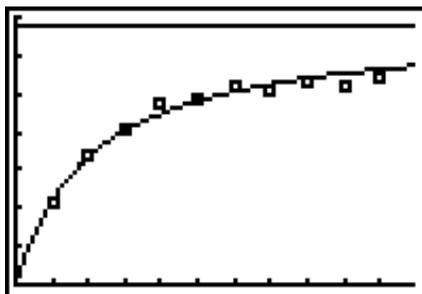


**DATA HANDLING AND ANALYSIS
ON THE TI-82
AND
TI-83/83 PLUS
GRAPHING CALCULATORS:**

**A RESOURCE FOR SCIENCE AND
MATHEMATICS STUDENTS**

**John L. McClure
Scott A. Sinex
Barbara A. Gage**

**Prince George's Community College
Department of Physical Sciences
Largo, MD 20774-2199**



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TABLE OF CONTENTS
with starting key strokes

General Operations.....	1
Transferring Information from Calculator to Calculator [LINK].....	1
Entering Data for Analysis [STAT] EDIT.....	1
Plotting the Data [STAT PLOT].....	2
Data Transformations [STAT] EDIT.....	3
Regression Analysis of Data [STAT] CALC.....	3
Graphing the Regression Function [Y=].....	4
Graphing a Function [Y=].....	5
Exploring a Function [TABLES].....	5
Exploring a Graph [TRACE] or [CALC].....	5
Some Trouble Shooting Tips.....	6
A Quick Tutorial Using Data.....	8
Managing Memory on the TI-83 Plus Graphing Calculator.....	12
Collecting Experimental Data Using Vernier’s ChemBio with the CBL.....	13
Appendix A - Types of Regressions on the TI-83/83 Plus.....	15

DATA HANDLING AND ANALYSIS...

We have included basic information on the use of the calculator and some trouble shooting hints. A short tutorial is given in the last section. Keystrokes for the calculator are denoted in bold brackets ([]) such as **[ON]**. Keystrokes are identical on the TI-83 and TI-83 Plus.

GENERAL OPERATIONS

- ' The TI-82 and TI-83 use full-screen menus to access their data analysis operations. To access a menu, press the appropriate key.
- ' Use the arrow keys to move the cursor through the menu options. The current menu option is highlighted by the cursor.
- ' Press **[ENTER]** to select a highlighted menu item.
- ' To leave a menu, you can usually press the key of the next menu you wish to access. Otherwise, you can leave a menu item by pressing **[2nd] [QUIT]**.
- ' To change the display contrast (display brightness), press **[2nd] [>]** (up arrow) to increase the contrast or **[2nd] [?]** (down arrow) to decrease the contrast.
- ' Press **[CLEAR]** to clear the display.
- ' To access keyboard operations in blue on the TI-82 or yellow on the TI-83 to the left above a key, press **[2nd]** and then the key.
- ' To access alphabet characters in grey on the TI-82 or green on the TI-83 to the right above a key, press **[ALPHA]** and then the key.
- ' If no action occurs after a keystroke, press **[ENTER]**.
- ' Press **[MODE]** and select FLOAT for the maximum precision in a calculation.
- ' Press **[MODE]** and select DEGREE to interpret and display angles in degrees.

TRANSFERRING INFORMATION FROM CALCULATOR TO CALCULATOR

Plug the link cable that comes with your calculator into the two calculators. To receive information, press **[2nd] [LINK]**, cursor right to RECEIVE and press **[ENTER]**. Calculator will go to the home screen and display "Waiting ..." on the screen. To send information, press **[2nd] [LINK]** and select the option you want to send. Then move the cursor to the selection wanted, press **[ENTER]** to select (box appears next to selected item). Cursor to TRANSMIT when ready. Both calculators will list what is transferred and display "Done" on completion.

ENTERING DATA FOR ANALYSIS

Before data can be analyzed or plotted, it must be entered into lists (by hand or from a CBL via a program). The lists are comparable to data tables or columns in a spreadsheet.

1. Press **[STAT]** **[ENTER]** to access the list editor.
2. There are 6 lists (columns L_1 , L_2 , L_3 , ... , L_6) to accommodate 6 sets of data or 3 sets of x, y data pairs. Note that when a CBL is used it stores commands in one of the lists. The TI-83 can have more than six lists if the lists are named through the "SetupEditor" under **[STAT]** **EDIT**.
3. To clear old data from a list, move the cursor to the header or list name (see highlighted L_1 on screen to the right) at the top of the column and press **[CLEAR]** **[ENTER]**.
4. Enter the data into one column or, if paired, two columns; x-data column and y-data column. Place the cursor at the appropriate place and type the data. It is entered by pressing either **[ENTER]** or **[↓]** (the down arrow key).
5. Press **[2nd]** **[QUIT]** or a new menu key to leave the lists screen.

L1	L2	L3	1
1	.219	-.0025	
2	.343	.00885	
3	.411	.00863	
4	.47	.02189	
5	.49	.00909	
6	.525	.01942	
7	.512	-.0128	

L1 = {1, 2, 3, 4, 5, 6...

The TI-83 will allow you to name your lists. See your manual for directions on how to do this in the SetupEditor .

PLOTTING THE DATA

You must "tell" the calculator how to plot and display the data. In the following procedure, **select** means to move the cursor to the appropriate item and press **[ENTER]**.

1. Press **[2nd]** **[STAT PLOT]** to access the plot menus.
2. Select Plot1, Plot2, or Plot3 as the plot for your data.
3. Set up the plot by selecting:

ON	OFF	turns plot on or off; on displays the plot
Type:		points plotted without line (preferred) or
		points plotted with line
Xlist:		column (L_1 , L_2 , L_3 ...) containing x-data
Ylist:		column (L_1 , L_2 , L_3 ...) containing y-data
Mark:		appearance of plotted points
4. Press **[ZOOM]** **[9]** to view your graphed data. The calculator automatically scales the axes using this feature.
5. To scale the axes yourself, press **[WINDOW]** and enter values for:

Xmin, Xmax	min and max values for the x-axis.
Xscal	interval between tick marks on x-axis.
Ymin, Ymax	min and max values for the y-axis.
Yscal	interval between tick marks on y-axis.

This is useful when you want to look closely at a region of the graph or explore beyond the range of your data.

6. Press **[GRAPH]** to view graph.

DATA TRANSFORMATIONS

You can do spreadsheet-like calculations on the data in lists to transform the data before it is plotted. For example, you can multiply each data point by a constant or subtract a constant value from each point. In data analysis, data is often transformed so that the resulting plot is linear. If the data is of the form $y=a/x$, then a plot of y vs. $1/x$ will be linear with slope a . Or, if the data is of the form $y=ae^{-kt}$, then a plot of $\ln y$ vs. t will be linear with slope $-k$ and y -intercept $\ln a$. To transform a data list:

1. Press [STAT] [ENTER] to access the list editor.
2. Move the cursor to the top of the list to highlight the list name. In this situation the bottom of the screen shows the list as a function. Press [ENTER] and the cursor moves to the function. Press [CLEAR] and any previous function is cleared. For example, if you selected L_2 , the bottom of the screen will show $L_2=$ with the cursor just after the = sign waiting for you to enter a new function.
3. Now enter the transformation calculation using the operation keys on the keyboard. For example, to multiply each data number in List 2 by a constant C , type in [2nd] [2] [x] [C]. The bottom line will show $L_2=L_2*C$. To transform the list to $\ln y$, type in [ln] [2nd] [2]. If you want to retain the original data enter the transformation calculation in a different list.
4. Press [ENTER] and the transformed data will replace the old data in the list. To plot the new data, press [ZOOM] [9] or scale the axes in [WINDOW] and press [GRAPH].

REGRESSION ANALYSIS OF DATA

The TI-82 will do eight types of regression analysis of data in lists. The TI-83 will do ten types. Data for the regression analyses comes from lists. Note that the list names, L_1 through L_6 , can be accessed via the keypad (in blue to the left above keys 1 through 6 for the TI-82; in yellow for the TI-83). Press [2nd] and the appropriate key to name or designate a given list.

1. Press [STAT] [<] to display the **STAT CALC** menu. The available types of analysis are:

On TI-82

- *5: LinReg (ax+b)
- 6: QuadReg
- 7: CubicReg
- 8: QuartReg
- *9: LinReg (a+bx)
- *0: LnReg
- *A: ExpReg
- *B: PwrReg

On TI-83 (see Appendix A for details)

- *4: LinReg (ax+b) Fits data to $y=ax+b$.
- **5: QuadReg Fits data to $y=ax^2+bx+c$.
- **6: CubicReg Fits data to $y=ax^3+bx^2+cx+d$.
- **7: QuartReg Fits data to $y=ax^4+bx^3+cx^2+dx+e$.
- *8: LinReg (a+bx) Fits data to $y=a+bx$.
- *9: LnReg Fits data to $y=a+b \ln(x)$.
- *0: ExpReg Fits data to $y=ab^x$. Power of base e is $\ln b$.
- *A: PwrReg Fits data to $y=ax^b$.
- B: Logistic Fits data to $y=c/(1 + ae^{(-bx)})$
- C: SinReg Fits data to $y=asin(bx+c) +d$

* The regression analysis returns a correlation coefficient (r), a measure of the goodness of fit. The closer the values approach +1 or -1, the better the fit is.

**The value of r^2 , the coefficient of determination, is given for these regressions.

On the TI-83 to get r or r^2 use [2nd] [CATALOG] and cursor down to **Diagnostic ON**. Press

[ENTER] and then [ENTER] again. DONE should appear on the home screen. (Some programs turn the Diagnostics off, so if you do a regression and do not get an r or r^2 value check to be sure you have DiagnosticsOn.)

The **coefficient of determination**, r^2 , is the proportion of the TOTAL variability of the y-data that can be explained by the x-variable. The limits of the coefficient of determination are $0 \leq r^2 \leq 1$. A value of 1 means all or 100% of the variation of y is explained by x.

2. Move the cursor to the desired regression command and press [ENTER] or press the number of the command.
3. The regression command is transferred to the home screen of the calculator and the prompt waits for you to enter the list names. Enter the list of the x-data, [,], and the list containing the y-data. For example to enter List 2 as "x" and List 4 as "y" you would key in [2nd] [2] [,] [2nd] [4]. Press [ENTER] to do the analysis. The coefficients, constants, and regression values are printed on the home screen.

GRAPHING THE REGRESSION FUNCTION

The equation editor of the calculator can be used to graph the regression function displayed on the home screen. The equation editor is accessed by the [Y=] key. Equations are automatically plotted if they are selected. You select or deselect ("turn on" or "turn off") functions by placing the cursor over the = sign and pressing [ENTER] to either highlight the = sign (select) or to remove the highlight (deselect). On the TI-83 if you move the cursor to the left again you can select the style of the line plotted- thin, thick, shaded above, shaded below, or animated. The function can be cleared by placing the cursor anywhere on the function and pressing [CLEAR].

1. Press [Y=] to display the equation editor. Clear or deselect unwanted functions and move the cursor to the first available function.
2. To select the regression line as the function for graphing, press [VARS] [5] (which selects **Statistics** as the source of the function) and then press [<] [<] to move cursor to the **VARS EQ** menu.
3. Press [7] on the TI-82 or [1] on the TI-83 to select **RegEQ**. This copies the regression equation to the **Y=** function.
4. Press [GRAPH] to display the regression line.
5. If the data were plotted with a line connecting the points, you can go to the **STAT PLOT** menu and change to plotting points only. Then the only line through the data points will be the regression line.

On the TI-83 you can take a shortcut to graphing the regression equation, When you select the regression function and put in the lists, you can enter the location for the regression equation. To do this:

1. *Enter the regression type and the two lists as above in the section on Regression Analysis of Data (Steps 1 - 3).*
2. *Enter a [,] after the second list.*
3. *Press [VARS] and arrow over to Y-VARS and select 1:FUNCTION*
4. *Select the Y function where you want the regression equation to go ($Y_1=$, $Y_2=$, $Y_3=$...)*

and press **[ENTER]**. You should now see a *Y* after the two list entries. When you press **[ENTER]** the calculator will compute the regression equation and paste the function into *Y=* for you. Press **[Y=]** to see the equation or **[GRAPH]** to see it graphed.

GRAPHING A FUNCTION

Either before or after collecting data, you can become familiar with the shape of a function by graphing it. The TI-82 or TI-83 allows you to quickly enter and graph any function.

1. If you wish to turn off your data plots, press **[2nd]** **[STAT PLOT]** and determine which plots are still on. To turn off a plot, select the plot that is **ON**, move the cursor to **OFF**, and press **[ENTER]**. Press **[CLEAR]** to return to the home screen.
2. Press **[Y=]** and clear or deselect unwanted functions (see Graphing the Regression Function, above). Selected functions have the = sign highlighted.
3. Move the cursor to the first available function and type in the function using the operation keys. The independent variable must be entered as *X* using the **[X,T,θ,n]** key on the TI-82 or **[X,T,θ,n]** on the TI-83 (next to the **[ALPHA]** key). Press **[ENTER]** when the function is complete.
4. Try pressing **[ZOOM]** **[6]** to see if the function will graph on the Standard scale axes. On the TI-83, **[ZOOM]** **[0]** will fit the function to a window. If not, press **[WINDOW]** and adjust the axes to your preference and press **[GRAPH]** to see the graphed function.
5. The TI-82 or TI-83 displays the graphs of all functions that are selected which means that you can graph several functions together for comparison. Enter each function as above and select those you wish to view.

EXPLORING A FUNCTION

Using **[2nd]** **[TABLE]** you may explore the values of a function or regression equation for any *x,y* points. This is useful for interpolation and extrapolation. The **[2nd]** **[TBLSET]** will allow you to set-up the table's starting point, TblStart=, and the change from point-to-point Tbl=. Any functions in **[Y=]** that are plotted will be evaluated in the table; use the right cursor to move to functions not shown.

EXPLORING A GRAPH

You can explore and analyze your graphed functions (and plotted data) using the **[TRACE]** and **[CALC]** keys. **TRACE** moves the cursor from point to point along your current graph and displays the coordinates of the point at the bottom of the screen. If the current graph is a graphed function, the function number appears in the upper right hand corner of the screen. If the current graph is a data plot (from data in lists), a *P*, followed by the plot number, appears in the upper right hand corner of the screen. If several graphs are displayed simultaneously, **TRACE** can be used to distinguish between the graphs. **CALC** operations work only on graphed functions. The directions below only refer to some of the operations available with **TRACE** and **CALC**. Refer to your guidebook for more information.

Exploring a Graph with TRACE

1. Press **[TRACE]**. If your graphs are not yet displayed, the calculator displays them with an **X** marking the current displayed point. **[<]** and **[=]** (right and left arrows) move the cursor from one point to the next point. If the graph is a graphed function, **[2nd] [<]** and **[2nd] [=]** move the cursor 5 points at a time.
2. With plots off (**[STAT PLOT]**), if you trace a function off the left or right edge of the screen, the viewing window automatically pans to the left or right. The values of **Xmin** and **Xmax** are updated to correspond the new viewing window. The values of **Ymin** and **Ymax** are not changed. If you wish to store the current viewing window, before tracing off the screen, press **[ZOOM] [<]** to display the **ZOOM MEMORY** menu. Select **2:ZoomSto** to store the current window values. Returning to this menu later, you can select **3:ZoomRcl** to restore the original window values.
3. If more than one function or plot appears on the screen, you can select which one to trace by pressing **[>]** or **[?]** (up or down arrows). The number of the selected function or plot appears in the upper right hand corner of the screen.
4. To leave **TRACE**, press **[CLEAR]**.

Exploring a Function with CALC

CALC, accessed by pressing **[2nd] [CALC]** (above the **TRACE** key), allows you to perform some simple analysis on graphed functions. Only two of the seven possible operations on the **CALC** menu are described here.

1. Press **[2nd] [CALC]** to access the **CALC** menu.
2. To find the value of your function at a specific value of **x**, select **1:value**. The present graph is displayed with a prompt for you to enter **X**. Enter a value for **X** between **Xmin** and **Xmax** and press **[ENTER]**. The cursor goes to the point on the first selected graph and the coordinates of the point are displayed under the graph.
3. To find the numerical derivative at a point of a function, select **6:dy/dx**. This is the slope of a tangent line on the curve at this selected point. The current graph is displayed and the cursor is visible at a point on the graph. Use the arrow keys to move the cursor to the **X** value of your choice and press **[ENTER]** to display the derivative.

SOME TROUBLE SHOOTING TIPS

Sometimes you are sure that you entered all your data correctly and pressed the correct keys but you get an error message. Although we cannot anticipate all the creative ways in which errors are generated, we can list some common errors that you may encounter. In some cases we have included the error screen that is generated and the possible cause. For any error screen, **ERR:**, you must press **[ENTER]** to acknowledge the error and move on.

1. Negative number verses subtraction

[(-)] is the negative key (gray key below the **[3]**) to be used when you want to enter a negative sign

in front of a function or number such as -log: **[(-)] [log]** or -3: **[(-)] [3]**

[-] is the subtraction key (blue key, along right side of calculator with the other arithmetic operations) used for operations such as 5-2: **[5] [-] [2]**

2. Parenthesis (they travel in pairs!)

$$\frac{4 \times 5}{2 \times 5}$$

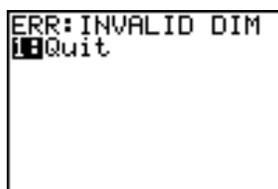
4*5/2*5	50
4*5/(2*5)	2
4*5/2/5	2

The first line above shows the error as the calculator uses its order of operation. The second and third lines show two ways to correct the problem.

3. Axes appear with NO data

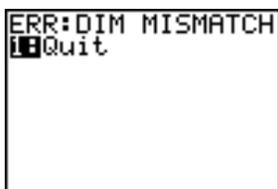
Check to see if the plot is turned on by pressing **[2nd] [STAT PLOT]**. If the plot is on try **[ZOOM][9]** to scale axes to data.

4. ERR: INVALID DIM



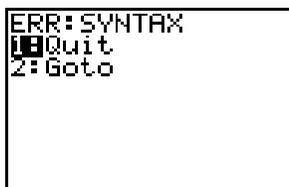
A plot is on but there is NO data in the list editor under **[STAT] EDIT**. This usually occurs if you have a second plot that you are not working with at the moment turned on. Go to **[STAT PLOT]** and check.

5. ERR: DIM MISMATCH

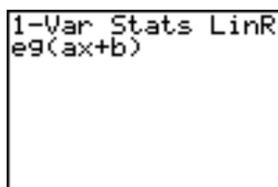


All lists to be plotted must have same number of items (number of x points must equal number of y points) in them to plot or do regressions.

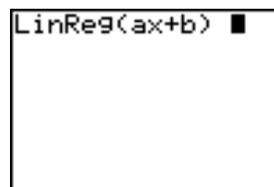
6. ERR: SYNTAX



Error



Incorrect



Correct

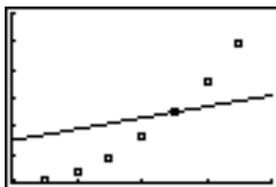
If you transfer an operation to the home screen, it must be on a clear line without any other entry. The example above shows a error when doing a linear regression.

This same error occurs if you paste a function into the function editor, [Y=], and there is already one in the Y_1 or wherever you selected.

7. Multiple plots

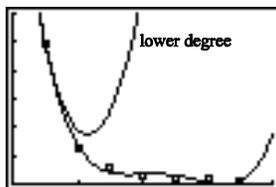
The calculator will plot up to three sets of data; however, all sets will show up only if the x-y scales are all comparable. If the scales are not comparable, data is usually hidden on the axes lines. In [STAT PLOT], turn plots off and plot individually, scaling each with [ZOOM][9].

8. Stray lines appear on a plot with data points



You need to turn off or clear functions in the function editor, [Y=].

9. Curve that misses the data points



When determining and graphing regression equations, set [MODE] to float, otherwise some small coefficients (a, b) may be rounded to zero. This lowers the degree of the equation and changes the form of the function, usually generating a curve of very poor fit (but the r^2 looks good!).

10. ERR: DOMAIN



The regressions ExpReg, LnReg, and PwrReg cannot handle the origin (0,0) or specifically $x = 0$ in a data set. If you change the zero to a very small number, such as 1×10^{-10} , it will work and not significantly change the data set.

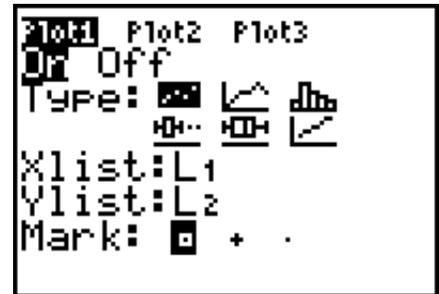
A QUICK TUTORIAL USING DATA

The data listed below are the measured heights of stacks of Oreo® cookies. Enter the data into the lists on the calculator - place the number of cookies in the stack into L_1 and the height into L_2 . To get the lists or list editor, press [STAT] EDIT and select EDIT (just press [ENTER]).

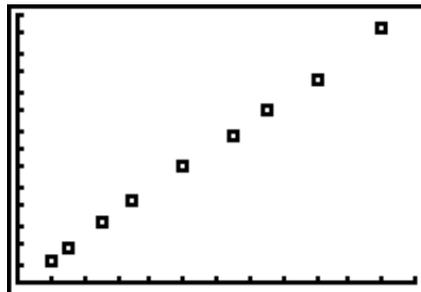
number of cookies in a stack	measured height of stack (cm)
2	2.4
3	3.5
5	6.1
7	8.6
10	12.3
13	15.3
15	18.2
18	21.3
22	26.5

After the data are entered, press [**2nd**] [**STAT PLOT**] and select Plot 1. Then set up the screen as shown to the right.

Now we want to plot the graph of height (y-variable) against the number of cookies in the stack (x-variable). To do this we press [**ZOOM**] [**9**] to have the calculator automatically scale the axes to the x and y variables.



A scatter plot of the data should look like the screen shown below.



Press [**TRACE**], watch for the flashing cursor, and use the right/left cursor keys ([**<**] or [**=**]) to move along each point to check that you entered them correctly (*mistakes in data entry are very common!*).

Now go to [STAT] CALC and select linear regression and press [ENTER] or press [4]. This puts you back onto the home screen showing what you selected. You must now inform the calculator of the x and y data needed to perform the regression. Press [2nd] [L₁],[,] [2nd] [L₂] to get the left screen below and then press [ENTER] to get the linear regression results shown on the right screen (r and r² will be discussed by your instructor later).

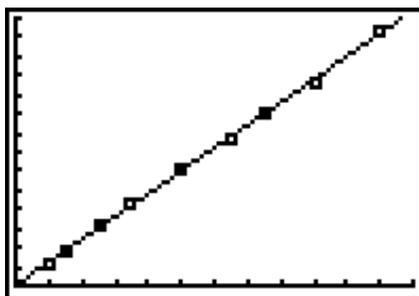
```
LinReg(ax+b) L1,
L2
```

```
LinReg
y=ax+b
a=1.195828539
b=.0662543153
r2=.9993326296
r=.9996662591
```

Now we want to graph this regression equation with the data points. To paste the regression equation into the function editor: Press [Y=] and move the cursor to Y₁, then press [VARS] [5] [<] [<] EQ, select RegEq [ENTER]. The regression equation should be in the function editor, [Y=], as shown below.

```
Plot2 Plot3
\Y1=1.1958285385
5X+.066254315305
\Y2=
\Y3=
\Y4=
\Y5=
```

Press [GRAPH] and the regression line will be shown with the data points.



Here are the data and the regression line which fits the data nicely (r² is very close to one). The slope of the line, as given by “a” in the regression is 1.196 or 1.2.

- ‘ What are the units of the slope?
- ‘ What does the slope in this example mean or represent?

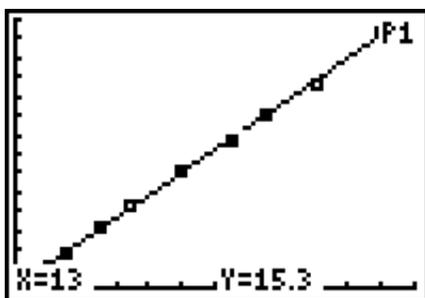
' What should the intercept value be?

The slope or rate of change of the line is given by:

$$\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta \text{height}}{\Delta \text{number of cookies}}$$

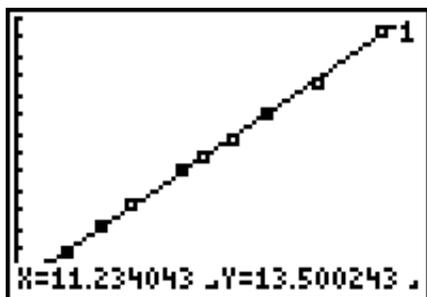
The slope in this example is the height per cookie or thickness with units of cm/cookie. The line should go through zero or the intercept should be zero; however, due to experimental error, the intercept is slightly greater than zero.

You can go back to your graph with the regression line, press [TRACE] then use the up and down cursor keys ([>] or [?]) to switch from the data points to the line, select two points on the line and calculate the slope using the formula given above. We illustrate this below.



This screen shows the trace function working along the data points that are in Plot 1 - notice the P1 in the upper right corner of the screen.

Here you can only hop from one datum point to another.



This screen shows the trace function working along the regression line in the function editor in Y₁ - notice the 1 in the upper right corner of the screen.

Here you can move along the line to any values which are displayed at the bottom of the screen. This allows you to interpolate data.

Is your calculated slope close to the value from the linear regression? It should be! You could also use [TABLE] to get the two points on the regression line (see Exploring a Function, p.5).

The graphing calculator is a powerful mathematical tool for handling and analyzing scientific data. Have fun and remember to ask your instructor for help if you have problems.

Managing Memory on the TI-83 Plus Graphing Calculator

```
ERR: MEMORY
1: Quit
2: Goto
```

Does this display to the left happen to you often? If you have a TI-83 Plus you have an option. The TI-83 Plus Graphing Calculator has an active memory (RAM) and storage memory (ARC). Archive is the transfer function that allows you to move items, such as programs, from RAM to ARC memory. Programs such as Vernier's ChemBio or Physics, or TI's Ranger software, require a large portion of the RAM memory. Vernier's ChemBio or Physics can be loaded as applications (under [APPS]), which are stored in ARC memory. TI gives away and sells a number of applications too! See <http://education.ti.com> for more information.

To check the calculator's memory, press [2nd] [MEM] and then select **2: Mem Mgmt/Del...**. A screen appears similar to the one below at the left. The two numbers at the top right of this screen are the bytes free in each area of memory.

```
RAM FREE    5692
ARC FREE    81212
1: All...
2: Real...
3: Complex...
4: List...
5: Matrix...
6: Y-Vars...
7: Prgm...
8: Pic...
9: GDB...
0: String...
A: APPS...
B: APP Vars...
```

Since programs are usually the most RAM memory consuming, archiving them can free up RAM memory. To archive programs, you cursor down to **7: Prgm...** as shown on the screen to the left and press [ENTER]. Then, a screen with your program names will appear, such as the one given to the right below.

In this display, the cursor, **▶**, is on ABTITR and if you press [ENTER] it will be archived. As you archive, the RAM FREE

```
RAM FREE    5692
ARC FREE    81212
▶ ABTITR      873
*BONDS       71
DECAY        363
DISTA        472
*HCARB       70
*LOADTR      80
```

will increase. To unarchive a program, simply move the cursor to that program and press [ENTER]. Archived programs are indicated by the asterisk, such as *BONDS.

You can store data as named lists also. Use [2nd] [QUIT] to exit. If you go to [PRGM] and select an archived program (* precedes name in the list of programs), it will not function and ERR: ARCHIVED appears. You would then need to unarchive the program to run it. For application (under [APPS], stored in ARC memory), they are always available.

Transferring programs via the TI-graph link software and cable to a computer is another way to free up memory and have a backup!

To delete unwanted programs, move the cursor to that program and press [DEL]. You will be prompted "Are you sure?" with the NO selected and you will need to select YES.

Updating your operating system

Press [2nd] [MEM] and select **1: About** to view which version of the operating system is on your calculator. A screen similar to the one below appears. The second line is the version (in this case 1.16, which is the latest available).

Download free operating system updates and instructions from <http://education.ti.com>. If you have early versions of the operating system (older TI-83 Plus calculators), updating is a good move. Your calculator will run faster!

```
TI-83 Plus
1.16
PRGM#: 04-1-01-10
ID: 04084-EB0F4-3019

Help: education.ti.com
```

Collecting Experimental Data Using Vernier's ChemBio with the CBL

Your TI-83 Plus should be hooked up to a CBL via the link cable with the appropriate probe plugged into Channel 1 on the CBL. Turn the CBL on.

Press the [APPS] key and select ChemBio to start the program as an application (stored in archived memory). On the TI-83 calculators press [PRGM] to select ChemBio. Instructions for Vernier's Physics programs are the same and include different probes commonly used in physics experiments. It is assumed the programs are loaded on the calculator.

```
APPLICATIONS
1: Finance...
2: CBL/CBR
3: ChemBio
4: Prob Sim
```

After you select ChemBio, this screen on the left below should appear (where the date is the version). As Vernier adds new probes you will want to update this application from their website (<http://www.vernier.com>).

```
VERNIER SOFTWARE
BIOLOGY AND
CHEMISTRY
WITH THE CBL
```

Press [ENTER] and the main menu appears as shown to the right.

```
8/11/00 [ENTER]
```

Your first operation is to set up probes, so select **1:SET UP PROBES**. If the screen to the right appears, check the link cable connection to your calculator and the CBL. This is a very common problem. Press [ENTER] after checking the connections.

```
*****MAIN MENU*****
1:SET UP PROBES
2:COLLECT DATA
3:VIEW GRAPH
4:VIEW DATA
5:FIT CURVE
6:RETRIEVE DATA
7:QUIT
```

```
***LINK ERROR***
PRESS HALT ON
THE CBL. MAKE
SURE THE LINK
CONNECTORS ARE
FIRMLY PUSHED
IN.
[ENTER]
```

The first step of SET UP PROBES is to select the number of probes (see screen to the right) and which probes (for the complete list of probes for ChemBio on four screens, see next page).

```
ENTER NUMBER OF
PROBES: 1
```

```

SELECT PROBE :
1: TEMPERATURE
2: PH
3: PRESSURE
4: COLORIMETER
5: VOLTAGE
6: CONDUCTIVITY
7: MORE PROBES

```

```

SELECT PROBE :
1: O. OXYGEN
2: BAROMETER
3: LIGHT
4: REL HUMID
5: BIO PRESSURE
6: HEART RATE
7: MORE PROBES

```

```

SELECT PROBE :
1: VERNR STD TEMP
2: LONG TEMP
3: THERMOCOUPLE
4: RESPIR. BELT
5: EKG
6: CO2 SENSOR
7: MORE PROBES

```

```

SELECT PROBE :
1: ION SELECTIVE
2: RETURN

```

For each probe, you will need to inform the program where it is connected on the CBL. You can have as many as three probes connected at once.

After the probe (probes) is (are) set up, you are ready to collect data. Some probes have further menus to select their units of measurement and other set-up requirements, such as calibration.

```

USE LOWEST
AVAILABLE
CHANNELS.

```

```

ENTER CHANNEL
NUMBER: 1

```

Select **2:COLLECT DATA** from the main menu. The data collection menu appears as shown below. Choice of method will depend on the experiment being performed.

```

DATA COLLECTION :
1: MONITOR INPUT
2: TIME GRAPH
3: TRIGGER/PROMPT
4: TRIGGER
5: SINGLE POINT
6: RETURN

```

Here is an explanation of the data collection options. Monitor input is a good way to check that the probe is functioning and ready for data collection. Time graph allows you to set up a period of data collection as a function of time. This is useful for warming water and watching the temperature profile as the water reaches the boiling point. Trigger/prompt

involves the trigger button on the CBL. When you press the trigger button on the CBL, it records the probe reading as the y-variable and then prompts you for the x-variable as input on the calculator. It will then ask you if you want to collect more data. If you have two probes collecting both the x and y-variables, trigger gets both readings recorded in appropriate lists when you press the trigger button on the CBL. It asks if more data is to be collected.

The Vernier software actually takes five readings on the CBL for each point and sends the average value to be stored in the calculator lists. Hence, do not record the reading on the CBL as this is only a single value. This process helps to minimize the noise in the CBL readings that you see in the monitor input.

After you finish collecting the data needed, select **3:VIEW GRAPH** to view a labeled plot of the data. If your data is acceptable, then select **7:QUIT** to exit the program. The data is stored in the appropriate lists of the calculator. Analysis is easier if you are not in the program. Please note: *If you restart ChemBio, the first thing it does is clear all the lists.* If you want to save the data from a previous run, store it in named lists on your calculator or transfer it to another calculator.

At this point you can also transfer the data to Vernier's Graphical Analysis program for further analysis on a computer with printing of the resulting graphs.

Appendix A - Types of Regressions on the TI-83/83 Plus¹

[STAT] CALC	Type of Regression	General Equation	Method of Fitting	Statistic
LinReg	linear	$y = ax + b$	least-squares	r, r^2
QuadReg	quadratic	$y = ax^2 + bx + c$	polynomial regression (4*)	R^2
CubicReg	cubic	$y = ax^3 + bx^2 + cx + d$	polynomial regression (5*)	R^2
QuartReg	quartic	$y = ax^4 + bx^3 + cx^2 + dx + e$	polynomial regression (6*)	R^2
LnReg	logarithmic	$y = a + b \ln x$	least-squares on transformed $\ln x$ and y	r, r^2
ExpReg	exponential	$y = ab^x$	least-squares on transformed x and $\ln y$	r, r^2
PwrReg	power	$y = ax^b$	least-squares on transformed $\ln x$ and $\ln y$	r, r^2
Logistic	logistic	$y = c/(1 + ae^{-bx})$	iterative least-squares	--
SinReg	sinusoidal	$y = a \sin (bx + c) + d$	iterative least-squares	--

* minimum number of points needed for polynomial regression

¹ From Texas Instruments, *TI-83 Graphing Calculator Guidebook*, 1996 and *TI-83 Plus Graphing Calculator Guidebook*, 1999.

QUICK GUIDE TO THE TI-82/83 GRAPHING CALCULATOR

KEYSTROKE	PURPOSE
[Y=]	to type in functions and to paste regression equations for graphing into the function editor
[STAT] EDIT	to get to the list editor or lists (spreadsheet)
[STAT] CALC	to perform regression calculations
[TRACE]	to move point-to-point on data; to interpolate and extrapolate on functions or regression equations
[STAT PLOT]	to set-up the graphing of data in lists; select lists and type of plot
[ZOOM] [9]	to automatically scale axes to data and then plot them
[WINDOW]	to manually set axes to minimum and maximum and scale (values of tick marks on axes)
[GRAPH]	to scale graph to [WINDOW] settings; to display graph
[PRGM]	to run a stored program
[LINK]	to transfer or receive data or programs calculator-to-calculator or calculator-to-computer with TI-Graph Link
[X,T,θ,n]	to get the variable X into an equation
[ENTER]	to get action from a previous keystroke