Part I: Texas Instruments TI-83, TI-83 Plus Graphics Calculator

I.1 Systems of Linear Equations

I.1.1 Basics: Press the ON key to begin using your TI-83 calculator. If you need to adjust the display contrast, first press 2nd, then press and hold ▲ (the *up* arrow key) to increase the contrast or ▼ (the *down* arrow key) to decrease the contrast. As you press and hold ▲ or ▼, an integer between 0 (lightest) and 9 (darkest) appears in the upper right corner of the display. When you have finished with the calculator, turn it off to conserve battery power by pressing 2nd and then OFF.

Check the TI-83's settings by pressing MODE. If necessary, use the arrow key to move the blinking cursor to a setting you want to change. Press ENTER to select a new setting. To start, select the options along the left side of the MODE menu as illustrated in Figure I.1: normal display, floating display decimals, radian measure, function graphs, connected lines, sequential plotting, real number system, and full screen display. Details on alternative options will be given later in this guide. For now, leave the MODE menu by pressing CLEAR.

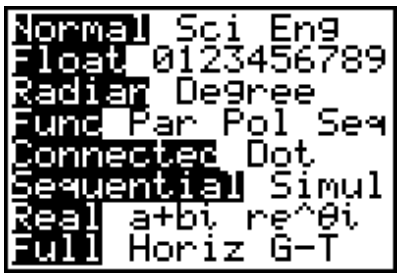

Figure I.1: MODE

I.1.2 Key Functions: Most keys on the TI-83 offer access to more than one function, just as the keys on a computer keyboard can produce more than one letter ("g" and "G") or even quite different characters ("5" and "%"). The primary function of a key is indicated on the key itself, and you access that function by a simple press on the key.

To access the *second* function indicated to the *left* above a key, first press 2nd (the cursor changes to a blinking ↑) and *then* press the key. For example, to calculate $\sqrt{25}$, press 2nd $\sqrt{}$ 25) ENTER.

When you want to use a letter or other character printed to the right above a key, first press ALPHA (the cursor changes to a blinking A) and then the key. For example to use the letter *K* in a formula, press ALPHA K. If you need several letters in a row, press 2nd A-LOCK, which is like Caps Lock on a computer keyboard, and then press all the letters you want. Remember to press ALPHA when you are finished and want to restore the keys to their primary functions.

Technology Tip: When your calculator is set to plot functions given in standard form (the choice FUNC in the fourth line of the MODE menu in Figure I.1), the X,T,θ,*n* key lets you enter the variable X easily without having to use the ALPHA key.

I.1.3 Algebraic Expressions and Memory: Your calculator can evaluate expressions such as $\frac{N(N+1)}{2}$ *after* you have entered a value for *N*. Suppose you want $N = 200$. Press 200 STO ▶ ALPHA N ENTER to store the value 200 in memory location *N*. Whenever you use *N* in an expression, the calculator will substitute the value 200 until you make a change by storing *another* number in *N*. Next enter the expression $\frac{N(N+1)}{2}$ by typing ALPHA N (ALPHA N + 1) ÷ 2 ENTER. For $N = 200$, you will find that $\frac{N(N+1)}{2} = 20100$.

Technology Tip: The contents of any memory location may be revealed by typing just its letter name and then ENTER. Simply press ALPHA N ENTER to see the current value of the variable *N*. And the TI-83 retains memorized values even when it is turned off, so long as its batteries are good.

I.1.4 The MATH Menu: Operators and functions associated with a scientific calculator are available either immediately from the keys of the TI-83 or by 2nd keys. You have direct key access to common arithmetic operations (x^2, 2nd $\sqrt{}$, x^{-1}, ^), trigonometric functions (SIN, COS, TAN) and their inverses (2nd SIN^{-1}, 2nd COS^{-1}, 2nd TAN^{-1}), exponential and logarithmic functions (LOG, 2nd 10^x, LN, 2nd e^x), and a famous constant (2nd π).

Note that the TI-83 distinguishes between *subtraction* and the *negative sign*. If you wish to enter a negative number, it is necessary to use the (-) key. For example, you would evaluate $-5 - (4 \cdot -3)$ by pressing (-) 5 – (4 x (-) 3) ENTER to get 7.

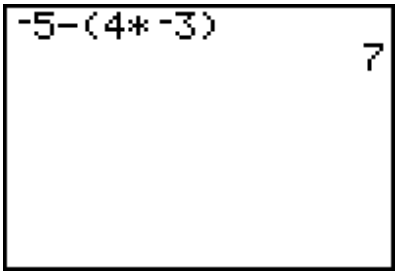

Figure I.2: *Subtraction* and the *Negative Sign*

A significant difference between the TI-83 and many scientific calculators is that the TI-83 requires the argument of a function *after* the function, as you would see a formula written in your textbook. For example, on the TI-83 you calculate $\sqrt{16}$ by pressing the keys 2nd $\sqrt{}$ 16) in that order.

Here are keystrokes for basic mathematical operations. Try them for practice on your TI-83.

Expressions	*Keystrokes*	*Display*
$\sqrt{3^2 + 4^2}$	2nd $\sqrt{}$ $3x^2 + 4x^2$) ENTER	5
$2\frac{1}{3}$	2 + $3x^{-1}$ ENTER or 2 + (1 ÷ 3) ENTER	2.333333333
log 200	LOG 200) ENTER	2.301029996
$2.34 \cdot 10^5$	2.34 x 2nd 10^x 5) ENTER	234000

Additional mathematical operations and functions are available from the MATH menu (Figure I.3). Press MATH to see the various options. You will learn in your mathematics textbook how to apply many of them. As an example calculate $\sqrt[3]{7}$ by pressing MATH and then *either* 4 *or* ▼ ▼ ▼ ENTER; finally press 7) ENTER to see 1.912931183. To leave the MATH menu and take no other action, press 2nd QUIT or just CLEAR.

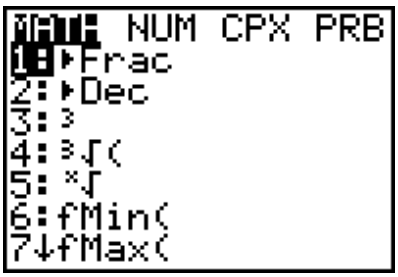

Figure I.3: MATH Menu

The *factorial* of a non-negative integer is the *product* of *all* the integers from 1 up to the given integer. The symbol for factorial is the exclamation point. So 4! (pronounced *four factorial*) is $1 \cdot 2 \cdot 3 \cdot 4 = 24$. You will learn more about applications of factorials in your textbook, but for now use the TI-83 to calculate 4! The factorial command is located in the MATH menu's PRB sub-menu. To compute 4!, press the keystrokes: 4 MATH ◄ 4 *[!]* ENTER *or* 4 MATH ◄ ▼ ▼ ▼ ENTER ENTER.

Technology Tip: Note that you can select a sub-menu from the MATH menu by pressing either ◄ or ►. It is quicker to press ◄ once than to press ► *three times* to get to the PRB sub-menu.

I.1.5 Graphing Linear Functions: Once you have entered a function in the Y = screen of the TI-83, just press GRAPH to see its graph.

For example, here is how to graph $y = -x + 3$. First press Y = and delete anything that may be there by moving with the arrow keys to Y_1 or to any of the other lines and pressing CLEAR wherever necessary. Then with the cursor on the top line Y_1 , press (-) X,T,θ,*n* + 3 to enter the function (as in Figure I.4). Now press GRAPH and the TI-83 changes to a window with the graph of $y = -x + 3$ (see Figure I.5).

Technology Tip: While the TI-83 is calculating coordinates for a plot, it displays a busy indicator at the top right of the graph window.

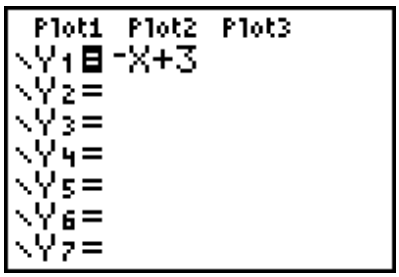

Figure I.4: Y= list

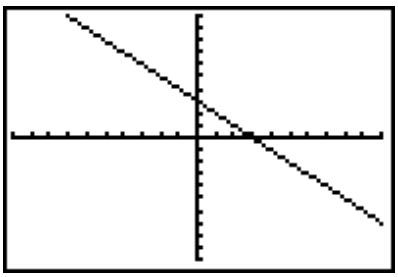

Figure I.5: Graph of $y = -x + 3$

The viewing rectangle in Figure I.5 shows the part of the graph that extends horizontally from −10 to 10 and vertically from –10 to 10. Press WINDOW to see information about your viewing rectangle. Figure I.6 shows the WINDOW screen that corresponds to the viewing rectangle in Figure I.5. This is the s*tandard* viewing rectangle for the TI-83.

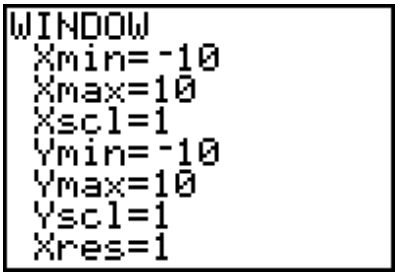

Figure I.6: Standard WINDOW

The variables Xmin and Xmax are the minimum and maximum *x*-values of the viewing rectangle: Ymin and Ymax are its minimum and maximum *y*-values.

Xscl and Yscl set the spacing between tick marks on the axes.

Xres sets the resolutions.

Use the arrow keys ▲ and ▼ to move up and down from one line to another in this list; pressing the ENTER key will move down the list. Press CLEAR to delete the current value and then enter a new value. Remember that a minimum *must* be less than the corresponding maximum or the TI-83 will issue an error message. Also, remember to use the (-) key, not – (which is subtraction), when you want to enter a negative value.

Technology Tip: To set the range quickly to standard values (see Figure I.6), press ZOOM 6.

Technology Tip: If you would like to see a function in the menu and its graph in a graph window, both at the same time, open the MODE menu, move the cursor down to the last line, and select Horiz. Your TI-83 screen is now divided horizontally (see Figure I.7), with an upper graph window and a lower window that can display the home screen or an editing screen. Press Y = to view the function list in the lower window. For now, restore the TI-83 to Fullscreen (select Full).

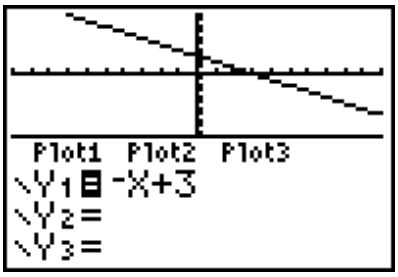

Figure I.7: Split screen: Y= below

I.1.6 Graphing Parametric Functions: The TI-83 plots up to six pairs of parametric functions as easily as it plots functions in rectangular form. Just use the MODE menu (Figure I.1), go to the fourth line from the top, and change the setting to Par. Be sure, if the independent parameter is an angle measure, that MODE is also set to whichever you need, Rad or Deg.

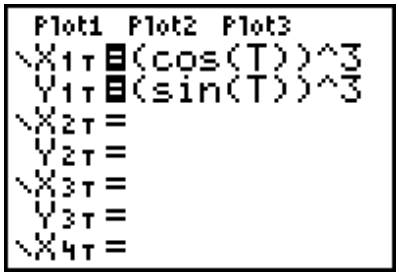

Figure I.8: Parametric Y= menu

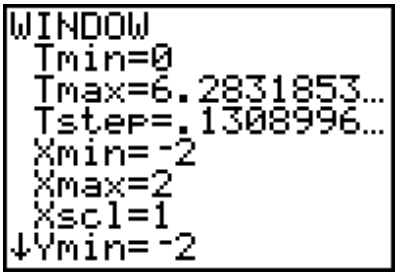

Figure I.9: Parametric WINDOW menu

For example, here are the keystrokes needed to graph the parametric equations $x = \cos^3 t$ and $y = \sin^3 t$. First check that angles are currently being measured in radians. Change to parametric mode and press Y = to examine the new parametric equation menu (Figure I.8). Enter the two parametric equations for X_{1T} and Y_{1T} by pressing (COS X,T,θ,*n*)) ^ 3 ENTER (SIN X,T,θ,*n*)) ^ 3 ENTER.

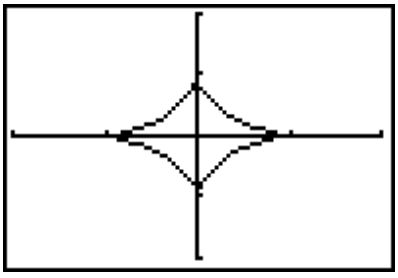

Figure I.10: Parametric graph of $x = \cos^3 t$ and $y = \sin^3 t$.

Technology Tip: Now, when you press the variable key X,T,θ,*n* you get a T because the calculator is in parametric mode.

Also, look at the new WINDOW menu (Figure I.9). In the standard window, the values of T go from 0 to 2π in steps of $\frac{\pi}{24} \approx .1309$, with the view from –10 to 10 in both directions. But here the viewing rectangle has been changed to extend from -2 to 2 in both directions. Press GRAPH to see the parametric graph (Figure I.10).

I.1.7 Solving Linear Systems: The solutions to a system of equations correspond to the points of intersection of their graph. As an example, let's graph and solve the system $\begin{cases} 3x - y = 1 \\ 2x - y = 0 \end{cases}$.

First transform each equation by solving for *y*: $\begin{cases} y = 3x - 1 \\ y = 2x \end{cases}$. Then press Y = and enter $3x - 1$ for Y_1 and $2x$ for Y_2 (Figure I.11).

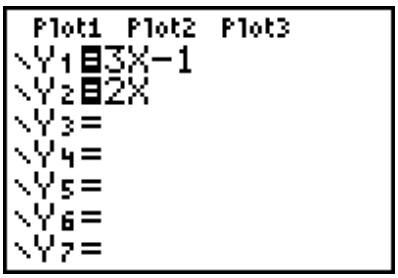

Figure I.11: $3x - 1$ for Y_1 and $2x$ for Y_2

Find the coordinates of a point of intersection of the two graphs by pressing 2nd CALC 5 *[intersect]*. Trace with the cursor keys ◄ or ► first along one graph near an intersection and press ENTER; then trace with the cursor along the other graph and press ENTER. Marks + are placed on the graphs at these points. Finally, move the cursor near the point of intersection (Figure I.12) and press ENTER again. Coordinates of the intersection will be displayed at the bottom of the window.

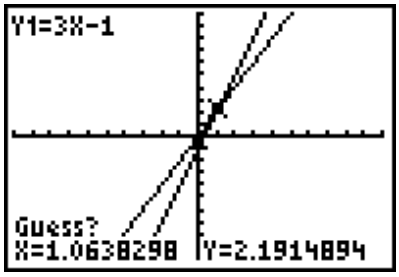

Figure I.12: Setting up to locate the intersection

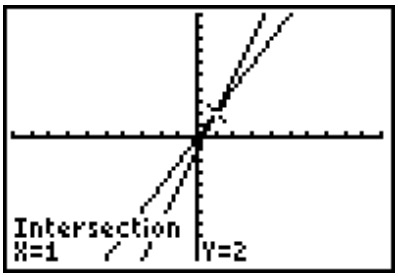

Figure I.13: Point of intersection

The TI-83 also has a numerical solver that you can use to solve a linear system. The technique is based on the fact that any solution of the system $\begin{cases} y = 3x - 1 \\ y = 2x \end{cases}$ is a *root* of the equation $3x - 1 = 2x$, which is equivalent to the equation $(3x - 1) - (2x) = 0$. So press MATH 0 *[Solver...]* or MATH ▲ ENTER and enter $(3x - 1) - (2x)$ then press ENTER ALPHA SOLVE for the *x*-coordinate of the point of intersection. Then to calculate its *y*-coordinate, save this value as *x* (press STO ► X,T,θ,*n* ENTER) and evaluate either $3x - 1$ or $2x$. If this function has already been used on your calculator, press ▲ to obtain the solver screen and enter the equation.

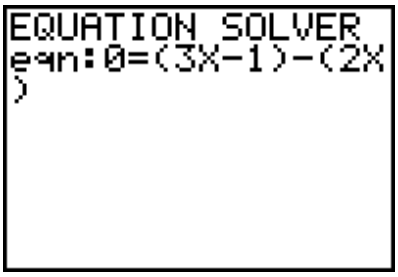

Figure I.14: Numerical solver

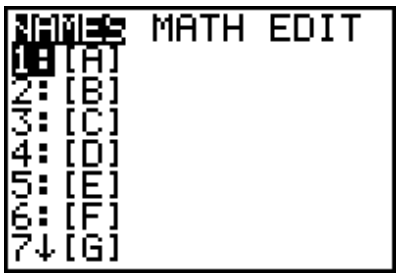

Figure I.15: MATRX menu

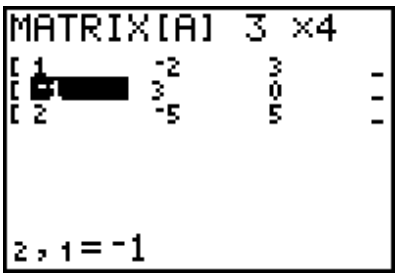

Figure I.16: Editing a matrix

Note: If you are using a TI-83 Plus, press 2nd MATRX *in the keystoke sequences given in this section to access the matrix menu.*

I.1.8 Making a Matrix: The TI-83 can display and use 10 different matrices. Here's how to create the 3×4 matrix $\begin{bmatrix} 1 & -2 & 3 & 9 \\ -1 & 3 & 0 & -4 \\ 2 & -5 & 5 & 17 \end{bmatrix}$ in your calculator.

Press MATRX to see the matrix menu (Figure I.15); then press ▶ ▶ or just ◀ to switch to the matrix EDIT menu (Figure I.16). Whenever you enter the matrix EDIT menu, the cursor starts at the top matrix. Move to another matrix by repeatedly pressing ▼. For now, press ENTER to edit matrix [A].

You may now change the dimensions of matrix [A] to 3×4 by pressing 3 ENTER 4 ENTER . Simply press ENTER or an arrow key to accept an existing dimension. The matrix shown in the window changes in size to reflect a changed dimension.

Use the arrow keys or ENTER to move the cursor to a matrix element you want to change. At the right edge of the screen in Figure I.16, there are dashes to indicate more columns than are shown. Go to them by pressing ▶ as many times as necessary. The ordered pair at the bottom left of the screen shows the cursor's current location within the matrix. The element in the second row and first column in Figure I.16 is currently highlighted, so the ordered pair at the bottom of the window is 2, 1. Continue to enter all the elements of matrix [A].

Leave the matrix [A] editing screen by pressing 2nd QUIT and return to the home screen.

Technology Tip: The TI-83 enables you to create an identity matrix quickly. If you want to make the 3×3 identity matrix, for example, press MATRX ▶ 5 3) ENTER. (see Figure I.17) If you want to save the 4×4 identity matrix as matrix [A], press MATRX ▶ 5 4) STO ► MATRX 1 ENTER.

Technology Tip: The TI-83 also enables you to create a matrix of any size and fill it with random single-digit integers -9 to 9. To create a 2×3 matrix filled with random integers, press MATRX ▶ 6 2 , 3) ENTER (see Figure I.17).

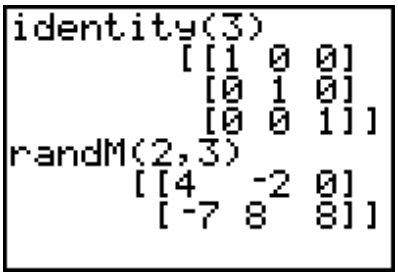

Figure I.17: Identity matrix and random matrix

I.1.9 Row Operations: Here are the keystrokes necessary to perform elementary row operations on a matrix. Your textbook provides more careful explanation of the elementary row operations and their uses.

To interchange the second and third rows of the matrix [A] that was defined above, press MATRX ▶ ALPHA C MATRX 1 , 2 , 3) ENTER (see Figure I.18). The format of this command is rowSwap(*matrix, row1, row2*).

To add row 2 and row 3 and store the results in row 3, press MATRX ▶ ALPHA D MATRX 1 , 2 , 3) Enter. The format of this command is row+(*matrix, row1, row2*).

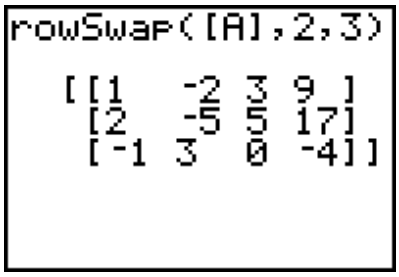

Figure I.18: Swap rows 2 and 3

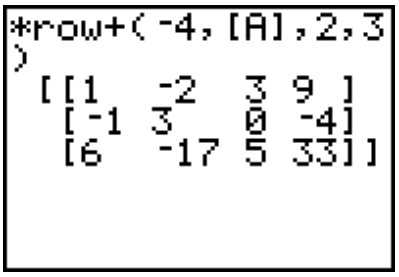

Figure I.19: Add -4 times row 2 to row 3

To multiply row 2 by -4 and *store* the results in row 2, thereby replacing row 2 with new values, press MATRX ▶ ALPHA E (-) 4 , MATRX 1 , 2) ENTER. The format of this command is *row(*scalar, matrix, row*).

To multiply row 2 by -4 and *add* the results to row 3, thereby replacing row 3 with new values, press MATRX ▶ ALPHA F (-) 4 , MATRX 1 , 2 , 3) ENTER (see Figure I.19). The format of this command is *row+(*scalar, matrix, row1, row2*).

Technology Tip: It is important to remember that your TI-83 does *not* store a matrix obtained as the result of any row operations. So when you need to perform several row operations in succession, it is a good idea to store the result of each one in a temporary place. You may wish to use matrix [E] to hold such intermediate results.

For example, use elementary row operations to solve this system of linear equations: $\begin{cases} x - 2y + 3z = 9 \\ -x + 3y = -4. \\ 2x - 5y + 5z = 17 \end{cases}$

First enter this *augmented matrix* as [A] in your TI-83: $\begin{bmatrix} 1 & -2 & 3 & 9 \\ -1 & 3 & 0 & -4 \\ 2 & -5 & 5 & 17 \end{bmatrix}$. Next store this matrix in [E] (press MATRX 1 STO ▶ MATRX 5 ENTER) so you may keep the original in case you need to recall it.

Here are the row operations and their associated keystrokes. At each step, the result is stored in [E] and replaces the previous matrix [E]. The solution is shown in Figure I.20.

Row Operation	*Keystrokes*
`row+([E] , 1, 2)`	MATRX ▷ ALPHA D MATRX 5 , 1 , 2) STO ► MATRX 5 ENTER
`*row+(-2, [E], 1, 3)`	MATRX ▷ ALPHA F (-) 2 , MATRX 5 , 1 , 3) STO ► MATRX 5 ENTER
`row+([E] , 2, 3)`	MATRX ▷ ALPHA D MATRX 5 , 2 , 3) STO ► MATRX 5 ENTER
`*row(1/2, [E], 3)`	MATRX ▷ ALPHA E 1 ÷ 2 , MATRX 5 , 3) STO ► MATRX 5 ENTER

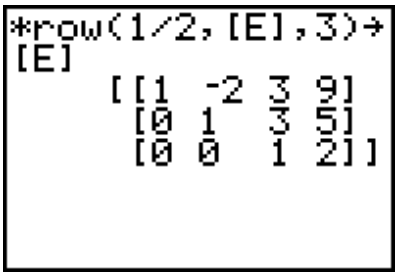

Figure I.20: Final matrix after row operations

Thus $z = 2$, so $y = -1$ and $x = 1$.

I.2 Matrices

I.2.1 Matrix Addition: From the home screen, you can perform many calculations with matrices. Add two matrices [A] and [B] by pressing MATRX 1 + MATRX 2 ENTER. Subtraction is similar.

I.2.2 Scalar Multiplication: Calculate the scalar multiplication 2 [A] by pressing 2 MATRX 1 ENTER. For example, use the matrix [A] shown here (Figure I.21).

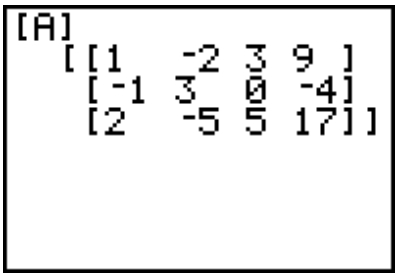

Figure I.21: Matrix [A]

To replace matrix [B] by 2 [A], press 2 MATRX 1 STO ► MATRX 2 ENTER, or if you do this immediately after calculating 2 [A], press only STO ► MATRX 2 ENTER (see Figure I.22). Press MATRX to verify that the dimensions of matrix [B] have been changed automatically to reflect this new value.

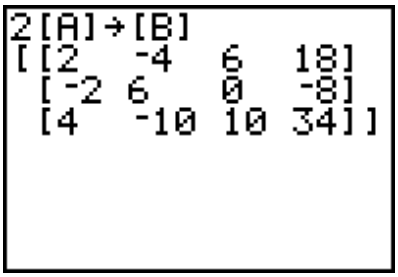

Figure I.22: Matrix [B]

I.2.3 Matrix Multiplication: Set the dimensions of matrix [C] to 2×3 and enter this matrix as [C]: $\begin{bmatrix} 2 & 0 & 3 \\ 1 & -5 & -1 \end{bmatrix}$. For matrix multiplication of [C] by [A], press MATRX 3 x MATRX 1 ENTER.

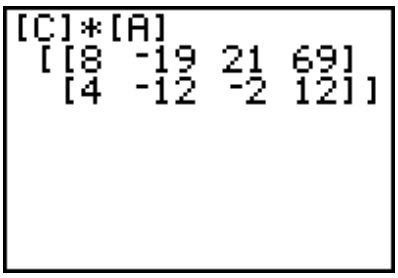

Figure I.23: Multiplication of two matrices

Technology Tip: If you tried to multiply [A] by [C], your TI-83 would signal an error because the dimensions of the two matrices do not permit multiplication this way.

I.2.4 Inverse of a Matrix: Create the square matrix $\begin{bmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{bmatrix}$ as matrix [D] in your calculator. The symbol of the inverse [D] is $[D]^{-1}$. Then to calculate this inverse, press MATRX 4 x^{-1} ENTER.

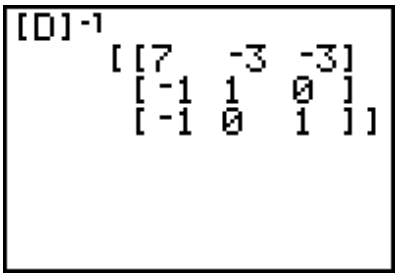

Figure I.24: Inverse

I.2.5 Transpose of a Matrix: The *transpose* of a matrix [A] is another matrix with the rows and columns interchanged. The symbol for the transpose of [A] is $[A]^T$. To calculate $[A]^T$, press MATRX 1 MATRX ▶ 2 ENTER.

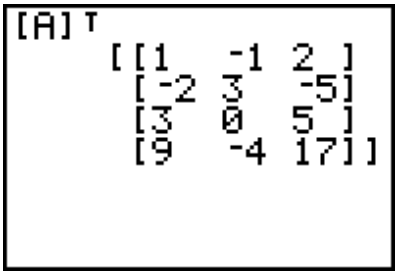

Figure I.25: Transpose

I.3 Determinants

I.3.1 Determinants of a Matrix: Enter the 3×3 matrix as [A]: $\begin{bmatrix} 1 & -2 & 3 \\ -1 & 3 & 0 \\ 2 & -5 & 5 \end{bmatrix}$. To calculate its determinate, $\left|\begin{bmatrix} 1 & -2 & 3 \\ -1 & 3 & 0 \\ 2 & -5 & 5 \end{bmatrix}\right|$, press MATRX ▶ 1 MATRX 1) ENTER. You should find that $|[A]| = 2$.

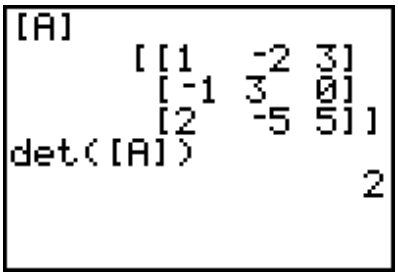

Figure I.26: Determinant

I.4 Additional Topics

Rectangular-Polar Conversion: The 2nd ANGLE menu provides functions for converting between rectangular and polar coordinate systems. These functions use the current MODE settings, so it is a good idea to check the default angle measure before any conversion. For the following examples, the TI-83 is set to radian measure.

Given the rectangular coordinates $(x, y) = (4, -3)$, convert *from* the rectangular coordinates *to* polar coordinates (r, θ) by pressing 2nd ANGLE 5 4 , (-) 3) ENTER to display the value of r. The value of θ is displayed after you press 2nd ANGLE 6 4 , (-) 3) ENTER.

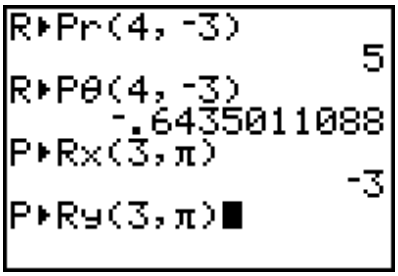

Figure I.27: Coordinate conversions

Suppose $(r, \theta) = (3, \pi)$. To convert *from* the polar coordinates *to* rectangular coordinates (x, y), press 2nd ANGLE 7 3 , 2nd π) ENTER for the x-coordinate; next press 2nd ANGLE 8 3 , 2nd π) ENTER to display the y-coordinate.

I.5 Program: Visualizing Row Operations

I.5.1 Entering the Program: The TI-83 is a programmable calculator that can store sequences of commands for later replay. Here's a useful program that demonstrates how elementary matrix row operations used in Gauss-Jordan elimination may be interpreted graphically.

Press PRGM to access the programming menu. The TI-83 has space for many programs, each called by a name you give it. Create a new program, so press PRGM ◀ 1.

For convenience, the cursor is blinking A, indicating that the calculator is set to receive alphabetic characters. Enter a descriptive title of up to eight characters, letters or numerals (but the first character must be a letter). Name this program ROWOPS and press ENTER to go to the program editor.

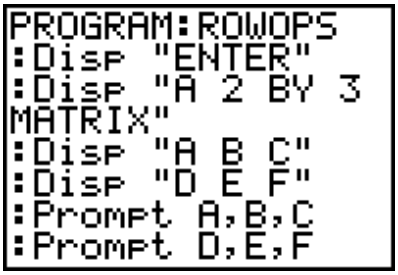

Figure I.28: Part of program ROWOPS

In the program, each line begins with a colon : supplied automatically by the calculator. Any command you could enter directly in the TI-83's home screen can be entered as a line in a program. There are also special programming commands.

Input the program ROWOPS by pressing the keystrokes given in the following listing. You may interrupt program input at any stage by pressing 2nd QUIT. To return later for more editing, press PGRM ▶, move the cursor down to the program's name, and press ENTER.

Program Line	*Keystrokes*
`:Disp "ENTER"`	PRGM ▶ 3 2nd A-LOCK " E N T E R " ENTER
`:Disp "A 2 BY 3 MATRIX"`	PRGM ▶ 3 2nd A-LOCK " A ␣ ALPHA 2 2nd A-LOCK ␣ BY ␣ ALPHA 3 2nd A-LOCK ␣ M A T R I X " ENTER
`:Disp "A B C"`	PRGM ▶ 3 2nd A-LOCK " A ␣ B ␣ C " ENTER
`:Disp "D E F"`	PRGM ▶ 3 2nd A-LOCK " D ␣ E ␣ F " ENTER
`:Prompt A, B, C`	PRGM ▶ 2 ALPHA A , ALPHA B , ALPHA C ENTER
`:Prompt D, E, F`	PRGM ▶ 2 ALPHA D , ALPHA E , ALPHA F ENTER
`:A→[A](1, 1): B→[A](1, 2)`	ALPHA A STO ▶ MATRX 1 (1 , 1) ALPHA : ALPHA B STO ▶ MATRX 1 (1 , 2) ENTER
`:C→[A](1, 3): D→[A](2, 1)`	ALPHA C STO ▶ MATRX 1 (1 , 3) ALPHA : ALPHA D STO ▶ MATRX 1 (2 , 1) ENTER


```
:E→[A](2, 2): F→[A](2, 3)
```
ALPHA E STO ▶ MATRX 1 (2 , 2) ALPHA : ALPHA F STO ▶ MATRX 1 (2 , 3) ENTER

```
:ClrHome
```
PRGM ▷ 8 ENTER

```
:Disp "ORIGINAL MATRIX"
```
PRGM ▷ 3 2nd A-LOCK " O R I G I N A L ␣ M A T R I X " ENTER

```
:Pause [A] ▶ Frac
```
PRGM 8 MATRX 1 MATH 1 ENTER

```
:"B^-1 (C-AX)"→Y2
```
ALPHA " ALPHA B x^{-1} (ALPHA C – ALPHA A X,T,θ,*n*) ALPHA " STO ▶ VARS ▷ 1 2 ENTER

```
:"E^-1 (F-DX)"→Y1
```
ALPHA " ALPHA E x^{-1} (ALPHA F – ALPHA D X,T,θ,*n*) ALPHA " STO ▶ VARS ▷ 1 1 ENTER

```
:ZStandard: Pause: ClrHome
```
ZOOM 6 ALPHA : PRGM 8 ALPHA : PRGM ▷ 8 ENTER

```
:Disp "OBTAIN LEADING"
```
PRGM ▷ 3 2nd A-LOCK " O B T A I N ␣ L E A D I N G " ENTER

```
:Disp "1 IN ROW 1"
```
PRGM ▷ 3 2nd ALPHA " 1 2nd A-LOCK ␣ I N ␣ R O W ␣ ALPHA 1 ALPHA " ENTER

```
:*row (A^-1, [A], 1)→[A]
```
MATRX ▷ ALPHA E ALPHA A x^{-1} , MATRX 1 , 1) STO ▶ MATRX 1 ENTER

```
:Pause [A] ▶ Frac: ClrDraw
```
PRGM 8 MATRX 1 MATH 1 ALPHA : 2nd DRAW 1 ENTER

```
:"(A/B) (C/A-X)"→Y2
```
ALPHA " (ALPHA A ÷ ALPHA B) (ALPHA C ÷ ALPHA A – X,T,θ,*n*) ALPHA " STO ▶ VARS ▷ 1 2 ENTER

```
:DispGraph: Pause: ClrHome
```
PRGM ▷ 4 ALPHA : PRGM 8 ALPHA : PRGM ▷ 8 ENTER

```
:Disp "OBTAIN 0 BELOW"
```
PRGM ▷ 3 2nd A-LOCK " O B T A I N ␣ ALPHA 0 2nd A-LOCK ␣ B E L O W " ENTER

```
:Disp "LEADING 1 IN"
```
PRGM ▷ 3 2nd A-LOCK " L E A D I N G ␣ ALPHA 1 2nd A-LOCK ␣ I N " ENTER

```
:Disp "COLUMN 1"
```
PRGM ▷ 3 2nd A-LOCK " C O L U M N ␣ ALPHA 1 ALPHA " ENTER

```
:*row+ (-D, [A], 1, 2)→[A]
```
MATRX ▷ ALPHA F (-) ALPHA D , MATRX 1 , 1 , 2) STO ▶ MATRX 1 ENTER

```
:Pause [A] ▶Frac: ClrDraw
```
PRGM 8 MATRX 1 MATH 1 ALPHA : 2nd DRAW 1 ENTER

```
:"(E-(BD/A))^-1 (F-(DC/A))"→Y1
```
ALPHA " (ALPHA E – (ALPHA B ALPHA D ÷ ALPHA A)) x^{-1} (ALPHA F – (ALPHA D ALPHA C ÷ ALPHA A)) ALPHA " STO ▶ VARS ▷ 1 1 ENTER

```
:DispGraph: Pause: ClrHome
```
PRGM ▷ 4 ALPHA : PRGM 8 ALPHA : PRGM ▷ 8 ENTER

`:[A](2, 2)→G`	MATRX 1 (2 , 2) STO ▶ ALPHA G ENTER
`:If G≠0`	PRGM 1 ALPHA G 2nd TEST 2 0 ENTER
`:Then`	PRGM 2 ENTER
`:*row (G^-1, [A], 2)→[A]`	MATRX ▷ ALPHA E ALPHA G x^{-1} , MATRX 1 , 2) STO ▶ MATRX 1 ENTER
`:Disp "OBTAIN LEADING"`	PRGM ▷ 3 2nd A-LOCK " O B T A I N ␣ L E A D I N G " ENTER
`:Disp "1 IN ROW 2"`	PRGM ▷ 3 2nd ALPHA " 1 2nd A-LOCK ␣ I N ␣ R O W ␣ ALPHA 2 ALPHA " ENTER
`:Pause [A] ▶ Frac`	PRGM 8 MATRX 1 MATH 1 ENTER
`:ClrDraw: DispGraph: Pause: ClrHome`	2nd DRAW 1 ALPHA : PRGM ▷ 4 ALPHA : PRGM 8 ALPHA : PRGM ▷ 8 ENTER
`:Disp "OBTAIN 0 ABOVE"`	PRGM ▷ 3 2nd A-LOCK " O B T A I N ␣ ALPHA 0 2nd A-LOCK ␣ A B O V E " ENTER
`:Disp "LEADING 1 IN"`	PRGM ▷ 3 2nd A-LOCK " L E A D I N G ␣ ALPHA 1 2nd A-LOCK ␣ I N " ENTER
`:Disp "COLUMN 2"`	PRGM ▷ 3 2nd A-LOCK " C O L U M N ␣ ALPHA 2 ALPHA " ENTER
`:[A](1, 2)→H`	MATRX 1 (1 , 2) STO ▶ ALPHA H ENTER
`:*row+ (-H, [A], 2, 1)→[A]`	MATRX ▷ ALPHA F (-) ALPHA H , MATRX 1 , 2 , 1) STO ▶ MATRX 1 ENTER
`:Pause [A] ▶Frac: ClrDraw: FnOff 2`	PRGM 8 MATRX 1 MATH 1 ALPHA : 2nd DRAW 1 ALPHA : VARS ▶ 4 2 2 ENTER
`:[A](1, 3)→J`	MATRX 1 (1 , 3) STO ▶ ALPHA J ENTER
`:Vertical J`	2nd DRAW 4 ALPHA J ENTER
`:DispGraph: Pause: ClrHome`	PRGM ▷ 4 ALPHA : PRGM 8 ALPHA : PRGM ▷ 8 ENTER
`:Disp "THE POINT OF"`	PRGM ▷ 3 2nd A-LOCK " T H E ␣ P O I N T ␣ O F " ENTER
`:Disp "INTERSECTION IS"`	PRGM ▷ 3 2nd A-LOCK " I N T E R S E C T I O N ␣ I S " ENTER
`:Disp "X = ", [A](1, 3)▶Frac, "Y = ", [A](2, 3)▶Frac`	PRGM ▷ 3 ALPHA " X,T,θ,*n* 2nd TEST 1 ALPHA " , MATRX 1 (1 , 3) MATH 1 , ALPHA " ALPHA Y 2nd TEST 1 ALPHA " , MATRX 1 (2 , 3) MATH 1 ENTER
`:Stop`	PRGM ALPHA F ENTER

`:Else`	PRGM 3 ENTER
`:If [A](2, 3) = 0`	PRGM 1 MATRX 1 (2 , 3) 2nd TEST 1 0 ENTER
`:Then`	PRGM 2 ENTER
`:Disp "INFINITELY MANY"`	PRGM ▶ 3 2nd A-LOCK " I N F I N I T E L Y ␣ M A N Y " ENTER
`:Disp "SOLUTIONS"`	PRGM ▶ 3 2nd A-LOCK " S O L U T I O N S " ENTER
`:Else`	PRGM 3 ENTER
`:Disp "INCONSISTENT"`	PRGM ▶ 3 2nd A-LOCK " I N C O N S I S T E N T " ENTER
`:Disp "SYSTEM"`	PRGM ▶ 3 2nd A-LOCK " S Y S T E M " ENTER
`:END`	PRGM 7

When you have finished, press 2nd QUIT to leave the program editor.

You may remove a program from memory by pressing 2nd MEM 2 7 . Then move the cursor to the program's name and press ENTER to delete the entire program.

I.5.2 Running the Program: Each time you want to run the program, start by setting matrix [A] to be 2×3. It does not matter if there are entries already in matrix [A], since the program ROWOPS will replace them, but the size of the matrix is important.

After matrix [A] is set, press PRGM and the number or letter that the program was named then ENTER. If you have forgotten its name, use the arrow keys to move through the program listing to find its description ROWOPS, then press ENTER to select the program and ENTER again to run it.

The program has been written to prompt you for values of the coefficients *a, b, c, d, e* and *f* in two linear equations, $ax + by = c$ and $dx + ey = f$. Input each value, then press ENTER to continue the program. This demonstration is most effective for equations that do not correspond to vertical or horizontal lines, and whose *y*-intercepts are between -10 and 10.

While the demonstration is running, note that each elementary row operation creates an equivalent system. The equivalence is reinforced graphically by the fact that while a row operation may change the *slope* of the lines, their *point of intersection* remains constant.

When the program comes to a pause, press ENTER to continue the program. If you need to interrupt the program during execution, press ON.

The instruction manual for your TI-83 gives detailed information about programming. Refer to it to learn more about programming and how to use other features of your calculator.

