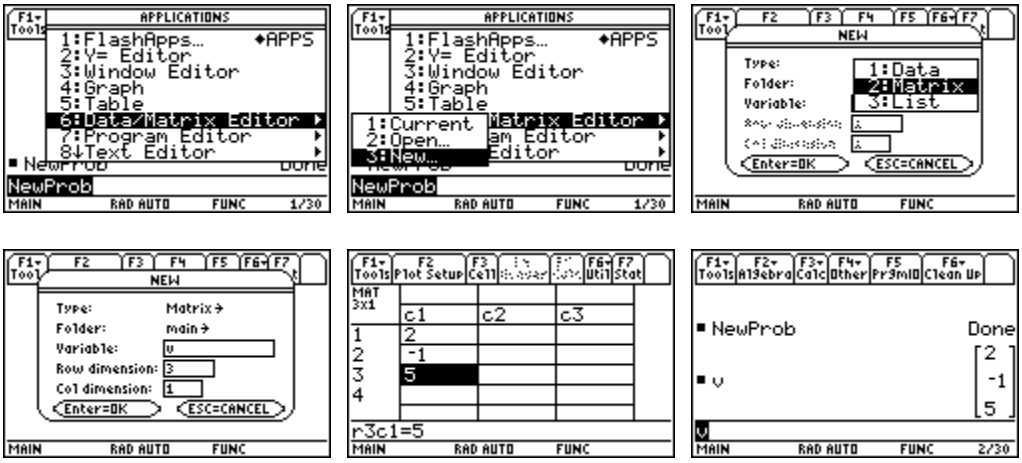
Chapter 1
Vectors

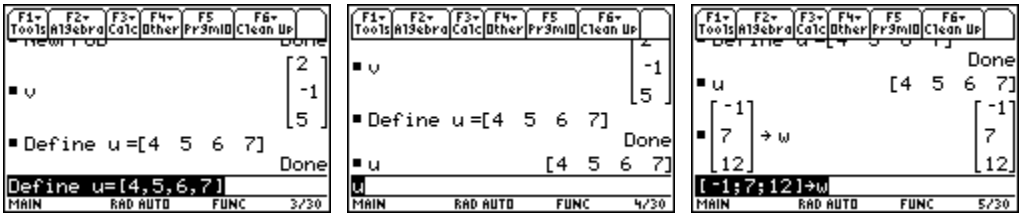
This chapter provides some tips on how to work with vectors on the TI-89 calculator (or the Voyage 200 and older TI-92 Plus handhelds). This is loosely coordinated with Chapter 1 of the text *Calculus with Early Vectors*, by Phillip Zenor, Edward Slaminka, and Donald Thaxton, Prentice Hall, 1999.

1. Storing Vectors in a Matrix

This family of calculators does not provide for vectors as a separate data type. (The TI-85/86 family did have a separate vector data type.) It is possible to store a vector using either a list or a matrix. We will use a list data type later for several other purposes. Generally we will want to store vectors in a matrix, partly because the special vector operations only work on matrices with a single row or a single column. First we look at how to use the Data/Matrix Editor.

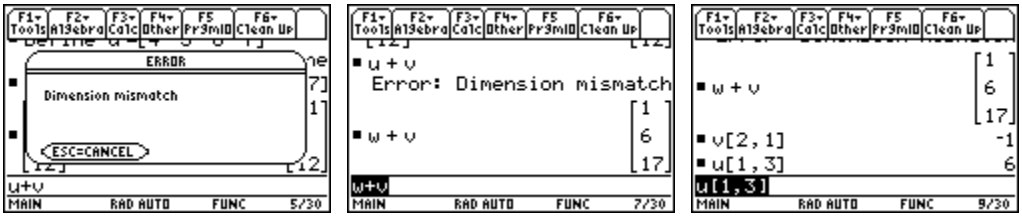


This editor is really more appropriate for a larger matrix, but it can be used. There is an easier way to create a new matrix in the Home screen when it is small.



We use either the F4 Other 1:Define command or the STO➢ key. Square brackets are used, "[" above the comma key and "]" above the divide key. Separating numbers by a comma continues a row, and separating numbers by a semicolon gives a new row. We can represent vectors by

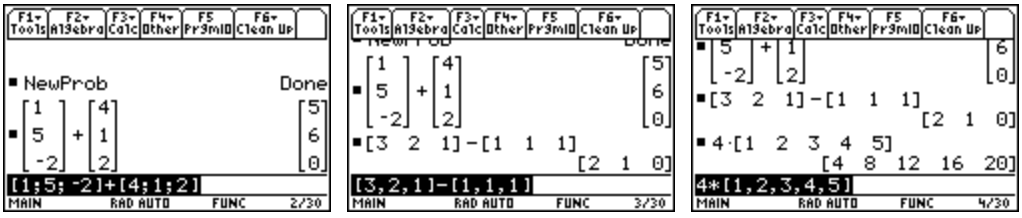
either a row matrix (e.g. *u* above is a 1 row, 3 column or 1×3 matrix) or a column matrix (e.g. both *v* and *w* above are 3×1 matrices). However you cannot mix the two types (row and column matrices) if you wish to perform vector operations such as vector addition.



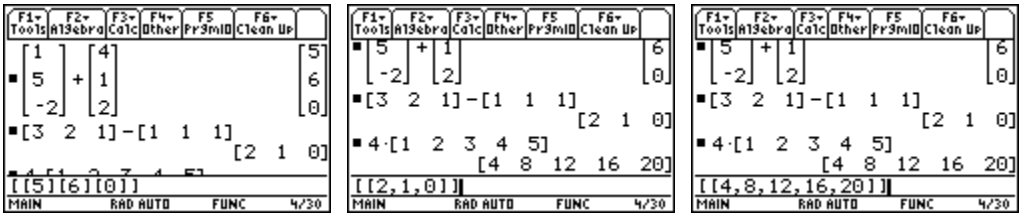
To access an individual component of a vector, it is important to remember that the calculator treats it as a matrix. Thus you must indicate both the row and the column desired (even when the matrix only has one row or one column), as in the third figure above.

2. Vector Operations

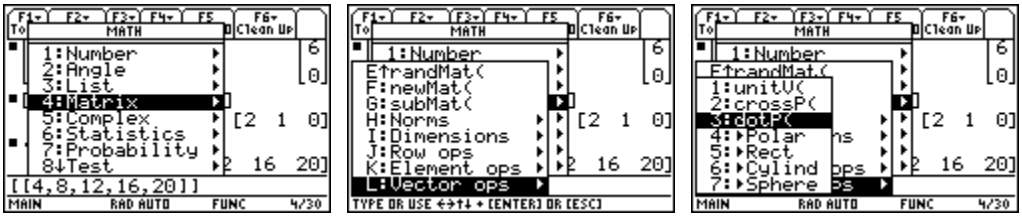
You can add vectors, subtract vectors, and multiply a vector by a scalar in the home screen. In fact, all of these operations work for matrices of the same size.

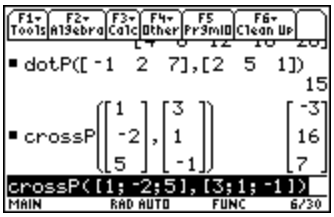


If we cursor up into the history, highlight one of the results above, and press ENTER to paste it down in the command line, we see an alternate way to enter in the matrices using additional square brackets.

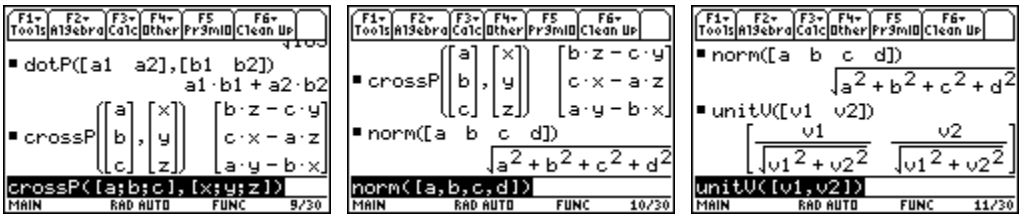


Other vector operations are found in the MATH menu 4:Matrix submenu.



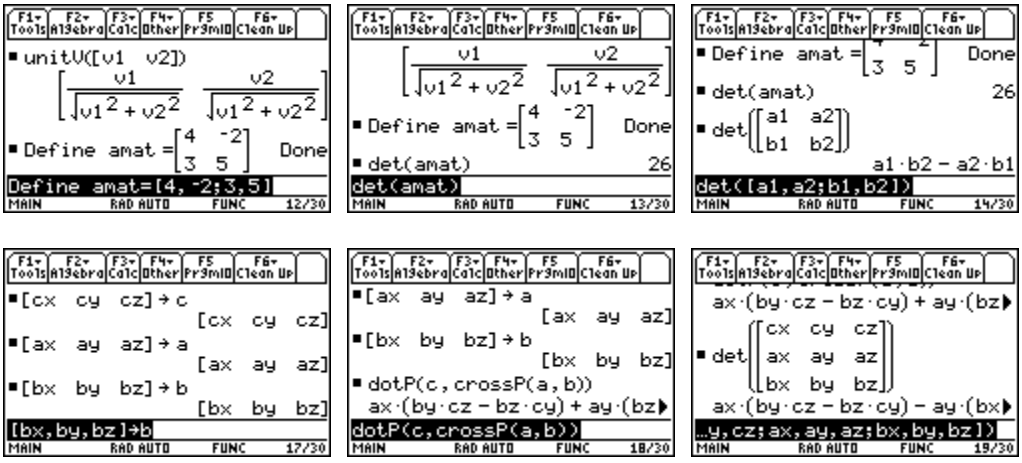


If we use undefined variables as the arguments in the commands, we can see the formula being used for the command.



3. Other Matrices and Determinants

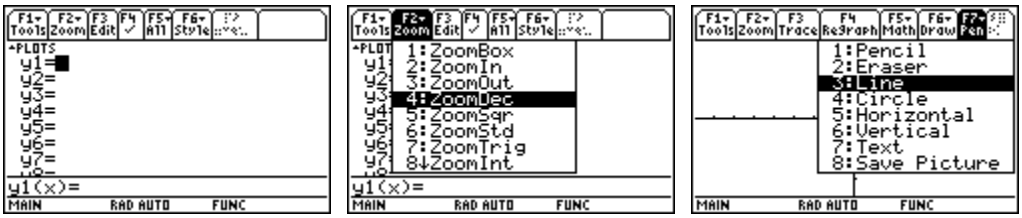
A matrix of any size can be created (either in the Home screen or in the Data/Matrix Editor). If the matrix is square (the same number of rows and columns), then we can compute its determinant. Square matrices and determinants are introduced in this chapter primarily to motivate the cross product of three-dimensional vectors. You will see much more about how matrices are important in multivariate calculus and later courses.



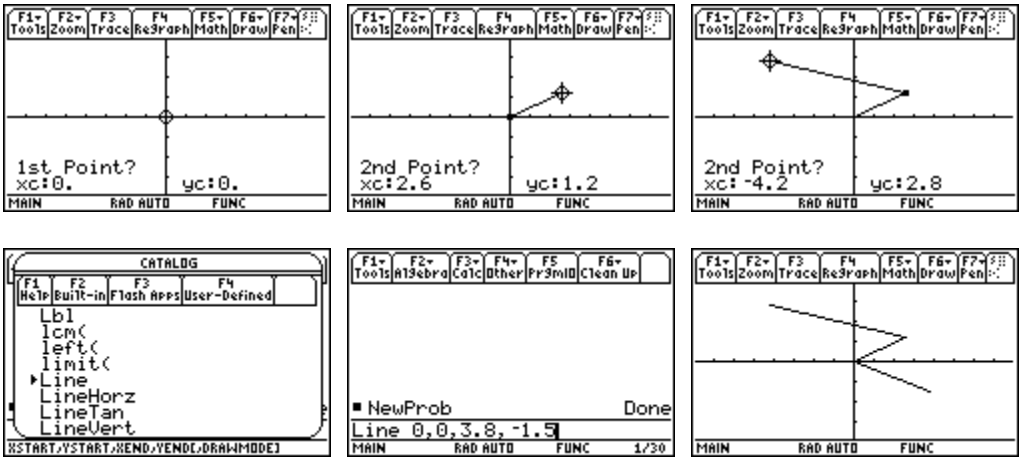
Note that if you scroll up into the history of the last figure to be able to look at the complete results, you will find that the last two answers are the same (but terms appear in slightly different order).

4. Visualization of 2D Vectors

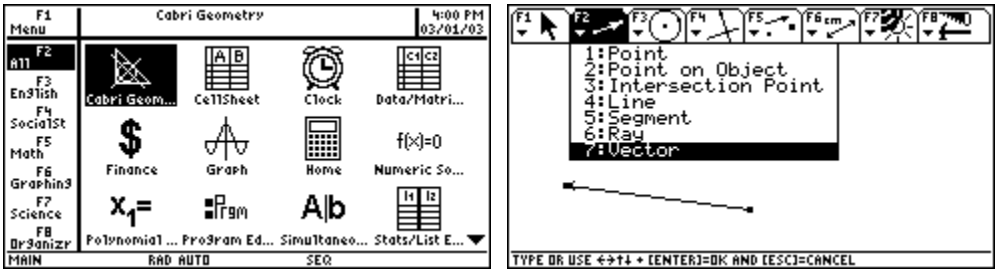
We can put line segments on the Function graph screen to give a visual representation for some of the operations with two-dimensional vectors. Unfortunately there is no easy way to put "arrows" at the ends to indicate the direction. We have no way to add line segments to a 3D plot.



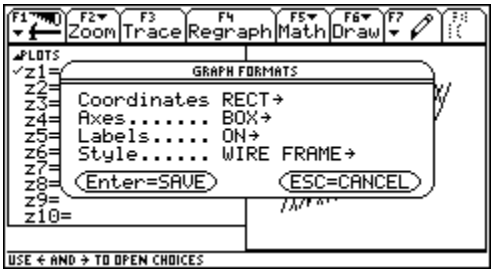
First we clear out (or de-select) all of the function slots in the Y= Editor in Function graphing mode. [Note that the NewProb command will de-select all functions.] We pick a nice square window with the F2 Zoom 4:ZoomDec command so that trace points on the screen will be in nice tenths. Interactively on the graph, we can place line segments with the F7 Pen 3:Line command. We just move the cursor point to the desired location for the beginning point and press ENTER. Then we move to the desired ending point and press ENTER again to complete the line. Press ESC when you want no further lines.

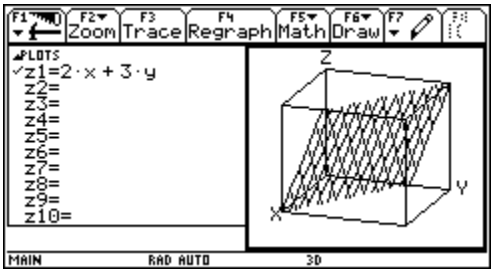


You can issue the Line command from the Home screen or from a program, giving the starting and ending coordinates. Note that all of these lines are "Drawn" objects on the graph. All "Drawn" objects disappear when the graph is resized or redrawn in any way.



If you have the Cabri Geometry application (as the Voyage 200 does), then one of the constructions is a vector. The nice thing about the geometric construction is that you can grab a point (or another object) with the "hand" and move it.





$-10 \le x \le 10, \quad -10 \le y \le 10, \quad -10 \le z \le 10$

The only object that we can visualize in 3D related to vectors is a plane that can be solved for *z*. For example, the last figure above shows the graph of the plane $2x + 3y - z = 0$. We cannot plot a normal vector such as $\vec{v} = [2, 3, -1]$ in the same plot.