-lock] **[L]** **[S]** **[F]** **[I]** **[T]**.)

- Press **[ENTER]** twice. Enter the data, starting with the input values. After each value, press **[ENTER]**. Be careful to use the gray **[(-)]** key for the negative input values! Once you have entered the column of x -values, press **[↓]**, followed by **[↔]**. This will put you in the first row of column 2.

F1-Tools	F2 Plot Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3			
1	-4					
2	-3					
3	-2					
4	-1					
r1c2=						

- Enter the output values in the same way, pressing **[ENTER]** after each value.

F1-Tools	F2 Plot Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3			
7	2	2.382				
8	3	4.361				
9	4	4.768				
10						
r10c2=						

4. Graph the data by pressing $\boxed{F2}$, then $\boxed{F1}$. Select /type

Plot Type: Scatter \rightarrow

Mark: Square \rightarrow

x: $\boxed{\alpha}$ [C] 1

y: $\boxed{\alpha}$ [C] 2

Freq and Categories?: No \rightarrow

Press \boxed{ENTER} twice.

5. Press $\boxed{\blacklozenge}$ [WINDOW] to set the window parameters to appropriate values. Since x -values range from -4 to 4 and y -values range from -1.932 to 4.768 , a suitable choice would be

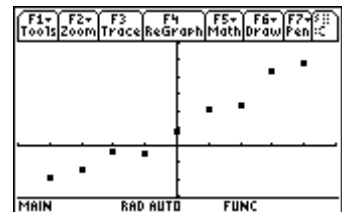
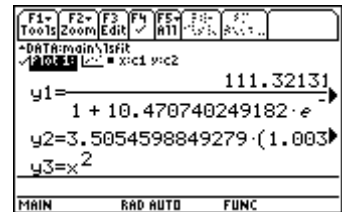
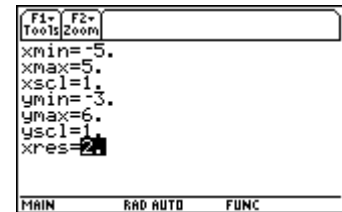
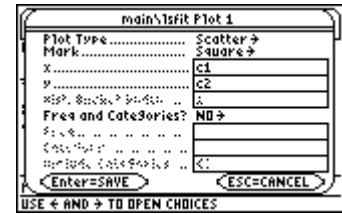
$x_{min} = -5$ $x_{max} = 5$ $x_{scl} = 1$

$y_{min} = -3$ $y_{max} = 6$ $y_{scl} = 1$

Press \boxed{ENTER} to confirm your choice of values.

6. Press $\boxed{\blacklozenge}$ [Y=] to check whether any other functions are selected to be graphed. If so, you can use $\boxed{F5}$ 1 to deselect them all at once. Move the cursor to Plot 1 and select it using the $\boxed{F4}$ key.

7. Now press $\boxed{\blacklozenge}$ [GRAPH].

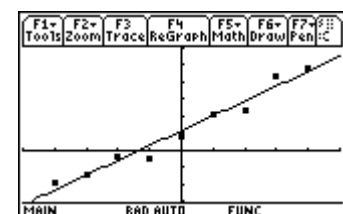
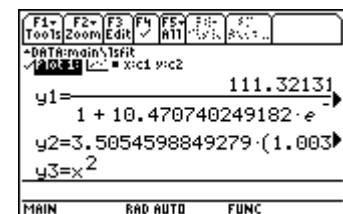
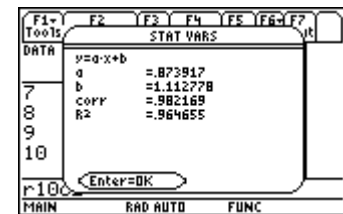
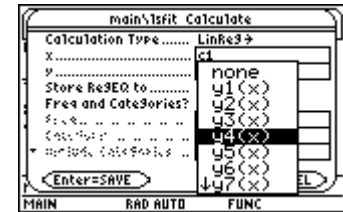
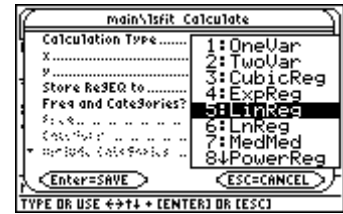


Our goal is to fit a linear function to this data. To access the different function types that can be fitted, you need to be in the Data/Matrix Editor.

8. Return to the Data/Matrix Editor and open the current data set by pressing \boxed{APPS} 6 1.

F1 Tools	F2 Plot Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA						
	c1	c2	c3			
1	-4	-1.932				
2	-3	-1.442				
3	-2	-.408				
4	-1	-.566				
r1c1=-4						
MAIN RAD AUTO FUNC						

9. Press $\boxed{F5}$ to access the different types of calculations. Select the Calculation Type to be **5:LinReg** by opening the menu using the \downarrow key, then moving down the list until your choice is highlighted. Press \boxed{ENTER} .
10. The x -values are stored in $c1$ and the y -values are stored in $c2$ as before, so type in those names in the appropriate fields. Finally, you need to specify the function name in which the fitted function is to be stored. (If you are not sure which y -functions are already in use, you can type $\downarrow[Y=]$, and then return to the window by repeating Steps 8 and 9.) Select an unused function from the menu, for example $y4(x)$.
11. Press \boxed{ENTER} twice. The window indicates that the fitted function is linear ($y = ax + b$) and lists the values for a ($= 0.873917 \approx 0.874$) and b ($= 1.112778 \approx 1.113$). (Note that this is the function used in Activity 4.1.1). Press \boxed{ENTER} .
12. Press $\downarrow[Y=]$ to check that the fitted function has been stored as $y4(x)$. Notice that $y4$ is checked (\checkmark) and that at the very top of the screen you see \wedge PLOTS 1. This indicates that there are statistical (data) plots listed, currently a single one.
13. Move the cursor to the top of the screen. Now you can see the specifics of the plot, for example, the name of the data (lsfit). This plot is also currently checked (\checkmark).
14. If you now press $\downarrow[GRAPH]$, both the data and the fitted function will be displayed together.



We will now use the example at the beginning of Chapter 3 to do a full analysis and in the process also learn how to fit function types other than a linear function. Please proceed to Calculator Lesson T5.

Now that you have had a full tour of the TI-89 functions involved in fitting a function to a given data set, here are two activities where you need to find a model (= fitted function) for the given data in order make predictions.

Activity 4.2.1

The table below gives the death rate (number of deaths per thousand people) for Americans at different ages.

Age	Death Rate
40	2.2
45	3.0
50	5.0
55	8.0
60	12.6
65	18.7

- Enter the data into a your calculator and graph it from within the Data/Matrix Editor. (Make sure that all other plots are deselected.) From the shape of the graph determine which type of function should be fitted. If more than one type is possible, list them all. Give reasons for your answer.
- Use the appropriate numerical tool (if available) for each of the function types of part a) to determine whether they fit the data. List any function type(s) that are still good candidates.
- For each type of function listed in part b), find the best fitting function (both graph and functional expression).
- Use the function **fitcomp** to check how good the best fit is for each function type. If more than one possible type remained in part c), determine which type is the best one overall.
- Does the function type you fitted make sense in the context of the problem? If several function types were fitted, which one is most likely in the context of the problem? Give reasons for your answer.
- Use the best fitting function that makes sense in the context to predict the death rate for a 5 year old and a 100 year old person. Do your predictions makes sense?

Activity 4.2.2

The table below gives the number of European, North American and South American countries issuing postage stamps from 1840 through 1880.

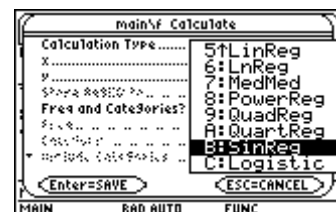
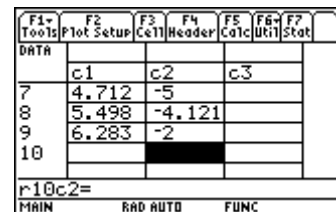
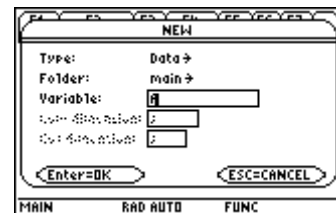
Years	1840	1845	1850	1855	1860	1865	1870	1875	1880
Countries	1	3	9	16	24	30	34	36	37

- Identify the meaning of the input and output variable.
- Enter the data into your calculator and graph it from within the Data/Matrix Editor. From the graph, determine which function type(s) are possible matches for the data. Give reasons for your answer.
- If numerical tools are available for the function type(s) identified in part b), use them to validate your guess(es). Otherwise, explain from the shape and/or context why a specific function type is appropriate.
- Fit all of the function types identified in part c) to the data. If more than one function type matches, use the function **fitcomp** to compare the fits of the different types.
- Use the best fitting function to predict the number of countries issuing postage stamps in the year 2000. How good is your prediction? (Think of ways you might determine the actual number of stamp issuing countries for the current year.)

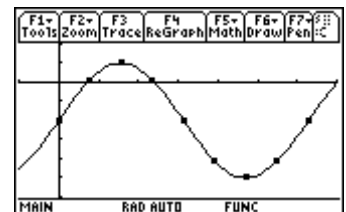
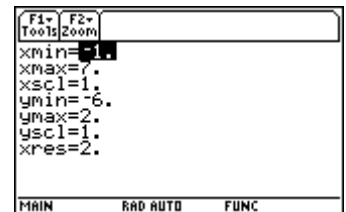
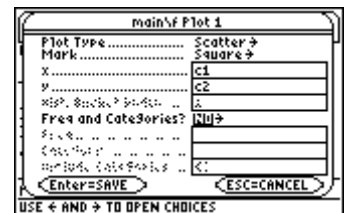
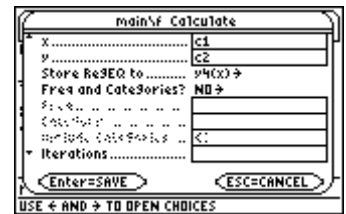
In the examples so far, we have not yet fitted a sine function. Recall that a sine function is used when the data shows a wave-like form. We will illustrate the use of the relevant TI-89 function with the data given in the example in Section 3.6:

x	$f(x)$
0	-2.
0.785	0.121
1.571	1
2.356	0.121
3.142	-2
3.927	-4.121
4.712	-5
5.498	-4.121
6.283	-2

1. Enter the data by pressing $\boxed{\text{APPS}}$ 6 3.
2. Give the data a name of your choice, for example f, by pressing $\boxed{\alpha}$ [F], then $\boxed{\text{ENTER}}$ twice. This will display the data editor.
3. Enter the x -values first, by typing each value, then pressing $\boxed{\text{ENTER}}$. After the last x -value is entered, press \blacktriangleright , then $\boxed{2\text{nd}}$ \blacktriangleleft . Now enter the y -values in the same manner.
4. Press $\boxed{\text{F5}}$ and select **B:SinReg** as Calculation Type. (Note that you have to move down beyond 8:Power Reg.) Press $\boxed{\text{ENTER}}$.



5. Type in α [C] 1 to indicate where the x -values are stored, and α [C] 2 for the location of the y -values. Select an appropriate (not yet used) function where the fitted function is to be stored (by accessing the menu using the \blacktriangleright key).
6. Press ENTER . The fit may take a moment -- check whether a highlighted **BUSY** is displayed at the lower right corner of the screen. Once the computation is finished, the screen on the right is displayed.
7. Press ENTER to return to the Data/Matrix editor, then F2 , followed by F1 . Select Scatter as the Plot Type, Square as the Mark, and type in α [C] 1 and α [C] 2 for the locations of the x - and y - values, respectively. Press ENTER twice.
8. Access the graphics window by pressing \blacklozenge [WINDOW] to define window parameters appropriate for the data. Good values for the graph would be $x_{\min} = -1$, $x_{\max} = 7$, $x_{\text{scl}} = 1$, $y_{\min} = -6$, $y_{\max} = 2$, $y_{\text{scl}} = 1$, and $x_{\text{res}} = 2$. Press ENTER .
9. Press \blacklozenge [Y=] and deselect all but the fitted function (by highlighting any other checked function, then pressing F4). Only the data plot (at the very top of the screen) and the fitted function should be selected (\checkmark).
10. Press \blacklozenge [GRAPH] to see the data together with the fitted function.



To conclude this section on fitting functions to data, the following activity gives a variety of data for you to determine an appropriate model.

Activity 4.2.3

- a) For each set of data, enter the data into your calculator and graph it.
- b) Determine which function types are appropriate using the shape of the graph, numerical tests (if available), and the context.
- c) Fit the function type that is most appropriate. If several types are possible use **fitcomp** to determine the best fit. Discuss whether you found a good model (= fitted function).

i)

Price (dollars)	Volume (liters)
0.50	0.3
1.00	1.0
1.50	2.25
2.00	4.0
2.50	6.3
3.00	9.2

ii)

Four week period	Soup sales (millions of 16 ounce cans)
1	200
2	215
3	180
4	160
5	150
6	120
7	110
8	100
9	110
10	130
11	155
12	200
13	210
14	200

iii)

Time since drug was given (hours)	Amount of drug remaining
1	575
3	374
5	240
7	153
9	98
11	63

iv)

Length (feet)	Width (feet)
20	25.0
22	27.5
24	30.0
25	31.3
27	31.0
29	30.0
32	27.8
34	25.3

Chapter Review

Key Terms

error	absolute error	squared error
total absolute error	total squared error	method of least squares fit

Short Answers

1. Why do we use either the absolute error or the squared error to measure how much the data values differ from the fitted function?
2. What does the method of least squares provide in the case of a straight line fit?
3. Describe the basic idea of the method of least squares fit.
4. If you are given the equations of several potential functions together with the data, how can you determine which of these functions fits best to the data?
5. How is the total squared error computed?

True - False Questions

- T F 1. The total squared error is the square of the total absolute error.
- T F 2. The method of least squares fit gives the equation or the values of the constants of the best fitting function of a given type.
- T F 3. There may be more than one best fitting function of a given type.
- T F 4. The method of least squares fit works only for straight lines.

Fill in the Blanks

1. The method of least squares fit uses methods from _____ to find the values of the constants of the best fitting function of a given type.
2. The error $\Delta = y - f(x)$ is positive if the data point is _____ the fitted function.