

Numeric Solver

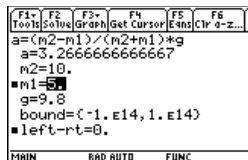
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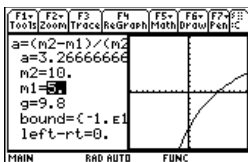
Note: To solve for the unknown variable from the Home screen or a program, use **nSolve()** as described in Appendix A.

The Numeric Solver lets you enter an expression or equation, define values for all but one unknown variable, and then solve for the unknown variable.

After entering an equation and its known values, place the cursor on the unknown variable and press **[F2]**.



You can also graph the solution.



The x axis is the unknown variable. The y axis is the left-rt value, which gives the solution's accuracy.

The solution is precise where the curve crosses the x axis.

As in the example above, the Numeric Solver is often used to solve closed-form equations. But it also gives you a quick way to solve equations such as transcendental equations in which there is no closed form.

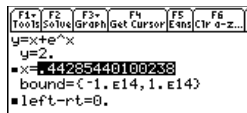
For example, you could rearrange the following equation manually to solve for any of the variables.

$$a = (m2 - m1) / (m2 + m1) * g \longrightarrow m1 = (g - a) / (g + a) * m2$$

With an equation such as the following, however, it may not be as easy to solve for x manually.

$$y = x + e^x$$

The Numeric Solver is particularly useful for such equations.



Preview of the Numeric Solver

Consider the equation $a=(m2-m1)/(m2+m1)*g$, where the known values are $m2=10$ and $g=9.8$. If you assume that $a=1/3 g$, find the value of $m1$.

Steps	TI-89 Keystrokes	TI-92 Plus Keystrokes	Display
1. Display the Numeric Solver.	[APPS] 9	[APPS] 9	
2. Enter the equation. <i>When you press [ENTER] or \ominus, the screen lists the variables used in the equation.</i>	[alpha] A [=] [] [alpha] M 2 [=] [] [alpha] M 1 [] [/] [] [=] [] [] [alpha] M 2 [+] [] [] [alpha] M 1 [] [*] [] [] [alpha] G [ENTER]	A [=] [] M 2 [=] [] M 1 [] [/] [] [=] [] [] M 2 [+] [] [] M 1 [] [*] [] [] G [ENTER]	
3. Enter values for each variable, except the unknown variable $m1$. <i>Define $m2$ and g first. Then define a. (You must define g before you can define a in terms of g.) Accept the default for bound. If a variable has been defined previously, its value is shown as a default.</i>	\ominus 10 \ominus \ominus 9.8 \ominus \ominus \ominus [alpha] G [=] 3	\ominus 10 \ominus \ominus 9.8 \ominus \ominus \ominus G [=] 3	
4. Move the cursor to the unknown variable $m1$. <i>Optionally, you can enter an initial guess for $m1$. Even if you enter a value for all variables, the Numeric Solver solves for the variable marked by the cursor.</i>	\ominus \ominus	\ominus \ominus	
5. Solve for the unknown variable. <i>To check the solution's accuracy, the left and right sides of the equation are evaluated separately. The difference is shown as left-rt. If the solution is precise, left-rt=0.</i>	[F2]	[F2]	
6. Graph the solution using a ZoomStd viewing window. <i>The graph is displayed in a split screen. You can explore the graph by tracing, zooming, etc.</i>	[F3] 3	[F3] 3	
7. Return to the Numeric Solver and exit the split screen. <i>You can press [ENTER] or \ominus to redisplay the list of variables.</i>	[2nd] [] [F3] 2	[2nd] [] [F3] 2	The variable marked by the cursor (unknown variable $m1$) is on the x axis, and left-rt is on the y axis.

Displaying the Solver and Entering an Equation

After you display the Numeric Solver, start by entering the equation that you want to solve.

Displaying the Numeric Solver

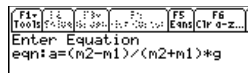
To display the Numeric Solver, press **[APPS]** 9.



The Numeric Solver screen shows the last entered equation, if any.

Entering an Equation

On the **eqn:** line, type in your equation.



Tips: In your equation:

- Do not use system function names (such as $y1(x)$ or $r1(\theta)$) as simple variables ($y1$ or $r1$).
- Be careful with implied multiplication. For example, $a(m2+m1)$ is treated as a function reference, not as $a*(m2+m1)$.

Note: When you define the variables, you can either define **exp** or solve for it.

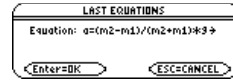
Note: After you press **[ENTER]** the current equation is stored automatically to the system variable **eqn**.

You can:	For example:
Type an equation directly.	$a=(m2-m1)/(m2+m1)*g$ $a+b=c+\sin(d)$
Refer to a function or equation defined elsewhere.	Suppose you defined $y1(x)$ on either the: <ul style="list-style-type: none"> • Y= Editor: $y1(x)=1.25*\cos(x)$ – or – • Home screen: Define $y1(x)=1.25x*\cos(x)$ In the Numeric Solver, you then would enter: $y1(x)=0$ or $y1(t)=0$, etc. <div style="border: 1px solid black; padding: 2px; margin-top: 5px; display: inline-block;"> The argument does not have to match the one used to define the function or equation. </div>
Type an expression without an = sign.	$e+f-\ln(g)$ After you press [ENTER] , the expression is set equal to a system variable called exp and entered as: $exp=e+f-\ln(g)$
Recall a previously entered equation or open a saved equation.	Refer to the applicable heading later in this section.

Recalling Previously Entered Equations

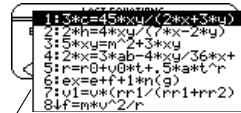
Your most recently entered equations (up to 11 with the default setting) are retained in memory. To recall one of these equations:

1. From the Numeric Solver screen, press **[F5]**.



A dialog box displays the most recently entered equation.

2. Select an equation.
 - To select the displayed equation, press **[ENTER]**.
 - To select a different equation, press **⏴** to display a list. Then select the one you want.
3. Press **[ENTER]**.



Only unique equations are listed. If you re-enter the same equation 5 times, it appears only once.

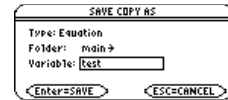
Tip: You can specify how many equations are retained. From the Numeric Solver, press **[F1]** and select 9:Format (or use **TI-89**: **▾** **[1]** **TI-92 Plus**: **▾** **[F]**). Then select a number from 1 through 11.

Saving Equations for Future Use

Because the number of equations that you can recall with **[F5]** Eqns is limited, a particular equation may not be retained indefinitely.

To store the current equation for future use, save it to a variable.

1. From the Numeric Solver screen, press **[F1]** and select 2:Save Copy As.
2. Specify a folder and a variable name for the equation.
3. Press **[ENTER]** twice.



Note: An equation variable has an **EXPR** data type, as shown on the **MEMORY** and **VAR-LINK** screens.

Opening a Saved Equation

To open a previously saved equation variable:

1. From the Numeric Solver screen, press **[F1]** and select 1:Open.
2. Select the applicable folder and equation variable.
3. Press **[ENTER]**.



Variable eqn contains the current equation; it always appears alphabetically in the list.

Defining the Known Variables

After you type an equation in the Numeric Solver, enter the applicable values for all variables except the unknown variable.

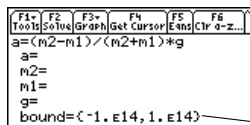
Defining the List of Variables

Note: If an existing variable is locked or archived, you cannot edit its value.

After typing your equation on the **eqn:** line, press **ENTER** or \odot .

The screen lists the variables in the order they appear in the equation. If a variable is already defined, its value is shown. You can edit these variable values.

Enter a number or expression for all variables except the one you want to solve for.

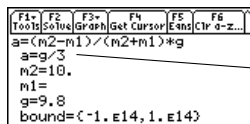


The solution must be within the specified bounds, which you can edit.

Notes and Common Errors

- If you define a variable:

- In terms of another variable in the equation, that variable must be defined first.
- In terms of another variable that is not in the equation, that variable must already have a value; it cannot be undefined.

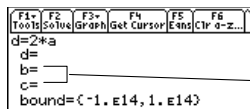


Since a is defined in terms of g, you must define g before a. When you move the cursor to another line, g/3 is evaluated.

- As an expression, it is evaluated when you move the cursor off the line. The expression must evaluate to a real number.

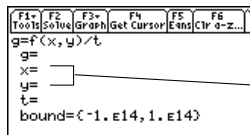
Note: When you assign a value to a variable in the Numeric Solver, that variable is defined globally. It still exists after you leave the solver.

- If the equation contains a variable already defined in terms of other variables, those other variables are listed.



If variable a was defined previously as $b+c>a$, then b and c are listed instead of a.

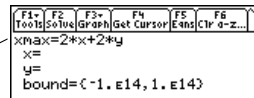
- If you refer to a previously defined function, any variables used as arguments in the function call are listed, not the variables used to define the function.



If $f(a,b)$ was defined previously as $\sqrt{a^2+b^2}$ and your equation contains $f(x,y)$, then x and y are listed, not a and b.

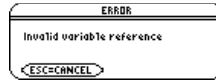
Note: You cannot solve for a system variable other than exp. Also, if the equation contains a system variable, you cannot use $\boxed{F3}$ to graph.

- If the equation contains a system variable (xmin, xmax, etc.), that variable is not listed. The solver uses the system variable's existing value.

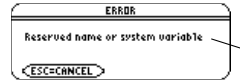


In the standard viewing window, xmax=10.

- Although you can use a system variable in the equation, an error occurs if you use $\boxed{F3}$ to graph the solution.



- If you see the error shown to the right, delete the entered variable value. Then edit the equation to use a different variable.



For example, y1(x) is undefined and you use y1.

Note: This error occurs if you use a reserved name incorrectly or refer to an undefined system function as a simple variable without parentheses.

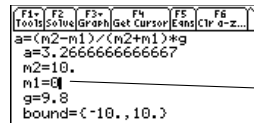
Editing the Equation

In the Numeric Solver, press \odot until the cursor is on the equation. The screen automatically changes to show only the **eqn:** line. Make your changes, and then press $\boxed{\text{ENTER}}$ or \odot to return to the list of variables.

Specifying an Initial Guess and/or Bounds (Optional)

To find a solution more quickly or to find a particular solution (if multiple solutions exist), you can optionally:

- Enter an initial guess for the unknown variable. The guess must be within the specified bounds.
- Enter lower and upper bounds close to the solution.



Initial guess must be within the bounds.

Tip: To select an initial guess graphically, refer to pages 340 and 341.

For the bounds, you can also enter variables or expressions that evaluate to appropriate values (bound={lower,upper}) or a valid list variable that contains a two-element list (bound=list). The bounds must be two floating point elements with the first one less than or equal to the second one.

Solving for the Unknown Variable

After you type an equation in the Numeric Solver and enter values for the known variables, you are ready to solve for the unknown variable.

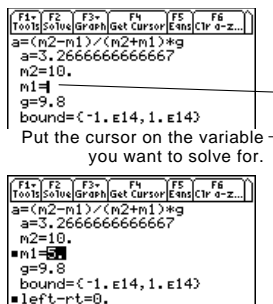
Finding the Solution

Note: To stop (break) a calculation, press \square . The unknown variable shows the value being tested when the break occurred.

With all known variables defined:

1. Move the cursor to the unknown variable.
2. Press \square Solve.

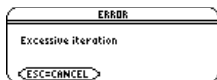
A \blacksquare marks the solution and left-rt. The \blacksquare disappears when you edit a value, move the cursor to the equation, or leave the solver.



Using the solution and your entered values, the left and right sides of the equation are evaluated separately. left-rt shows the difference, which indicates the solution's accuracy. The smaller the value, the more accurate the solution. If the solution is precise, left-rt=0.

If you:	Do this:
Want to solve for other values	Edit the equation or variable values.
Want to find a different solution for an equation with multiple solutions	Enter an initial guess and/or a new set of bounds close to the other solution.
See the message:	Press \square . The unknown variable shows the value being tested when the error occurred.

Note: An iterative process is used to solve an equation. If the iterative process cannot converge on a solution, this error occurs.



- The left-rt value may be small enough for you to accept the result.
- If not, enter a different set of bounds.

Graphing the Solution

You can graph an equation's solutions any time after defining the known variables, either before or after you solve for the unknown variable. By graphing the solutions, you can see how many solutions exist and use the cursor to select an accurate initial guess and bounds.

Displaying the Graph

Tips: With split screens:

- Use $\boxed{2nd} \boxed{[=]}$ to switch between sides.
- The active side has a thick border.
- The toolbar belongs to the active side.

For more information, refer to Chapter 14.

How the Graph Affects Various Settings

Note: If you were previously using different mode settings, you will need to reselect those settings manually.

In the Numeric Solver, leave the cursor on the unknown variable. Press $\boxed{F3}$ and select:

- 1:Graph View
- or –
- 3:ZoomStd
- or –
- 4:ZoomFit

The graph is shown in a split screen, where:

- The unknown variable is plotted on the x axis.
- left-rt is plotted on the y axis.

Solutions for the equation exist at left-rt=0, where the graph crosses the x axis.

You can explore the graph by using the free-moving cursor, tracing, zooming, etc., as described in Chapter 6.

When you use the Numeric Solver to display a graph:

- The following modes are changed automatically to these settings:

Mode	Setting
Graph	FUNCTION
Split Screen	LEFT-RIGHT
Number of Graphs	1

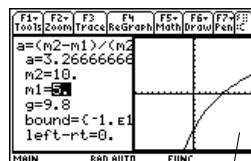
Any functions selected in the Y= Editor will not be graphed.

- All stat plots are deselected.
- After you leave the Numeric Solver, the Graph screen may continue to display the equation's solution, ignoring any selected Y= functions. If so, display the Y= Editor and then return to the Graph screen. Also, the graph is reset when you change the Graph mode or use **ClrGraph** from the Home screen ($\boxed{F4} \boxed{5}$) or a program.



Graph View uses the current Window variable values.

For information about ZoomStd and ZoomFit, refer to Chapter 6.



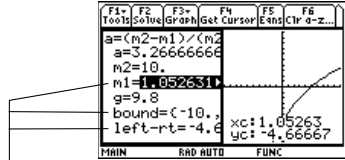
The current graph format settings are used.

Selecting a New Initial Guess from the Graph

Note: Cursor coordinate xc is the unknown variable value, and yc is the left-rt value.

To use the graph cursor to select an initial guess:

1. Move the cursor (either free-moving or trace) to the point that you want to use as the new guess.
2. Use 2nd [F4] to make the Numeric Solver screen active.
3. Make sure the cursor is on the unknown variable, and press F4 .
4. Press F2 to re-solve the equation.



F4 sets the graph cursor's xc value as an initial guess and the yc value as left-rt. The graph's $xmin$ and $xmax$ values are set as the bounds.

Returning to a Full Screen

From the split screen:

- To display the Numeric Solver full screen, use 2nd [F4] to make the solver screen active, press F3 , and then select 2:Clear Graph View.
 - or –
- To display the Home screen, press 2nd [QUIT] twice.

Clearing Variables Before Leaving the Numeric Solver

Tip: Any time you want to clear single-character variables listed in the solver, use:

TI-89: 2nd [F6]

TI-92 Plus: [F6]

When you solve an equation, its variables still exist after you leave the Numeric Solver. If the equation contains single-character variables, their values may inadvertently affect later symbolic calculations. Before leaving the Numeric Solver, you may want to:

1. Press:
 - TI-89:** 2nd [F6]
 - TI-92 Plus:** [F6]
 to clear all single-character variables in the current folder.
2. Press ENTER to confirm the action.

The screen returns to the solver's **eqn:** line.

