

The following is a file made by Richard White.

## Solving Simultaneous Equations on a TI Calculator

Many physics problems require solving two or more linear equations in two or more unknowns. "Two equations in two unknowns" is a fairly common type of algebra problem that is easily solved by hand:

**Example:**  $3x + 2y = 5$  and  $5x + 4y = 27$

Solve for  $x$  in the first equation to get  $x = (5-2y)/3$   
...substitute into the second equation to get...  
 $5[(5-2y)/3] + 4y = 27$   
...solve for  $y$  to get...  $y = 28$   
...and substitute back into either original equation  
to get....  $x = -17$

Solving two equations in two unknowns is relatively simple, but what about three equations in three unknowns? The procedure is the same -- solve for a variable and substitute into another equation -- but doing it by hand can be tedious and time-consuming. And four equations in four unknowns is ridiculous!

Both the TI-85 and TI-86 graphing calculators have Simultaneous Equation solvers on them, but users of these calculators may find it more convenient to solve simultaneous equations using matrices, following a process similar to the one outlined below. Users of the TI-82 or TI-83 calculators do NOT have Simultaneous Equation solvers on their calculators, but they can still solve these types of problems with matrices. The procedure is simple:

### How to Solve Simultaneous Linear Equations Using Matrices on the TI-83

**1) Arrange the linear equations to be solved so they have the form  $Ax + By = C$ .**  
Example: Using the equations above, we have  $3x + 2y = 5$  and  $5x + 4y = 27$ .

**2) Write these equations in matrix form, using the coefficients A, B, and C to fill in the matrix.**

The matrix for these equations would look like this:

$$\begin{array}{ccc} 3 & 2 & 5 \\ 5 & 4 & 27 \end{array}$$

The first column is a list of the x coefficients, the second column is a list of the y coefficients, and the third column is a list of values.

**3) Turn on the TI-83, hit the [Matrix] key, select "Edit", select the name of a matrix that you want to use to solve this problem (A-J), and hit [Enter].**

Example: We'll say that you've chosen to use matrix A.

**3) Define the size of your matrix.**

Example: In this case, our matrix is two rows-by-three columns, so press "2" [Enter] "3" [Enter]. A problem that requires solving three equations in three unknowns will require a 3x4 matrix.

**4) Enter the coefficients into the matrix in the calculator and then Quit.**

Example: Press "3" [Enter] "2" [Enter] "5" [Enter] "5" [Enter] "4" [Enter] "27" [Enter] [Quit]

**5) Hit the [Matrix] key again, select "Math", select "rref", then hit the [Matrix] key again, select the name of the matrix you're using, and hit [Enter].**

Example: rref([A])

NOTE: You MUST select the matrix name from the Matrix menu -- you cannot simply type in [A]!

This command tells the calculator to display the matrix in "reduced row echelon format". It's not critical that you understand this step, although the mathematical process is pretty cool!

**6) Interpret Your Answer.**

What appears on the calculator screen is this:

$$\begin{bmatrix} 1 & 0 & -17 \\ 0 & 1 & 28 \end{bmatrix}$$

The 1 in the first row, first column is an indication that the value of -17 (at the end of that row) is the solution for the first variable, "x". The 1 in the second row, second column, indicates that the value of 23 is the solution for the second variable, "y". If your matrix solution doesn't have this form, with ones and zeroes in the first columns

and numbers in the last column that represent solutions, than you've done something wrong!

Using matrices to help you find solutions to simultaneous linear equations is one of the ways that graphing calculators can assist your problem-solving in physics. Please make sure, however, that you don't become TOO dependent on the calculator. Being able to manipulate variables and equations "by hand", as well as being able to substitute and solve equations in several unknowns is a valuable skill that cannot be replaced with a calculator, however powerful it may be.

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## How to Solve Simultaneous Linear Equations Using Matrices on the TI-82

**1) Arrange the linear equations to be solved so they have the form  $Ax + By = C$ .**

Example: Using the equations above, we have  $3x + 2y = 5$  and  $5x + 4y = 27$ .

**2) Write these equations in matrix form, using the coefficients A, B, and C to fill in the matrix.**

The matrix for these equations would look like this:

$$\begin{array}{ccc} 3 & 2 & 5 \\ 5 & 4 & 27 \end{array}$$

The first column is a list of the x coefficients, the second column is a list of the y coefficients, and the third column is a list of values.

**3) Turn on the TI-82, hit the [Matrix] key, select "Edit", select the name of a matrix that you want to use to solve this problem (A-E), and hit [Enter].**

Example: We'll say that you've chosen to use matrix A for the coefficient matrix.

**4) Define the size of your coefficient matrix.**

Example: In this case, our coefficient matrix is two rows-by-two columns, so press "2" [Enter] "2" [Enter]. A problem that requires solving three equations in three unknowns will require a 3x3 coefficient matrix.

**5) Enter the coefficients into the matrix in the calculator and then Quit.**

Example: Press "3" [Enter] "2" [Enter] "5" [Enter] "4" [Enter][Quit]

**6) Hit the [Matrix] key, select "Edit", select the name of a second matrix that you want to use to solve this problem (A-E), and hit [Enter].**

Example: We'll say that you've chosen to use matrix B for the value matrix.

**7) Define the size of your value matrix.**

Example: In this case, our value matrix is two rows-by-one column, so press "2" [Enter] "1" [Enter]. A problem that requires solving three equations in three unknowns will require a 3x1 coefficient matrix.

**8) Enter the values into the matrix in the calculator and then Quit.**

Example: Press "5" [Enter] "27" [Enter][Quit]

**9) Hit the [Matrix] key again, select Matrix A, hit [Enter], hit [ $x^{-1}$ ], hit [\*], hit [Matrix], select Matrix B, hit [Enter], then hit [Enter] again.**

Example:  $[A]^{-1} * [B]$

NOTE: You MUST select the matrix name from the Matrix menu -- you cannot simply type in [A]!

This command tells the calculator to invert the first matrix, then multiply it by the second matrix, to get a matrix that lists your solutions in order. It's not critical that you understand this step, although the mathematical process is pretty cool!

**10) Interpret Your Answer.**

What appears on the calculator screen is this:

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[ [-17]
  28]]
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The -17 is the solution for the first variable, "x", and the 28 is the solution for the second variable, "y".

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Using matrices to help you find solutions to simultaneous linear equations is one of the ways that graphing calculators can assist your problem-solving in physics. Please make sure, however, that you don't become TOO dependent on the calculator. Being able to manipulate variables and equations "by hand", as well as being able to substitute and solve equations in several unknowns is a valuable skill that cannot be replaced with a calculator, however powerful it may be.