Essentials for the TI-83+

Special Keys.

2nd	Press and release, then press the appropriate key to access the 2nd (yellow) operation.
ALPHA	Press and release to access characters and letters indicated above the keys. The sequence 2nd ALPHA sets the ALPHA-lock.
STO▶	Stores answers, matrices, quantities, etc. into variable names
2nd [ENTRY]	The calculator will display your last entry. To recall the last entry you press 2nd [ENTRY], to recall the second to last entry press: 2nd [ENTRY] 2nd [ENTRY], and so on.
2nd [ANS]	The calculator will display the last answer.
MATH ENTER	Displays the last answer in fractions, if possible.

Entering Matrices. There are several ways to enter matrices in the TI-83+. One method consists of entering the matrix directly as an expression, while another method is through the use of the matrix editor found in the 2nd MATRX [EDIT] menu. Below are examples that illustrate the creation of matrices and vectors using these methods. On the TI-83+, a (column) vector is simply an n×1 column matrix. For additional information, consult the TI-83+ Guidebook.

Direct Entry. Begin a matrix with a square bracket, and each row of the matrix with a matching pair of square brackets; separate the entries in the rows with commas. Figure 1 below shows how you can enter the matrix $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$ directly and assign to it the name [A] from the 2nd MATRX [EDIT] menu. The symbol → appears after pressing the STO▶ key.
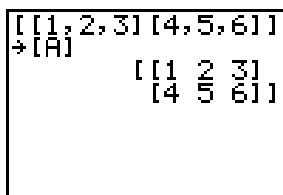
Figure 1: [A] entered directly.

The Matrix Editor. Press 2nd MATRX [EDIT]. The editor allows you to create a matrix by specifying a variable name, a size—row size and column size—and the entries of the matrix. After choosing [EDIT], a screen such as Figure 2 (on the following page) will appear. Select a name by pressing ENTER on a particular matrix, input rows, columns, and entries, your screen should be similar to Figure 3 (on the following page). To view the matrix from the home screen, press 2nd [QUIT] to return home, and then choose 2nd MATRX and select the matrix. You can create vectors in a similar fashion. Simply enter vectors in as n×1 column matrices.
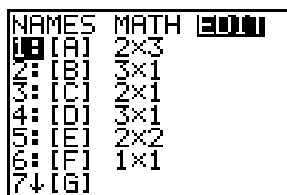
Figure 2: Matrix, edit menu

Figure 3: Matrix editor

Commands and Operations. The TI-83+ calculator contains powerful built-in commands for linear algebra. Before you use them, however, you need to understand how and why they work. These commands and operations will be introduced in the projects as they are needed. The TI-83+ Guidebook describes each of these commands.

You will use the ⊞, ⊟, ⊠, and ⊡ keys to perform the algebraic operations of addition, subtraction, multiplication and division, *on numbers*. Some of these operations can also be done on matrices, but remember that the size of matrices play a major role in the definition of these operations. To add (or subtract) two matrices of the same size, A and B, you enter A + B (or A – B) followed by the ENTER key. To multiply two matrices, C and D, that are compatible for multiplication (the number of columns in C should equal the number of rows in D), you enter C×D then press the ENTER key (in general it is not true that $C \times D = D \times C$, so you need to be careful). *Division is not defined for matrices*.

Scalar multiplication, that is, the product of a number times a matrix or vector is performed by entering a number and then multiplying it by a matrix in the usual way.

Data Files. The data sets for problems from the text and for the projects, are available through the Web site www.laylinalgebra.com that accompanies Lay's *Linear Algebra and its Applications, Third Edition*. Instructions for downloading and transferring the data are in a ReadMe file on the Web, specifically for the TI Calculators.

Programs. At first, you will work with more elementary programs that will not only save you computational time but also help you to learn fundamental concepts. These "teaching programs" are located on the Web site. By the end of the course, you will be able to use your TI-83+ to solve interesting problems that are completely impractical for hand calculations.

Transferring Data and Programs. You will need to transfer the data and programs to your TI-83+. You can do this transfer in the computer lab or from another TI-83+ which has the data and programs already. To transfer data and programs from one TI-83+ to another, you use a calculator-to-calculator cable. The directions for transferring data and programs this way is in the TI-83+ Guidebook (Both the cable and Guidebook came with your calculator.) You can also transfer data and programs from your computer to your TI-83+. (Visit www.education.ti.com for details.)

Running a Program: The PRGM button displays a menu containing the names of the programs that are stored in the TI-83+'s memory (in alphabetical order); you can scroll down using the down arrow to see all of the programs. The programs that were written for this text are all embedded in the program called [ALINEAR]. Press ENTER on the [ALINEAR] program, and ENTER again on the desired program to begin execution of the program. All of the programs will prompt the user for input, such as a matrix, or a real number. At the prompt, a data item can be entered directly, or by name if the item has been stored into memory; press the ENTER key after each input item to resume execution of the program. (Figure 4 on the following page.)

```
prgmGAUSS
MATRIX:
```

Figure 4: Program prompts.

The output of a program is automatically displayed on the output screen, where scrolling is not possible, and it is also stored in the system variable Ans. This variable is useful if the output from a program is too big to fit in the output screen, or if you want to store the output in a variable name of your choice. Use the sequence [2nd] [ANS] to recall Ans to the home screen *immediately* after the program stops execution, then use the cursor keys to scroll and view the entire object, or use the [STO▸] key to save the output as a named variable of your choice.

Plotting Statistical Data. You can plot statistical data on your TI-83+ and use the calculator to analyze the data graphically and numerically. The following directions describe methods for inputting lists of data into the calculator, and how to plot those data values. Your Guidebook will describe how to utilize the numeric capabilities of the TI-83+.

Entering Data. The data for a statistical plot is entered in a list. There are two main methods for entering data into a list. For additional information consult the TI-83+ Guidebook.

Entering Lists Directly. Each list must be contained inside a pair of opening and closing "curly braces". A comma separates the numbers in a list. Press [2nd] [{] and [2nd] [}] for the curly braces. To store a list under a particular name, choose a name under the [2nd] [LIST] [NAMES].

Entering Lists in the STAT menu. Select [STAT] [EDIT] [ENTER] to enter a list. If a list is not empty, put your cursor on a list name such as L1, and press [CLEAR]. Pressing the down arrow will delete entries in the list.

Selecting the Plot. To plot statistical data you need to enter the data into two lists. Once the data has been input, press [2nd] [STAT PLOT] and press [ENTER] on the plot you want to access (Figure 5, on the following page). Press [ENTER] to turn the plot on. Scroll down (with the cursor keys) to select type (scatterplot, histogram, box plot, etc.) by pressing [ENTER], set Xlist and Ylist and choose a mark. Lists 1 through 6 can be accessed by pressing [2nd] and the numbers 1 through 6 respectively. Press [2nd] [QUIT] to leave the stat plot menu.

```
Plot1  Plot2  Plot3
On  Off
Type: ▦  ⋰  ▥
      ⊡⋯ ⊞⊞ ⊏
Xlist:L₁
Ylist:L₂
Mark: ▫  +  ·
```
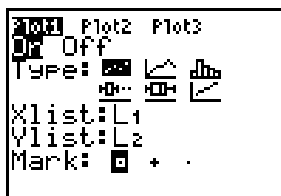
Figure 5: Plot 1.

Plotting Data. Before viewing the data, go to the [Y=] menu and turn off all functions by pressing [ENTER] on any equals sign that is currently highlighted. Then select [ZOOM] [9] to plot all the data in an appropriate window.

Essentials for the TI-86

Special Keys.

2nd	Press and release, then press the appropriate key to access the 2nd (yellow) operation.
ALPHA	Press and release to access characters and letters (blue) indicated to the right of the keys. The sequence 2nd ALPHA is needed for lower-case characters.
STO▶	Sets the keyboard automatically to ALPHA-lock. Is used for naming objects to be stored in memory.
2nd [ENTRY]	The calculator will display your last entry. To recall the last entry you press 2nd [ENTRY], to recall the second to last entry press: 2nd [ENTRY] 2nd [ENTRY], and so on.
2nd [ANS]	The calculator will display the last answer.
F1 F2 F3 F4 F5	Menu keys, used to access the items in a displayed menu.
MORE	This key is used to reveal other items in the same menu. I have chosen not to include all the applications of this key throughout this document. You must be aware that the menu item referenced may not show in the first page of the menu, if this is the case press the MORE key as many times as necessary until the item shows in the menu.
[M1] [M2] [M3] [M4] [M5]	Second menu keys, used to access the items in a menu displayed in the seventh line—above the menu items.
2nd [MATH] [MISC] [Frac]	Displays the last answer in fractions, if possible.

Entering Matrices. There are several ways to enter matrices and vectors into the TI-86. One method consists of entering the matrix directly as an expression, another method is through the use of the matrix (vector, respectively) editor found in the [MATRX] ([VECTR], respectively) menu. Below are examples that illustrate the creation of matrices and vectors using these methods. The entries in a matrix or vector can be either real or complex (pairs of real numbers). For additional information, consult the TI-86 Guidebook.

Direct Entry. Begin a matrix with a square bracket, and each row of the matrix with a matching pair of square brackets; separate the entries in the rows with commas. Figure 1 (on the following page) shows how you can enter the matrix $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$ directly and assign to it the name MAT1 (case sensitive)—the symbol ➔ appears after pressing the STO▶ key—press ENTER to display the matrix MAT1 on the screen. For complex numbers, follow the same procedure, only enter the entries as pairs of real numbers (i.e. (real, imaginary)).
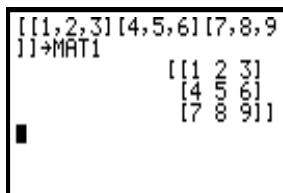
Figure 1: MAT1 entered directly.

The Matrix Editor. Press `2nd` (yellow key), `[MATRX]` (`7` key), to see `[EDIT]` in the menu. The editor allows you to create a matrix by specifying a variable name, a size—row size and column size—and the entries of the matrix. The editor, Figure 2, is accessed by pressing the `F2` menu key. Select from the matrix names shown or enter a new name for the matrix. For example to enter the matrix $Q = \begin{bmatrix} -1 & 0 & 4 \\ 5 & 1 & 3 \end{bmatrix}$, press Q and `ENTER` ; your screen should be similar to Figure 3.
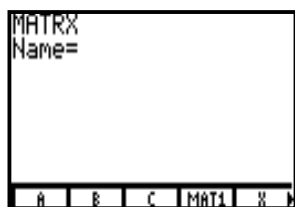

Figure 2: The matrix editor
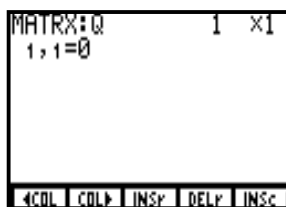

Figure 3: Matrix editor, ready to receive the matrix Q.

The cursor is blinking at the top right, ready for you to enter the number of rows, press `2` and `ENTER` ; for the number of columns, press `3` and `ENTER` . Type in the entries as prompted by rows. With the TI-86 use the cursor arrows to move up or down in a column, or left and right in a row. Press the `EXIT` key to exit the editor. To view the matrix Q on the screen, press `ALPHA` (blue key), `[Q]` (`4` key) and `ENTER` .

You can create vectors in a similar fashion. If using direct entry, a vector is entered as a row vector: [1, 2, 3, 4]. If using the vector editor, the procedure is similar to the matrix editor described above.

WARNING: Vectors and matrices are different objects on the TI-86. Operations in the `[MATRX]` menu are only for matrices, and operations in the `[VECTR]` menu are only for vectors. Vectors can also be entered as n×1 matrices; it will be impossible to use the operations in the `[VECTR]` menu on these. In the following notes the term vector is never used for an n×1 matrix. The programs `[MtoV]` and `[VtoM]` convert an n×1 matrix into a vector, or a vector into a matrix respectively.

Commands and Operations. The TI-86 calculator contains powerful built-in commands for linear algebra. Before you use them, however, you need to understand how and why they work. These commands and operations will be introduced in the projects as they are needed. The TI-86 Guidebook describes of each of these commands.

Using the `CUSTOM` menu feature will save you many repeated keystrokes. You can load and delete operations and commands on the menu as required throughout the term. See your Guidebook for details.

You will use the `+`, `−`, `×`, and `÷` keys to perform the algebraic operations of addition, subtraction, multiplication and division, *on numbers*. Some of these operations can also be done on vectors and matrices, but remember that the size of matrices and vectors play a major role in the definition of these operations. To add (or subtract) two matrices or vectors of the same size, A and B, you enter A + B (or A – B) followed by the `ENTER` key. To multiply two matrices, C and D, that are compatible for multiplication

(the number of columns in C should equal the number of rows in D), you enter C×D then press the $\boxed{\text{ENTER}}$ key (in general it is not true that $C \times D = D \times C$, so you need to be careful). This multiplication is not defined for vectors. *Division is not defined for vectors or matrices*.

Scalar multiplication, that is, the product of a number times a matrix or vector is performed by entering a number and then multiplying it by a matrix in the usual way.

Data Files. The data sets for problems from the text and for the projects, are available through the Web site www.laylinalgebra.com that accompanies Lay's *Linear Algebra and its Applications, Third Edition*. Instructions for downloading and transferring the data are in a ReadMe file on the Web, specifically for the TI Calculators.

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Running a Program. The sequence $\boxed{\text{PRGM}}$ [NAMES] displays a menu containing the names of the programs that are stored in the TI-86's memory (in alphabetical order); you can use the $\boxed{\text{MORE}}$ key to move around the menu. Press the corresponding menu key ($\boxed{\text{F1}}$-$\boxed{\text{F5}}$) to copy the name of the program to the cursor location, press $\boxed{\text{ENTER}}$ to begin execution of the program. All the programs described below will prompt the user for input, such as a matrix, a vector, or a real number. At the prompt, a data item can be entered directly, or by name if the item has been stored into memory; press the $\boxed{\text{ENTER}}$ key after each input item to resume execution of the program. (See Figure 4.)
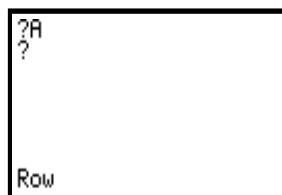
```
?A
?



Row
```

Figure 4: Program prompts.

The output of a program is automatically displayed on the output screen, where scrolling is not possible, and it is also stored in the system variable Ans. This variable is useful if the output from a program is too big to fit in the output screen, or if you want to store the output in a variable name of your choice. Use the sequence $\boxed{\text{2nd}}$ [ANS] to recall Ans, to the home screen *immediately* after the program stops execution, then use the cursor keys to scroll and view the entire object, or use the $\boxed{\text{STO►}}$ key to save the output as a named variable of your choice.

Plotting Statistical Data You can plot statistical data on your TI-86 and use the calculator to analyze the data graphically and numerically. The following directions describe methods for inputting lists of data

into the calculator, and how to plot those data values. Your Guidebook will describe how to utilize the numeric capabilities of the TI-86.

Entering Data. The data for a statistical plot is entered in a list. There are two main methods for entering data into a list. For additional information consult the TI-86 Guidebook.

Entering Lists Directly. Each list must be contained inside a pair of opening and closing "curly braces". A comma separates the numbers in a list. Press the [2nd] [-] keys to access the [LIST] menu, the [F1] and [F2] keys give you the curly braces. To store a list under a particular name, choose a name under the [LIST] [NAMES] menu.

Entering Lists in the STAT menu. Access the statistical list editor by pressing the [2nd] [STAT] [EDIT] keys. You can choose to edit any of the lists that appear in the menu, or you can name your own. (See Figure 5.) Enter the data into the list, pressing [ENTER] after each entry, then [EXIT], to exit the editor. To remove a list, move the cursor to the name of the list and press [DEL].
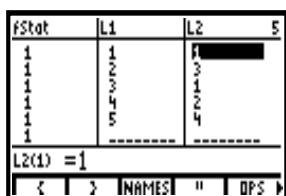

Figure 5: The STAT EDIT menu .

Selecting the Plot: To plot statistical data you need to enter the data into two lists; the first list, L1, will contain the data for the x-axis, the second list, L2 = {1, 3, 1, 2, 4}, will be the data for the y-axis. To access the [STAT] menu press the [2nd] [+] keys, then select the [PLOT] menu ([F3] key). Select one of the plots, for example PLOT1 (Figure 6), (press the [F1] key).

Figure 6: Plot 1.

Press the [ENTER] key to turn the plot on. Scroll down (with the cursor keys) to Xlist, and type in L1, scroll down to Ylist and type in L2. Scroll down to Mark and select a mark. Press the [EXIT] key twice.

Plotting Data. Before viewing the data, go to the [Y=] menu and turn off all functions by pressing [SELECT] on any function that is currently in use. Then select [GRAPH] [ZDATA] from the [ZOOM] menu to plot all the data in an appropriate window.

Essentials for the TI-89

Special Keys.

[2nd]	Press and release, then press the appropriate key to access the 2nd (yellow) operation.
[alpha]	Press and release to access characters and letters indicated above the keys. The sequence [2nd] [alpha] sets the ALPHA-lock.
[STO▶]	Stores answers, matrices, quantities, etc. into variable names
[2nd][MATH][ENTER][ENTER](value)	Displays the value in fractions, if possible.
[←]	Backspace key deletes mistakes on a given line.

Entering Matrices. There are several ways to enter matrices into the TI-89. One method consists of entering the matrix directly as an expression, another method is through the use of the matrix editor found in the Data/Matrix Editor in the [APPS] menu. Below are examples that illustrate the creation of matrices using these methods. On the TI-89, a (column) vector is simply an n×1 column matrix. For additional information, consult the TI-89 Guidebook.

Direct Entry. Begin a matrix with a square bracket, and each row of the matrix with a matching pair of square brackets; separate the entries in the rows with commas. Figure 1 below shows how you can enter the matrix $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$ directly and assign to it the name aa—the symbol ➔ appears after pressing the [STO▶] key, press [ENTER] to display the matrix aa on the screen. Matrices can be denoted by nearly any combination of letters and numbers, but double lower-case letters will be used to denote matrices in this text. Entries can either be real or complex. To input complex entries, simply input them in with the form a+bi.
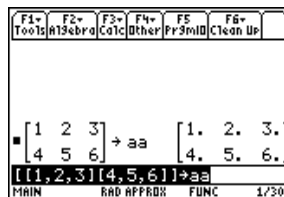

Figure 1: aa entered directly.

The Matrix Editor. Press [APPS], scroll down to the Data/Matrix Editor and press [ENTER]. See Figure 2. You will be asked whether you want to work on the current data item, open a data item, or make a new data item. Choose [New] to construct a new matrix. See Figure 3.

Figure 2: Choose data/matrix editor

Figure 3: Choose new

Use the right arrow to select either Data, Matrix, or List. Choose [Matrix] by pressing ⟨ENTER⟩. Scroll down to Variable, type in the name of the matrix, input number of rows and columns in the appropriate places, and press ⟨ENTER⟩ twice. See Figure 4. If the variable name is not being used for anything else, the TI-89 will allow you to start inputting entries directly into the matrix. See Figure 5.

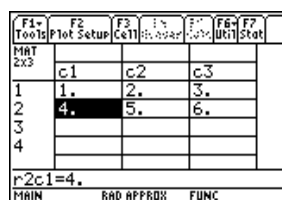Figure 4: Choose name, rows and columns   Figure 5: Input the matrix

If you want to change a matrix, simply select [Open] instead of [New], and open an existing matrix.

Commands and Operations. The TI-89 calculator contains powerful built-in commands for linear algebra. Before you use them, however, you need to understand how and why they work. These commands and operations will be introduced in the projects as they are needed. The TI-89 Guidebook describes each of these commands.

You will use the ⊞, ⊟, ⊠, and ⊡ keys to perform the algebraic operations of addition, subtraction, multiplication and division, *on numbers*. Some of these operations can also be done on matrices, but remember that the size of matrices play a major role in the definition of these operations. To add (or subtract) two matrices of the same size, A and B, you enter A + B (or A – B) followed by the ⟨ENTER⟩ key. To multiply two matrices, C and D, that are compatible for multiplication (the number of columns in C should equal the number of rows in D), you enter C×D then press the ⟨ENTER⟩ key (in general it is not true that $C \times D = D \times C$, so you need to be careful). *Division is not defined for matrices*.

Scalar multiplication, that is, the product of a number times a matrix or vector is performed by entering a number and then multiplying it by a matrix in the usual way.

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Running a Program: The ⟨2nd⟩ [VAR-LINK] button displays a menu containing the names of the programs that are stored in the TI-89's memory (in alphabetical order); you can scroll down using the down arrow to see all of the programs. The programs that were written for this text are all embedded in the program called

[alinear]. Press ENTER on the [alinear] program, the right parentheses and ENTER again to begin execution of the program. Then select the desired program from the menu. All of the programs will prompt the user for input, such as a matrix, or a real number. At the prompt, a data item can be entered directly, or by name if the item has been stored into memory; press the ENTER key after each input item to resume execution of the program. (Figure 6)
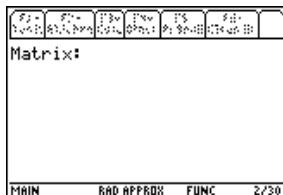

Figure 6: Program prompts.

The output of a program is automatically displayed on the program output screen, where scrolling isn't always possible. To perform other functions, press the HOME key to exit to the home page.

Plotting Statistical Data. You can plot statistical data on your TI-89 and use the calculator to analyze the data graphically and numerically. The following directions describe methods for inputting lists of data into the calculator, and how to plot those data values. Your Guidebook will describe how to utilize the numeric capabilities of the TI-89.

Entering Data. The data for a statistical plot is entered in a list. There are two main methods for entering data into a list. For additional information consult either the TI-89 Guidebook.

Entering Lists Directly. Each list must be contained inside a pair of opening and closing "curly braces". A comma separates the numbers in a list. Press 2nd [{] and 2nd [}] for the curly braces. You can choose practically any name for your list. If a variable name is already in use, you can delete the variable by pressing 2nd [VAR-LINK], scrolling down to the variable and pressing F1 to manage the variable.

Entering Lists in the List menu. Select APPS 6 3 to define a new list. When asked for type, choose [List], and select the variable name. Input the values in the list. Do the same procedure to define another list.

Selecting the Plot. To plot statistical data you need to enter the data into two lists. Once the data has been input, and you are still in the List editor, press F2 for Plot Setup and F1 to define the plot. Choose the plot type, choose the mark, and set lists in x and y. See Figure 7.
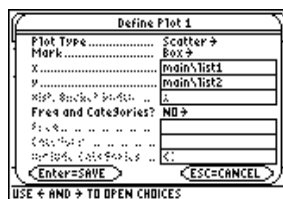

Figure 7: Plot 1.

Plotting Data. Before viewing the data, go to the Y= menu and turn off all functions by pressing F4 on any function that is currently marked. Then select F2 9 to plot all the data in an appropriate window