

# TI-83 Plus Polynomial Root Finder & Simultaneous Equation Solver Application

## Getting Started

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- Polynomial Root Finder – Precalculus Level Example
- Polynomial Root Finder – Calculus Level Example
- Simultaneous Equation Solver

## How To...

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- Load Values from a List
- Load Values from a Matrix
- Store Data into Lists
- Store Data into Matrices

## Examples

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- Finding the Roots of a Polynomial
- Solving a System of Equations
- Displaying a Matrix in Reduced Row-Echelon Form

## More Information

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- Customer Support
- Error Recovery

## Important Information

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## **What Is the Polynomial Root Finder & Simultaneous Equation Solver Application?**

The Polynomial Root Finder application calculates the roots (zeros) of polynomials of degree 1 through 30, with a convenient, easy to use interface. You can store solutions into lists, load lists into the application for editing, and graph the polynomial. Because the application uses the operating system's eigenvalue routines, solutions are computed numerically only.

The Simultaneous Equation Solver application finds solutions to systems of linear equations. You can load matrices containing the coefficients of linear systems and identify whether a given system has a unique solution, an infinite number of solutions, or no solution.

# What You Need to Install and Use the Application

To install and run the application, you need:

- A TI-83 Plus calculator with version 1.13 or later of the operating system software to optimize the performance of your calculator and the application.
  - To check the operating system version, press  $\boxed{2\text{nd}}$  [MEM], and then select **About**. The version number is displayed below the product name.
  - You can download a free copy of the latest operating system software from [education.ti.com/softwareupdates](http://education.ti.com/softwareupdates). Follow the link to Operating Systems.
- A computer with Windows® 95/98/2000, Windows NT®, or Apple® Mac® OS 7.0 or later installed.
- A TI-GRAPH LINK™ computer-to-calculator cable. If you do not have this cable, call your distributor, or order the cable online from TI's [online store](#).
- TI-GRAPH LINK software that is compatible with the TI-83 Plus. You can download a free copy of the TI-GRAPH LINK software from [education.ti.com/softwareupdates](http://education.ti.com/softwareupdates). Follow the link to Connectivity Software, then TI-GRAPH LINK.

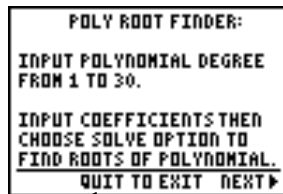
# Where to Find Installation Instructions

Detailed installation instructions are available from [education.ti.com/guides](http://education.ti.com/guides). Follow the link to Flash installation instructions.

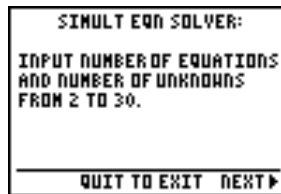
## Getting Help

This application contains built-in help screens that give you information about how to use both the Polynomial Root Finder and the Simultaneous Equation Solver applications. To access and use the help screens:

1. From the MAIN MENU, select either **Poly Help** or **Simult Help**.
2. Press  $\square$  to display subsequent screens.
3. Press  $\square$  [QUIT] to exit the help screens and return to the MAIN MENU.



Press  $\square$  [QUIT] to exit the help screens and return to the Main Menu.



Press  $\square$  to view the next help screen.

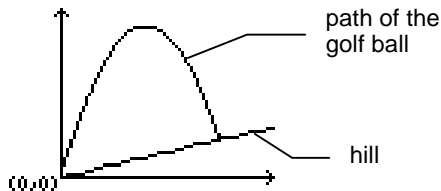
# Polynomial Root Finder Application

## Getting Started with the Polynomial Root Finder Application

### Precalculus Level Example

Work through the following example to get acquainted with the main features of the Polynomial Root Finder application.

- ▶ A golfer hits a golf ball from a tee at the bottom of a hill. The hill can be described by  $y(x) = .8x$ . The ball follows the path  $y(x) = -x^2 + 12x$ . If the golfer is standing at the tee  $(0,0)$  and hits the ball, where does the ball hit the ground on the hill?



To solve this problem, you need to find where the path of the golf ball,  $y(x) = -x^2 + 12x$ , will hit the hill,  $y(x) = .8x$ . Solve this by hand first, and then follow the instructions below to verify your calculation.

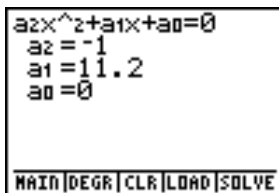
1. First, equate the two equations.

$$-x^2 + 12x = .8x$$

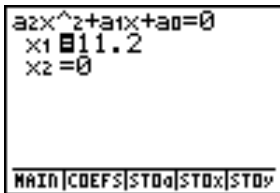
$$-x^2 + 11.2x = 0$$

The roots of the resulting polynomial will give the intersection points of the ball path and the hill.

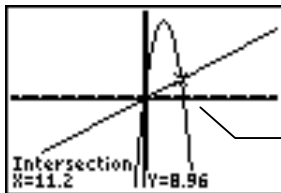
2. Press **[APPS]** to display a list of applications on your calculator.
3. Select **PolySmlt**. The information screen is displayed.
4. Press any key to continue. The MAIN MENU is displayed.
5. Select **Poly Root Finder**.
6. Enter the degree of the polynomial (**2**), and then press **[ENTER]**.
7. Enter the coefficients of the polynomial  $\{-1, 11.2, 0\}$ . Press **[ENTER]** after each coefficient to move the cursor to the next line.



8. Select **SOLVE** (press **GRAPH**) to calculate and display the roots.



Two answers,  $x_1 = 11.2$  and  $x_2 = 0$ , are displayed. If you exit the application, graph the two functions, and find their intersection (press **2nd** **CALC**, and then select **Intersect**), you can see that the ball starts at (0,0) and hits the hill at (11.2, 8.96).



To see this graph:

1. Press **ZOOM**
2. Select Zoom Out.
3. Move the cursor near (0,0).
4. Press **ENTER**.



## Calculus Level Example

Work through the following example to get acquainted with the main features of the Polynomial Root Finder application.

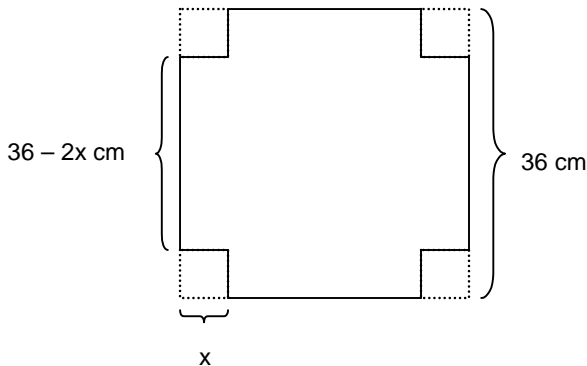
- An open box is to be made from a square piece of material 36 centimeters on a side by cutting equal squares from the corners and turning up the sides. What is the largest volume box that can be made with this construction?

$$L = (36 - 2x)$$

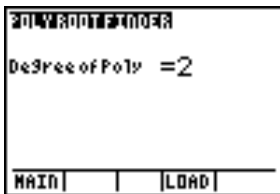
$$W = (36 - 2x)$$

$$H = x$$

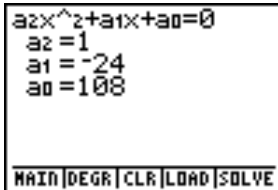
The volume of the box is  $V(x) = x(36-2x)^2$ .



1. To find the extreme values of the volume, set the first derivative of  $V$  to zero.  
 $V(x) = x(36-2x)^2$   
 $V(x) = 4x^3 - 144x^2 + 1296x$   
 $V'(x) = 12x^2 - 288x + 1296 = 0$   
 $x^2 - 24x + 108 = 0$
2. Now, if you find the roots of  $x^2 - 24x + 108 = 0$ , you will find the critical points of the function.
3. Press **[APPS]** to display a list of applications on your calculator.
4. Select **PolySmlt**. The information screen is displayed.
5. Press any key to continue. The MAIN MENU is displayed.
6. Select **Poly Root Finder**.
7. Enter the degree of the polynomial (**2**), and then press **[ENTER]**.

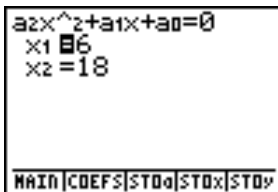


8. Enter the coefficients of the polynomial  $\{1, -24, 108\}$ . Press **ENTER** after each coefficient to move the cursor to the next line.



The calculator screen displays the polynomial equation  $a_2x^2+a_1x+a_0=0$  and the entered coefficients:  $a_2=1$ ,  $a_1=-24$ , and  $a_0=108$ . The bottom menu bar shows **MAIN**, **DEGR**, **CLR**, **LOAD**, and **SOLVE**.

9. Select **SOLVE** (press **GRAPH**) to calculate and display the roots.

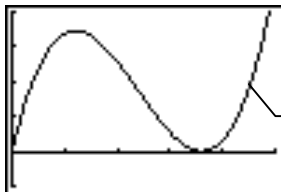


The calculator screen displays the polynomial equation  $a_2x^2+a_1x+a_0=0$  and the calculated roots:  $x_1=6$  and  $x_2=18$ . The bottom menu bar shows **MAIN**, **COEFS**, **STO**, **STOx**, and **STOy**.

Two answers,  $x_1 = 18$  and  $x_2 = 6$ , are displayed. Which do you choose?

10. To test that  $x = 6$  is the maximum, remember to check the sign of the second derivative at  $x = 6$  (i.e., make sure that  $V''(6) < 0$ ).

If you graph  $V(x)$ , you can see that 6 is the maximum value for  $x$  that you can use to construct a box.



The reasonable physical domain has  $x$  from 0 to 18 (fold the paper in half). This window gives a nice picture of the function for positive  $x = 0$  to 25.

```
WINDOW
Xmin=0
Xmax=25
Xscl=5
Ymin=-1000
Ymax=4000
Yscl=1000
Xres=1
```

11. Since the volume of the box is  $V(x) = x(36-2x)^2$ , you can find the maximum volume by substituting 6 for  $x$ . (Answer: 3456)

Now that you have completed the Getting Started example, you can read further for more detailed instructions on how to use the Polynomial Root Finder application. Some topics you might want to explore are:

- [Loading a list of coefficients into the application](#)
- [Storing coefficients to a list](#)
- [Storing solutions \(roots\) to a list](#)
- [Storing equations to the Y= editor](#)

# Starting and Quitting the Polynomial Root Finder Application

## Starting the Application

1. Press **[APPS]** to display a list of applications on your calculator.
2. Select **PolySmlt**. The information screen is displayed.
3. Press any key to display the Main Menu.
4. Select **Poly Root Finder**. The POLY ROOT FINDER main screen is displayed.

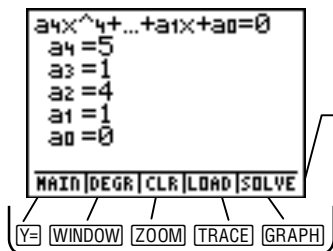
## Quitting the Application

1. From any screen, select **MAIN** to return to the Main Menu.
2. Select **Quit PolySmlt**.

**Shortcut** You can also press **[2nd][QUIT]** to exit the application. If the cursor is at a name prompt, you must press **[2nd][QUIT]** twice.

## Selecting Polynomial Root Finder Options

Several that you can use to accomplish specific tasks options are displayed across the bottom of each screen. To select an option, press the graphing key directly under the option.



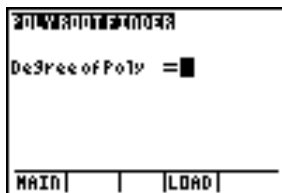
Press a graphing key to select one of these options.

## Options You Can Use

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Use options on this screen ...	To do this:
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Degree entry screen

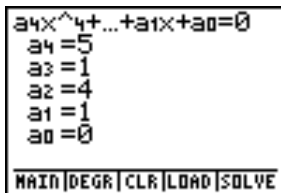
MAIN displays the main menu.

LOAD displays a list prompt so that you can enter a list name that contains the coefficient values you want to use. You must set up the list in the list editor before you can use the list in the Polynomial Root Finder application. You cannot access the list editor while the application is running.

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**Use options on this screen ... To do this:**

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Coefficient entry screen

MAIN displays the main menu.

DEGR displays the degree entry screen where you can view or change the degree of the polynomial.

CLR clears all of the coefficient values that you have entered.

LOAD displays a list prompt so that you can enter a list name that contains the coefficient values you want to use. You must set up the list in the list editor before you can use the list in the Polynomial Root Finder application. You cannot access the list editor while the application is running.

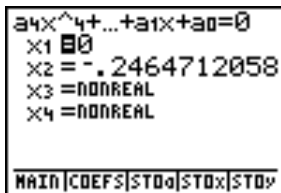
SOLVE computes and displays the roots of the polynomial.

The solution may be too long to display on one screen. If an up or down arrow is displayed on the left side of the screen, press  $\downarrow$  and  $\uparrow$  as necessary to view the entire solution.

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**Use options on this screen ... To do this:**

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```
34X^4+...+a1X+a0=0
X1 0
X2 = -.2464712058
X3 =NONREAL
X4 =NONREAL
MAIN|COEFS|STOa|STOx|STOy
```

Solution screen

MAIN displays the main menu.

COEFS displays the coefficient entry screen so that you can view or change the coefficients.

STOa displays a list prompt so that you can enter the list name where you want the coefficients stored.

STOx displays a list prompt so that you can enter the list name where you want the solutions stored.

STOy stores the polynomial equation to the next available y-variable in the Y= editor.

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## Changing Mode Settings

This application has a unique mode settings screen that is based on the calculator's mode settings. These mode settings only apply while the Polynomial Root Finder/Simultaneous Equation Solver application is running. The settings are saved and are applied each time you run the application. When you exit the application, your calculator's previous mode settings are restored.

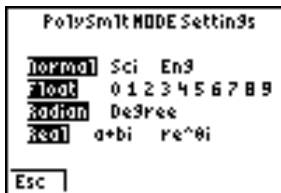
### Note

- If RAM is reset, the saved Polynomial Root Finder / Simultaneous Equation Solver mode settings will be lost.
- Mode settings are stored in an application variable (AppVar). If you want to share the application and your mode settings with another TI-83 Plus user, you must send both the application and the AppVar named APPVARO.
- If a list name prompt (for example, STOx LIST = ) is displayed, you must exit the prompt before you can change the mode settings.

To change the mode settings:

1. Start the [Polynomial Root Finder](#) application.

- From any screen, press **[MODE]** to display the PolySmlt MODE Settings screen.



- Move the cursor to a setting and press **[ENTER]** to select the setting.

Setting			Description
Normal	Sci	Eng	<p><b>Normal</b> notation mode is the usual way to express numbers, with digits to the left and right of the decimal, as in 12345.67.</p> <p><b>Sci</b> (scientific) notation mode expresses numbers in two parts. The significant digits display with one digit to the left of the decimal. The appropriate power of 10 displays to the right of E, as in 1.234567E4.</p> <p><b>Eng</b> (engineering) notation mode is similar to scientific notation. However, the number can have up to three digits before the decimal. The power-of-10 exponent is a multiple of three, as in 12.34567E3.</p>

Setting		Description
Float	0 1 2 3 4 5 6 7 8 9	<p><b>Float</b> (floating) decimal mode displays up to 10 digits, plus the sign and decimal.</p> <p><b>0123456789</b> (fixed) decimal mode specifies the number of digits (0 through 9) to display to the right of the decimal.</p>
Radian	Degree	<p><b>Radian</b> mode interprets angle values as radians. Answers display in radians.</p> <p><b>Degree</b> mode interprets angle values as degrees. Answers display in degrees.</p>
Real	a+bi      re <sup>θi</sup>	<p><b>Real</b> mode does not display complex results. If you select this mode setting and the answer is complex, <b>NONREAL</b> is displayed as the result.</p> <p><b>a+bi</b> (rectangular complex) mode displays complex numbers in the form <math>a+bi</math>. You may need to press <math>\blacktriangleright</math> to display all of the complex number.</p> <p><b>re<sup>θi</sup></b> (polar complex) mode displays complex numbers in the form of <math>re^{θi}</math>. You may need to press <math>\blacktriangleright</math> to display all of the complex number.</p>

4. Select **ESC** to save the settings and return to the previous screen.

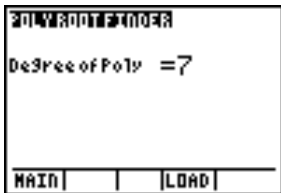
## Entering and Solving a Problem

To find the roots of a polynomial, you enter the degree of the polynomial, then the value for each coefficient. The degree of the polynomial must be an integer between 1 and 30. The value for each coefficient must be a real number.

The following example uses the Polynomial Root Finder application to calculate the roots of the function:

$$f(x) = 7x^7 - 5x^6 + 8x^5 + 6x^4 - 9x^3 - 3x^2 + 2x + 1$$

1. Enter the degree of the polynomial, and then press **ENTER**.



## 2. Enter a value for each coefficient.

### Tip

- The coefficient of the largest term cannot be 0.
- You can use  $\uparrow$  and  $\downarrow$  to scroll through the list of coefficients to edit values, if necessary.

```
a7x^7+...+a1x+a0=0
a7 = 7
a6 = -5
a5 = 8
a4 = 6
a3 = -9
↓ a2 = -3
MAIN|DEGR|CLR|LOAD|SOLVE
```

## 3. Select **SOLVE** to display the solution. This may take several seconds.

The arrow indicates that you must press  $\downarrow$  to view the remaining roots.

```
a7x^7+...+a1x+a0=0
x1 = -.7242996307
x2 = NONREAL
x3 = NONREAL
x4 = NONREAL
x5 = NONREAL
↓ x6 = NONREAL
MAIN|COEFS|STO0|STOX|STO^
```

### Note

When NONREAL is displayed, the Poly/Simult mode is set to REAL. To see the complex solutions, set the mode to  $a+bi$  or  $re^{\theta i}$ .

## Loading Values

You can load a list of coefficients from the POLY ROOT FINDER screen or the coefficient entry screen.

**Note** You must set up the list in the list editor before you can use the list in the Polynomial Root Finder application. You cannot access the list editor while the application is running.

The list must contain from 2 to 31 values. The length of the list must be appropriate for the degree of the polynomial. For example, if you want to work with a polynomial of degree 5, the list must contain 6 elements.

To load a list:

1. From either the Degree of Poly screen or the coefficient entry screen, select **LOAD**. The **LOAD List =** prompt is displayed.

## 2. Enter the list name.

### Tip

- You can enter a list name using one of the following methods:
  - Type the list name at the prompt.
  - Press  $\boxed{2\text{nd}}$   $\boxed{[\text{LIST}]}$  to display the lists on your calculator, and then select the list name.
  - If your list is named L1 – L6, press  $\boxed{2\text{nd}}$  plus the list name (for example,  $\boxed{2\text{nd}}$   $\boxed{[\text{L1}]}$ ).
- To enter an alphabetical character, press  $\boxed{[\text{ALPHA}]}$  plus the letter.
- To turn the alpha lock on so that you can easily enter a list name that contains all alphabetical characters, press  $\boxed{2\text{nd}}$   $\boxed{[\text{A-LOCK}]}$
- To clear the list name from the prompt, press  $\boxed{[\text{CLEAR}]}$ .
- To exit the name prompt, press  $\boxed{[\text{CLEAR}]}$ .

## 3. Press $\boxed{[\text{ENTER}]}$ to load the values into the coefficient list.

### Storing Data

After the solution is displayed, you can store the coefficients of the polynomial and the roots of the polynomial to lists. You can also store the polynomial to the next available y-variable in the Y= editor.

## Storing Coefficients and Roots

1. From the solutions screen, select **STOa** to store coefficients or **STOx** to store roots. The **STOa List =** (or **STOx List =**) prompt is displayed.
2. Enter the name of the list, up to 5 characters long, and then press **[ENTER]**. The list is stored.

### Tip

- A list name cannot begin with a number, but can contain numbers. To enter an alphabetical character, press **[ALPHA]** plus the letter
- To turn the alpha lock on so that you can easily enter a list name that contains all alphabetical characters, press **[2nd]** **[A-LOCK]**.
- To clear the list name from the prompt, press **[CLEAR]**.
- To exit the name prompt and return to the solutions screen, press **[CLEAR]**.
- To enter a list name L1 – L6, press **[2nd]** plus the list name (for example, **[2nd]** **[L2]**).
- If a list name already exists, the error message "List already exists" is displayed; the list is not overwritten.



## Storing Equations to the Y= Editor

To store the polynomial to the Y= editor, select **STOy**. The polynomial is stored to the next available function in the Y=editor. A message is displayed to confirm that the polynomial has been stored.

# Simultaneous Equation Solver Application

## Getting Started with the Simultaneous Equation Solver Application

Work through the following example to get acquainted with the main features of the Simultaneous Equation Solver application.

- ▶ A small corporation borrowed \$500,000 to expand its product line. Some of the money was borrowed at 9% interest, some at 10%, and some at 12%. How much was borrowed at each rate if the annual interest was \$52,000 and the amount borrowed at 10% was 2.5 times the amount borrowed at 9%?

Let  $x$  = amount of money borrowed at 9%

$y$  = amount of money borrowed at 10%

$z$  = amount of money borrowed at 12%

1. Write an equation for each of the statements.

$$x + y + z = 500,000$$

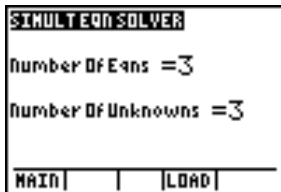
$$.09x + .1y + .12z = 52,000$$

$$y = 2.5x \rightarrow 2.5x - y = 0$$

2. Press **[APPS]** to display a list of applications on your calculator.
3. Select **PolySmlt**. The information screen is displayed.

4. Press any key to continue. The MAIN MENU is displayed.
5. Select **Simult Eqn Solver**.
6. Enter the number of equations (**3**) and the number of unknowns (**3**). Press **ENTER** after each entry.

**Tip** You can press  or  to move the cursor to an entry to change it.



7. Enter the coefficients for the variables and the constants in the matrix:

$$\begin{bmatrix} 1 & 1 & 1 & : & 500000 \\ .09 & .1 & .12 & : & 52000 \\ 2.5 & -1 & 0 & : & 0 \end{bmatrix}$$

This matrix shows the values in Float mode.

```
SYS MATRIX (3x4)
[1 1 1 | 500000]
[.09 .1 .12 | 52000]
[2.5 -1 0 | 0]

1, 1=1
MAIN|NEW|CLR|LOAD|SOLVE
```

8. Select **SOLVE** (press **GRAPH**) to solve the system of equations. You see that the corporation borrowed \$100,000 at 9%, \$250,000 at 10%, and \$150,000 at 12%.

```
Solution
x1=100000
x2=250000
x3=150000

MAIN|BACK|STO|sys|STO|x|
```

Now that you have completed the Getting Started example, you can read further for more detailed instructions on how to use the Simultaneous Equation Solver application. Some topics you might want to explore are

- [Loading a matrix into the application](#)
- [Storing data to a matrix](#)
- [Displaying a matrix in reduced row-echelon form](#)

# Starting and Quitting the Simultaneous Equation Solver Application

## Starting the Application

1. Press **[APPS]** to display a list of applications on your calculator.
2. Select **PolySmlt**. The information screen is displayed.
3. Press any key to display the main menu.
4. Select **Simult Eqn Solver**. The SIMULT EQN SOLVER main screen is displayed.

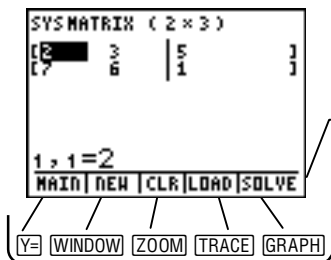
## Quitting the Application

1. From any screen, select **MAIN** to return to the main menu.
2. Select **Quit PolySmlt**.

**Shortcut** | You can also press **[2nd] [QUIT]** to exit the application. If the cursor is at a name prompt, you must press **[2nd] [QUIT]** twice. |

## Selecting Simultaneous Equation Solver Options

Several options are that you can use to accomplish specific tasks displayed across the bottom of each screen. To select an option, press the graphing key directly under the option.



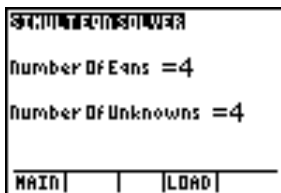
Press a graphing key to select one of these options.

## Options You Can Use

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**Use options on this screen ...**

**To do this:**



Equations/unknowns entry screen

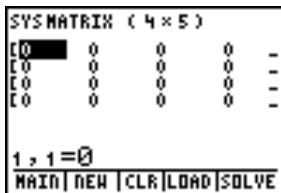
MAIN displays the main menu.

LOAD displays a prompt so that you can enter a matrix name that contains the matrix values you want to use. You must set up the matrix in the matrix editor before you can use it in the Simultaneous Equation Solver application. You cannot access the matrix editor while the application is running.

---

**Use options on this screen ... To do this:**

---



SYSMATRIX screen

MAIN displays the main menu.

NEW displays the equations/unknowns entry screen where you can view or change the number of equations and number of unknowns.

CLR clears all of the matrix values that you have entered. (Pressing **CLEAR** does not clear the matrix values.)

LOAD displays a prompt so that you can enter a matrix name that contains the matrix values you want to use. You must set up the matrix in the matrix editor before you can use it in the Simultaneous Equation Solver application. You cannot access the matrix editor while the application is running.

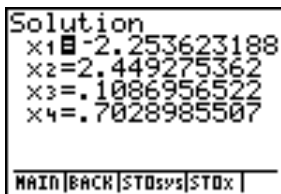
SOLVE solves the system of equations. The entire solution may not fit on one screen. If an arrow is displayed on the left side of the screen, press **▼** and **▲** as necessary to view the entire solution. Each line of the matrix may not fit on the screen. Press **▶** scroll to the right to view the part of the line that is off the screen..



---

**Use options on this screen ... To do this:**

---



```
Solution
x1=-2.253623188
x2=2.449275362
x3=.1086956522
x4=.7028985507
MAIN|BACK|STOSys|STOx|
```

Solution screen

MAIN displays the main menu.

BACK displays the SYSMATRIX screen so that you can view or change the values.

STOSys stores the coefficients to a matrix variable that you select.

STOx stores the solutions to a matrix variable that you select.

---



```
No Solution Found
MAIN|BACK|STOSys|RREF|
```

No Solution Found screen

MAIN displays the main menu.

BACK displays the matrix entry screen so that you can view or change the values.

STOSys stores the coefficients to a matrix variable that you select.

RREF displays the reduced row-echelon form of a matrix that has either no solution or infinite solutions.

---

**Use options on this screen ... To do this:**

---

The screenshot shows a calculator screen with the title "RREF ( 4 x 4 )". Below the title is a 4x4 matrix displayed in a grid with a vertical line separating the first three columns from the last column. The matrix is:

[	1	0	0		0	]
[	0	1	0		0	]
[	0	0	1		0	]
[	0	0	0		1	]

At the bottom of the screen, there is a menu bar with the options: **MAIN** | **BACK** | **STORE RREF**

RREF screen

MAIN displays the main menu.

BACK displays the matrix entry screen so that you can view or change the values.

STORE RREF stores the reduced row-echelon form of a matrix to a matrix variable that you select.

---

## Changing Mode Settings

This application has a unique mode settings screen that is based on the calculator's mode settings. These mode settings only apply while the Polynomial Root Finder / Simultaneous Equation Solver application is running. The settings are saved and are applied each time you run the application. When you exit the application, your calculator's previous mode settings are restored.

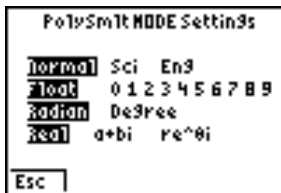
### Note

- If RAM is reset, the saved Polynomial Root Finder / Simultaneous Equation Solver mode settings will be lost.
- Mode settings are stored in an application variable (AppVar). If you want to share the application and your mode settings with another TI-83 Plus user, you must send both the application and the AppVar named APPVARO.
- The mode settings cannot be changed from the RREF matrix screen.
- If a matrix variable prompt (for example, STOSys MAT = ) is displayed, you must exit the prompt before you can change the mode settings.

To change the mode settings:

1. Start the [Simultaneous Equation Solver](#) application.

2. Press **[MODE]** to display the PolySmlt MODE Settings screen.



3. Move the cursor to a setting and press **[ENTER]** to select the setting.

Setting			Description
Normal	Sci	Eng	<b>Normal</b> notation mode is the usual way to express numbers, with digits to the left and right of the decimal, as in 12345.67.  <b>Sci</b> (scientific) notation mode expresses numbers in two parts. The significant digits display with one digit to the left of the decimal. The appropriate power of 10 displays to the right of E, as in 1.234567E4.  <b>Eng</b> (engineering) notation mode is similar to scientific notation. However, the number can have up to three digits before the decimal. The power-of-10 exponent is a multiple of three, as in 12.34567E3.

Setting		Description
Float	0 1 2 3 4 5 6 7 8 9	<p><b>Float</b> (floating) decimal mode displays up to 10 digits, plus the sign and decimal.</p> <p><b>0123456789</b> (fixed) decimal mode specifies the number of digits (0 through 9) to display to the right of the decimal.</p>
Radian	Degree	<p><b>Radian</b> mode interprets angle values as radians. Answers display in radians.</p> <p><b>Degree</b> mode interprets angle values as degrees. Answers display in degrees.</p>
Real	a+bi      re <sup>θi</sup>	<p><b>Real</b> mode does not display complex results. If you select this mode setting and the answer is complex, <b>NONREAL</b> is displayed as the result.</p> <p><b>a+bi</b> (rectangular complex) mode displays complex numbers in the form <math>a+bi</math>.</p> <p><b>re<sup>θi</sup></b> (polar complex) mode displays complex numbers in the form of <math>re^{θi}</math>.</p>

4. Select **ESC** to save the settings and return to the previous screen.

## Entering and Solving a Problem

To solve a system of equations, you enter the number of equations, the number of unknowns, and then you enter the augmented matrix (one that contains the coefficients as well as the constants) of the system.

### Note

The Simultaneous Equation Solver application does not find solutions to complex systems. The augmented matrix can only contain real numbers.

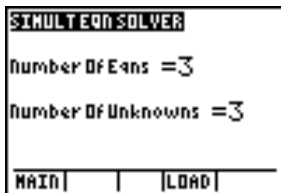
The following example solves this system of equations:

$$x + y + z = 5$$

$$2x - .5y + z = 10$$

$$x - 2y + 3z = 15$$

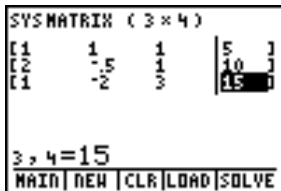
1. Enter the number of equations (**3**) and the number of unknowns (**3**), pressing **ENTER** after each entry.



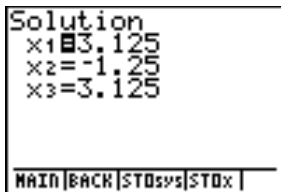
2. Enter a value for each coefficient and a value for each constant. Press **ENTER** after each entry to move to the next value.

**Tip**

You can use **▲**, **▼**, **▶**, and **◀** to scroll through the list of coefficients and constants to edit values, if necessary.



3. Select **SOLVE** to display the solution. This may take several seconds.



## Loading a Matrix

You can load an augmented matrix from the equations/unknowns entry screen or the SYSMATRIX screen. You must set up the matrix in the matrix editor before you can use it in the Simultaneous Equation Solver application. You cannot access the matrix editor while the application is running.

The matrix size cannot be smaller than  $2 \times 3$  or larger than  $30 \times 30$ . The size of the matrix must be appropriate for the number of equations and number of unknowns. For example, if you enter 5 as the number of equations and 3 as the number of unknowns, the matrix must be  $5 \times 4$ .

To load a matrix:

1. Select **LOAD**. The **LOAD Mat=** prompt is displayed.
2. Pres  $\boxed{2nd}$   $\boxed{[MATRX]}$  to display a list of the matrices on your calculator.



- Use  $\blacktriangle$  and  $\blacktriangledown$  to select the matrix, and then press  $\boxed{\text{ENTER}}$  to copy the matrix name to the **LOAD Mat =** prompt.

### Tip

- Press  $\boxed{\text{CLEAR}}$  to clear the list name from the **LOAD Mat =** prompt.
- Press  $\boxed{\text{CLEAR}}$  to cancel the load option when there is no list name at the **LOAD Mat =** prompt.

- Press  $\boxed{\text{ENTER}}$  to load the values into the matrix.

### Note

- If the matrix you load does not have the same dimension that was specified on the equations/unknowns entry screen, the matrix dimension is changed to match the matrix being loaded.
- The matrix is assumed to be an augmented matrix. The number of unknowns is changed automatically, if necessary.

## Storing Data

You can store an augmented matrix (one that contains the coefficients as well as the constants) and the solution for the system of equations to matrices. The solutions are stored to column matrices. If the system of equations has no solution or has infinite solutions, you can store the reduced row-echelon form of the matrix.

To store data:

1. Select **STOsys** to store the augmented matrix, **STOx** to store the solution to a column matrix, or **STORE RREF** to store the reduced row-echelon matrix. The **STOsys Mat =** (or **STOx Mat =** or **STORE RREF**) prompt is displayed.
2. Press  $\boxed{2\text{nd}}$   $\boxed{[MATRX]}$ , and then select a matrix name from the NAMES menu.

**Note**

You must select an unused matrix name. If all of the matrix names are used, you must exit the application and delete a matrix before you can store the new matrix.

3. Press  $\boxed{ENTER}$  to save the matrix.

## Displaying a Matrix in Reduced Row-Echelon Form

If the system of equations has no solution or has infinite solutions, you can display the reduced row-echelon form of the matrix.

The following example solves this system of equations:

$$x - y + 2z = 4$$

$$x + z = 6$$

$$2x - 3y + 5z = 4$$

$$3x + 2y - z = 1$$

1. Start the [Simultaneous Equation Solver](#) application.
2. Enter the number of equations (4) and the number of unknowns (3), pressing **ENTER** after each entry.
3. Enter a value for each coefficient and a value for each constant. Press **ENTER** after each entry to move to the next value.

4. Select **SOLVE** to display the solution. **No Solutions Found** is displayed.
5. Select **RREF** to display the matrix in reduced row-echelon form.

RREF ( 4 x 4 )				
[1	0	0		0 ]
[0	1	0		0 ]
[0	0	1		0 ]
[0	0	0		1 ]

---

MAIN	BACK	STORE	RREF
------	------	-------	------

## Deleting the Application and AppVars

Deleting the application completely removes the application from your calculator.

**Tip** You can use the TI-GRAPH LINK™ software to save a copy of the application on your computer.

To delete the application from your calculator, make sure the home screen is displayed, and then follow the instructions below.

1. Press **[2nd]** **[MEM]** to display the MEMORY menu.
2. Select **Mem Mgmt/Del**.
3. Use **[↓]** or **[↑]** to select **Apps**.
4. Use **[↓]** or **[↑]** to move the cursor to **PolySmlt**.
5. Press **[DEL]**.
6. Select **Yes**.
7. Press **[CLEAR]** to return to the home screen.

To free more RAM on your calculator, you can also delete the AppVars that this application creates. To delete the AppVars, make sure the home screen is displayed, and then follow the instructions below to delete **APPVARL**, **APPVARM**, and **APPVARO**.

**Note** If you delete the AppVars, the application's mode settings as well as the data that you entered most recently will be lost. Data that you exported to lists or matrices will not be lost.

1. Press  $\boxed{2\text{nd}}$   $\boxed{[\text{MEM}]}$  to display the MEMORY menu.
2. Select **Mem Mgmt/Del**.
3. Use  $\boxed{\downarrow}$  or  $\boxed{\uparrow}$  to select **AppVars**.
4. Use  $\boxed{\downarrow}$  or  $\boxed{\uparrow}$  to move the cursor to **APPVARL**.
5. Press  $\boxed{[\text{DEL}]}$ .
6. Move the cursor to **APPVARM**, and then press  $\boxed{[\text{DEL}]}$ .
7. Move the cursor to **APPVARO**, and then press  $\boxed{[\text{DEL}]}$ .
8. Press  $\boxed{[\text{CLEAR}]}$  to return to the home screen.

# Installation Error Messages

## Low Battery

Do not attempt to download a Flash application if the low-battery message appears on the TI-83 Plus home screen. Low battery indication is shown on the initial screen. If you receive this error during an installation, change the batteries before trying again.

## Archive Full

This error occurs when the TI-83 Plus does not have sufficient memory for the application. In order to make room for another application, you must delete an application and/or archived variables from the TI-83 Plus. Before you delete an application from the TI-83 Plus, you can save it on your computer using the TI-GRAPH LINK™ software for the TI-83 Plus. You can reload it to the TI-83 Plus later using the TI-GRAPH LINK software.

## Link Transmission Error

This error indicates that the TI-GRAPH LINK™ software is unable to communicate with the TI-83 Plus. The problem is usually associated with the TI-GRAPH LINK cable and its connection to the TI-83 Plus and/or to the computer.

- Make sure the cable is firmly inserted in the calculator I/O port and the computer.
- Verify that the correct cable type is selected in the TI-GRAPH LINK™ link settings.
- Verify that the correct communications port (Com Port) is selected in the TI-GRAPH LINK link settings.

If this does not correct the problem, try a different TI-GRAPH LINK cable and reboot your computer. If you continue to get this error, please contact [TI-Cares™](#) Customer Support for assistance.



## Error in Xmit

This problem is usually associated with the unit-to-unit cable and its connection between the TI-83 Plus calculators. Make sure the cable is firmly inserted in the I/O port of each calculator.

If you continue to get this error, please contact [TI-Cares](#)™ Customer Support.

## Invalid Signature or Certificate

Either this calculator does not have a certificate to run the application, or electrical interference caused a link to fail. Try to install the application again. If you continue to receive this error, contact [TI-Cares](#) Customer Support.

## Other Errors

See pages B-6 through B-10 in the [TI-83 Plus manual](#) for information about the specific error or contact [TI-Cares](#) Customer Support.

# Checking Version Numbers and Free Space

## Verify Operating System Version and ID Number

The Polynomial Root Finder/Simultaneous Equation Solver application is compatible with TI-83 Plus operating system 1.13 and higher.

To verify your operating system version number:

1. From the home screen, press  $\boxed{2\text{nd}}$  [MEM].
2. Select **ABOUT**.

The operating system version number is displayed below the product name and has the format x.yy. The ID number appears on the line below the product number.

## Verify Flash Application Version

1. Press **[APPS]**.
2. Select **PolySmlt**. The information screen is displayed.

The version number appears on the information screen below the application name.

You can also access the information screen by selecting **About** from the application's MAIN MENU.

## Check Amount of Flash Application Free Space

1. From the home screen, press **[2nd]** **[MEM]**.
2. Select **Mem Mgmt/Del**.

The Polynomial Root Finder/Simultaneous Equation Solver application requires at least 33,070 bytes of ARC FREE (Flash) to load the application.

For more information about memory and memory management, refer to the [TI-83 Plus manual](#).

# Texas Instruments (TI) Support and Service Information

## For General Information

**E-mail:** ti-cares@ti.com

**Phone:** 1-800-TI-CARES (1-800-842-2737)  
For US, Canada, Mexico, Puerto Rico, and  
Virgin Islands only

**Home page:** [education.ti.com](http://education.ti.com)

## For Technical Questions

**Phone:** 1-972-917-8324

## For Product (Hardware) Service

**Customers in the US, Canada, Mexico, Puerto Rico, and Virgin Islands:** Always contact TI Customer Support before returning a product for service.

**All other customers:** Refer to the leaflet enclosed with your product (hardware) or contact your local TI retailer/distributor.

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## Page Reference

This PDF document contains electronic bookmarks designed for easy on-screen navigation. If you decide to print this document, please use the page numbers below to find specific topics.

Important Information.....	2
What Is the Polynomial Root Finder & Simultaneous Equation Solver Application? .....	3
What You Need to Install and Use the Application .....	4
Where to Find Installation Instructions .....	5
Getting Help .....	5
Polynomial Root Finder Application .....	6
Getting Started with the Polynomial Root Finder Application.....	6
Starting and Quitting the Polynomial Root Finder Application.....	13
Selecting Polynomial Root Finder Options.....	14
Options You Can Use .....	14
Changing Mode Settings.....	17
Entering and Solving a Problem.....	20
Loading Values .....	22
Storing Data .....	23
Simultaneous Equation Solver Application .....	26
Getting Started with the Simultaneous Equation Solver Application.....	26

Starting and Quitting the Simultaneous Equation Solver Application.....	29
Selecting Simultaneous Equation Solver Options.....	30
Options You Can Use .....	30
Changing Mode Settings.....	34
Entering and Solving a Problem.....	37
Loading a Matrix.....	39
Storing Data .....	40
Displaying a Matrix in Reduced Row-Echelon Form.....	42
Deleting the Application and AppVars .....	44
Installation Error Messages .....	46
Checking Version Numbers and Free Space .....	49
Verify Operating System Version and ID Number .....	49
Verify Flash Application Version .....	50
Check Amount of Flash Application Free Space .....	50
Texas Instruments (TI) Support and Service Information.....	51
End-User License Agreement.....	52