Texas Instruments

TI-89/TI-92 Plus/Voyage™ 200
Simultaneous Equation Solver

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What Is Simultaneous Equation Solver?

Simultaneous Equation Solver finds solutions to systems of linear equations. It provides a convenient, easy-to-use interface to simplify setting up a problem, solving it, and exploring the solution. You can:

- Enter, load, and edit coefficient matrices and up to five vectors representing different right sides.

- Store the solution as a vector (an nx1 matrix).

- Display solutions as a list of values or in reduced row echelon form (RREF).

- Solve over-determined systems of equations (systems in which there are more equations than unknowns).

- Solve under-determined systems of equations (systems in which there are fewer equations than unknowns).

- Solve systems containing both numeric and symbolic coefficients.

- Identify whether a given system has a unique solution, an infinite number of solutions, or no solution.
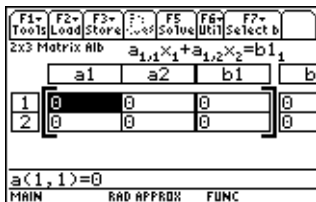
Entering Data

Entering data manually

1. [Start](#) Simultaneous Equation Solver and select **New**.

2. Enter the number of equations and press $\odot$. Values entered in this dialog box must be integers from 2 to 30.

3. Enter the number of unknowns.

4. Press ENTER ENTER to accept the problem size and display the matrix. The first coefficient is selected, and its matrix row and column designators are displayed on the entry line.
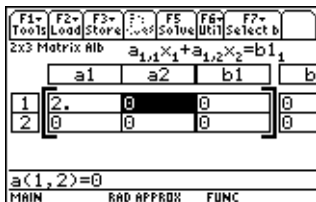
5. Enter the first coefficient and press [ENTER]. The cursor returns to the matrix and moves to the next column (right). You can change the cursor to move to the next row (down) instead in the [FORMATS] dialog box.

You can enter a real or complex value or an expression that resolves to a real or complex value. You can also enter symbolic data.

Loading existing data

You can load an existing matrix as all or part of the problem from within Simultaneous Equation Solver by using either of the following methods.

- Press [F1] **1:Load Augmented A|b**.

- Press [F2] **1:Augmented A|b**, **2:Coefficient A**, **3:Constant b**, or **4:Two Matrices A and b**.

Editing coefficients

1. Move the cursor to a coefficient and press ENTER. The cursor moves to the entry line.

2. Edit the value and press ENTER. The new value appears in the matrix.

Clearing coefficients

Press F1 **8:Clear All**.

Starting a new problem

Press F1 **3:New Problem**.

Solving

1. Enter values for the [coefficient matrix](#) and values for the right side. You can enter $b_1 \ldots b_5$ and then select a different [right side](#).

2. Press $\boxed{\text{F5}}$ to solve the problem. The busy indicator on the status line displays while the solution is calculated. The solution values $x_1 \ldots x_n$ are displayed in the specified Exact/Approx mode. The [RREF](#) of the augmented matrix can be shown instead.
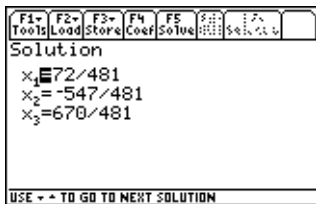
Displayed as list
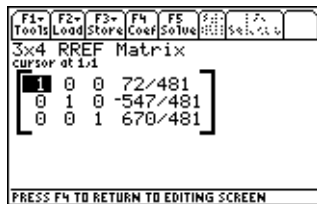
Displayed as RREF

If Angle Format is Degree and Complex Format is Polar, computations are automatically performed numerically.

Storing

Once you have entered the coefficients, you can store:

- The augmented matrix (coefficients and the current right side).

- The coefficient matrix.

- Constant vectors $b_1 \ldots b_5$.

- An individual element of a coefficient matrix or constant vectors.

Once you have calculated the solution, you can also store:

- The solution as a vector (an nx1 matrix).

- An individual element of a solution.

- The RREF matrix.

- The residual vector, provided **Show Residuals** has been set to **YES** in the FORMATS dialog box.

From either the Coefficients screen or Solution screen, press [F3] and select

- **1:Augmented A|b**, select a folder, and enter a name. You can also do this from [F1].

- **2:Coefficient A**, select a folder, and enter a matrix name.

- **3:Constant b**, select a folder, enter a name and indicate which right side contents (vectors $b_1 \ldots b_5$) you want to store. The values are stored as a vector (an nx1 matrix).

- **4:Solution x**, select a folder, and enter a name. The values are stored as a vector (an nx1 matrix).

- **5:RREF Matrix**, select a folder, and enter a name.

- **6:Residuals**, select a folder, and enter a name. The values are stored as a vector (an nx1 matrix).

To store individual coefficients or roots from the Coefficients or Solution screen:

1. Place the cursor on the value you want to store.

2. Press [STO▶].

3. Enter a variable name, and then press [ENTER].

Navigating Within Simultaneous Equation

- $\boxed{\text{ENTER}}$ moves the cursor to the next coefficient in the equation or to the next equation, unless you change the Cursor Movement direction in the FORMATS dialog box.

- Pressing $\boxed{\text{ENTER}}$ after entering $b1_i$ automatically moves the cursor to the next $a_{i,1}$. You can alter the Cursor Movement direction in the FORMATS dialog box.

- $\boxed{\text{F4}}$ returns to the Coefficients screen from the Solution screen.

- $\textcircled{\scriptsize{$\triangleleft$}}$, $\textcircled{\scriptsize{$\triangleright$}}$, $\textcircled{\scriptsize{$\triangle$}}$, or $\textcircled{\scriptsize{$\triangledown$}}$ moves among the coefficients for editing.

- $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangleleft$}}$ or $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangleright$}}$ on the entry line moves the cursor to the beginning or end of the value.

- $\boxed{\uparrow}$ $\textcircled{\scriptsize{$\triangleleft$}}$ or $\boxed{\uparrow}$ $\textcircled{\scriptsize{$\triangleright$}}$ on the entry line highlights characters for copying.

- $\boxed{\bullet}$ $\textcircled{\scriptsize{$\triangleleft$}}$, $\boxed{\bullet}$ $\textcircled{\scriptsize{$\triangleright$}}$, $\boxed{\bullet}$ $\textcircled{\scriptsize{$\triangle$}}$, or $\boxed{\bullet}$ $\textcircled{\scriptsize{$\triangledown$}}$ moves the cursor to the beginning or end of the row or column.

- $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangleleft$}}$, $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangleright$}}$, $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangle$}}$, or $\boxed{\text{2nd}}$ $\textcircled{\scriptsize{$\triangledown$}}$ in the matrix moves the cursor one page.

- Use the $\boxed{\text{2nd}}$ $\boxed{\text{F6}}$ (TI-89) or $\boxed{\text{F6}}$ menu to insert a column or row, delete a column or row, or resize the matrix.

- If the Split Screen mode is set to **Top-Bottom** when the application is started, the TI-89 automatically switches to **Full**; the TI-92 Plus / Voyage™ 200 PLT automatically places the application in the top portion.

- To see the solution displayed in RREF, press [F5] from the Solution screen.

- If another application is running, [2nd] [⊞] toggles between the applications.

Right sides

- To enter additional right sides (b_2 through b_5), use the cursor to move to those cells.

- To select a different right side to use in a calculation, use the [2nd] [F7] (TI-89) or [F7] menu.

- [F3] **1:Augmented A│b** stores only the current b. To store additional right sides separately, use the [F3] **3:Constant b** command.

FORMATS Dialog Box

To display the FORMATS dialog box, press [F1] **9:Format** or shortcut keys [♦] [I] (TI-89) or [♦] F.

Format settings

Column Width: Sets the number of characters to display in each column. The default is 6. (Do not confuse this option with the MODE setting Display Digits, which determines the number of digits displayed.)

Cursor Movement: Determines whether the cursor moves to the next column (right) or next row (down) after data are entered. The default is Right.

Answer in RREF: Sets the default Solution screen display mode when the system is solved the first time. If **NO**, the solution is displayed in list form. If **YES**, the solution is displayed in RREF form. The default is No.

Show Residuals: Toggles display of the residual vector b-Ax, where x is the computed solution. The default is No.

When Show Residuals is set to **YES**, residuals are displayed in the column to the right of b_5 on the Coefficients screen. **|resid|** is the magnitude of the difference between the coefficient matrix times the computed solution and the right side. (For example, $resid_i = a_{i,1} \cdot x_1 + a_{i,2} \cdot x_2 \ldots a_{i,n} \cdot x_n - b_i$, where i=1…n.) The entry line shows the current residual element.

Tolerance: Default sets the tolerance to 5E-14•max(dim(Augmented matrix)) •rownorm(Augmented matrix). **User-Defined** enables the **Tolerance** field, where you can enter a preferred tolerance level.

Example — Three Equations, Three Unknowns

1. Press MODE F2 and set Exact/Approx to **Exact**.

2. Start Simultaneous Equation Solver and select **New**.

3. Press **3 ⊙ 3** ENTER ENTER for a problem with three equations and three unknowns.

4. Enter the coefficients:

$a_{1,1}$ = **9** $a_{1,2}$ = **8** $a_{1,3}$ = **7** $b1_1$ = **2**

$a_{2,1}$ = **5** $a_{2,2}$ = **-6** $a_{2,3}$ = **-4** $b1_2$ = **2**

$a_{3,1}$ = **1** $a_{3,2}$ = **5** $a_{3,3}$ = **9** $b1_3$ = **7**

5. Press F5 to solve the problem. The busy indicator on the status line displays while the solution is calculated.

The values for x_1, x_2, and x_3 are displayed:

x_1 = 72 / 481
x_2 = -547 / 481
x_3 = 670 / 481

Example — Undefined Variable

1. Press $\boxed{\text{MODE}}$ $\boxed{\text{F2}}$ and set Exact/Approx to **Exact**.

2. [Start](#) Simultaneous Equation Solver and select **New**.

3. Press **3** $\odot$ **3** $\boxed{\text{ENTER}}$ $\boxed{\text{ENTER}}$ for a problem with three equations and three unknowns.

4. Enter the coefficients:

   $a_{1,1}$ = **2** $a_{1,2}$ = **3** $a_{1,3}$ = **-2** $b1_1$ = **-3**

   $a_{2,1}$ = **3** $a_{2,2}$ = **-1** $a_{2,3}$ = **unk** $b1_2$ = **-2**

   $a_{3,1}$ = **3** $a_{3,2}$ = **2** $a_{3,3}$ = **-1** $b1_3$ = **-1**

5. Press $\boxed{\text{F5}}$ to solve the problem according to the mode setting. The busy indicator on the status line displays while the solution is calculated.

   The values for x_1, x_2, and x_3 are displayed:

   x_1 = 26/(5∗(5∗unk−7))+3/5
   x_2 = -104/(5∗(5∗unk−7)) −7/5
   x_3 = -26/(5∗unk−7)

6. Press $\boxed{\text{MODE}}$ $\boxed{\text{F2}}$ and set Exact/Approx to **Approximate**.

The solution is automatically recalculated and expressed as:

x_1 = 1.04⁄(unk−1.4)+.6
x_2 = ⁻4.16⁄(unk−1.4) −1.4
x_3 = ⁻5.2⁄(unk−1.4)

Example — Overdetermined Matrix

1. Press $\boxed{\text{MODE}}$ $\boxed{\text{F2}}$ and set Exact/Approx to **Exact**.

2. [Start] Simultaneous Equation Solver and select **New**.

3. Press **5** $\odot$ **3** $\boxed{\text{ENTER}}$ $\boxed{\text{ENTER}}$ for a problem with five equations and three unknowns.

4. Enter the coefficients:

   $a_{1,1}$ = **9** $a_{1,2}$ = **-6** $a_{1,3}$ = **2** $b1_1$ = **6**

   $a_{2,1}$ = **-9** $a_{2,2}$ = **9** $a_{2,3}$ = **-4** $b1_2$ = **-1**

   $a_{3,1}$ = **-9** $a_{3,2}$ = **4** $a_{3,3}$ = **-9** $b1_3$ = **-7**

   $a_{4,1}$ = **-4** $a_{4,2}$ = **-4** $a_{4,3}$ = **9** $b1_4$ = **7**

   $a_{5,1}$ = **1** $a_{5,2}$ = **-9** $a_{5,3}$ = **-7** $b1_5$ = **8**

5. Press $\boxed{\text{F5}}$ to solve the problem. The busy indicator on the status line displays while the solution is calculated.

   The display shows **No solution found**.

6. Press F5 again to view the RREF matrix.

Example — Underdetermined Matrix

1. Press $\boxed{\text{MODE}}$ $\boxed{\text{F2}}$ and set Exact/Approx to **Exact**.

2. [Start] Simultaneous Equation Solver and select **New**.

3. Press **3** $\odot$ **5** $\boxed{\text{ENTER}}$ $\boxed{\text{ENTER}}$ for a problem with three equations and five unknowns.

4. Enter the coefficients:

   $a_{1,1} =$ **3** $a_{1,2} =$ **8** $a_{1,3} =$ **3** $a_{1,4} =$ **1** $a_{1,5} =$ **4** $b1_1 =$ **9**

   $a_{2,1} =$ **-1** $a_{2,2} =$ **-7** $a_{2,3} =$ **-2** $a_{2,4} =$ **7** $a_{2,5} =$ **4** $b1_2 =$ **4**

   $a_{3,1} =$ **-9** $a_{3,2} =$ **-9** $a_{3,3} =$ **-8** $a_{3,4} =$ **2** $a_{3,5} =$ **2** $b1_3 =$ **-2**

5. Press $\boxed{\text{F5}}$ to solve the problem. The busy indicator on the status line displays while the solution is calculated.

The display shows two arbitrary constants (**@1** and **@2**) and an infinite number of solutions expressed in terms of those constants:

$x_1 = {}^-307*@1/32-155*@2/16+15$
$x_2 = {}^-37*@1/32-29*@2/16+3$
$x_3 = 395*@1/32+211*@2/16-20$
$x_4 = @1$
$x_5 = @2$

Errors, Error Messages, and Restrictions

Message	Description
The variables used in the editor need to be defined as real or non-real numbers.	Coefficients can contain undefined variables (variables with no assigned value), but the variable type is limited to real numbers and non-real numbers.
Coefficient A and Constant b matrices do not have the same number of rows.	This occurs only when the matrices specified from [F2] **4:Two Matrices A and b** are incompatible sizes.
Memory	Simultaneous Equation Solver requires at least 6000 bytes of RAM to run properly. When the amount of available RAM falls below this threshold, the application may display an **Error: Memory** dialog box and return to the Home screen or simply exit to the Home screen. If this occurs, archive or delete some variables before returning to the application.
Element value must be a scalar or scalar expression.	Only scalar expressions are accepted as input. When using a variable as input, verify that it is not a list, matrix, or other non-scalar expression. Choose a different variable that is scalar.

Message	Description
Existing variable SMLTDATA is preventing TISMLTEQ from saving its place. Press ENTER to write over the existing variable.	This error message appears when the SMLTDATA variable is archived or locked. Unlock or unarchive the SMLTDATA variable.
TISMLTEQ.simult is incompatible with cylindrical and spherical vector formats and with hex and bin bases.	Change the vector format mode to rectangular and the base mode to DEC (decimal).
Tolerance value must be a nonnegative real number.	User-defined tolerance in the FORMATS dialog box must be zero or a positive real number.

Installing Simultaneous Equation Solver

Detailed Flash application installation instructions are available from education.ti.com/guides.

You will need:

- A TI-89 / TI-92 Plus / Voyage™ 200 PLT with the latest Advanced Mathematics Software Operating System. Download a free copy from education.ti.com/softwareupdates.

- A computer using either Microsoft® Windows® or Apple® Macintosh® operating system software.

- A TI-GRAPH LINK™ computer-to-calculator cable, available for purchase from the TI Online Store at education.ti.com/buy.

- Either TI Connect™ software or TI-GRAPH LINK connectivity software for the TI-89 / TI-92 Plus. Download a free copy from education.ti.com/softwareupdates.

Starting and Quitting the Application

Starting Simultaneous Equation Solver

The instructions in this guidebook refer to this Flash application only. For help using this product, refer to the comprehensive guidebook at education.ti.com/guides.

1. Press APPS and select **Simultaneous Eqn Solver**.

2. Select the problem type from the menu.

   - **Current** returns to the screen you were on when you left Simultaneous Equation Solver.

   - **Open** lets you select an existing matrix as an augmented A|b matrix to use.

   - **New** creates a new problem.

Quitting Simultaneous Equation Solver

Press 2nd [QUIT] from any screen.

Deleting an Application

Deleting an application removes it from the handheld device and increases space for other applications. Before deleting an application, consider storing it on a computer for reinstallation later.

1. [Quit](#) the application.

2. Press [2nd] [VAR-LINK] to display the VAR-LINK [ALL] screen.

3. Press [2nd] [F7] (TI-89) or [F7] to display the list of installed applications.

4. Select the application you want to delete.

5. Press [F1] **1:Delete**. The VAR-LINK delete confirmation dialog box displays.

6. Press [ENTER] to delete the application.

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Page Reference

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