

Calculator Lesson 31

The Matrix Menus

Main Menu

In this lesson we will discuss some of the commands in the Matrix menu. This discussion is intended for students in an introductory course in linear algebra. Many of the commands in that menu deal with concepts that are not likely to be encountered by such students and will be omitted from this discussion. Press **LS MTH F2-MATRX** to see the main Matrix menu. The first page of the menu has five submenus that will be discussed below, and the sixth is one of those we will omit from this discussion.

Press **NXT** to find five more commands. Note that **F6-MTH** takes you back to the **MTH** menu. The first command on this page is **F1-RSD**. This command finds the residual $\mathbf{B} - \mathbf{AX}$ of an approximated solution to a system of equations of the form $\mathbf{AX} = \mathbf{B}$ where \mathbf{X} and \mathbf{B} may be vectors or matrices. With \mathbf{B} on level 3, \mathbf{A} on level 2, and \mathbf{X} on level 1, press **F1-RSD**. The closer the entries of the residual are to zero, the better the approximation.

With a square matrix on level 1 the command **F3-EGVL** will produce a vector containing the eigenvalues of a matrix. The command **F2-EGV**, produced not only the vector of eigenvalues, which it leaves on level 1, but also a matrix of eigenvectors, which it leaves on level 2. Each column of the matrix is the eigenvector for the corresponding eigenvalue in the vector.

With a matrix on level 1 the command **F4→DIAG** creates a vector that consists of the diagonal elements of the matrix. The command **F5-DIAG→** requires a vector on level 2 and a list with the dimension of the desired matrix on level 1. Pressing **F5-DIAG→** will produce a matrix of the given dimension with the elements of the given vector as its diagonal elements and all other elements zero. If the give dimension is too small for the given vector, the trailing elements will be ignored. If the given dimension is too big, the rest of the diagonal will be filled in with zeros. For example, with the vector $[1\ 2\ 3]$ on level 2 and the coordinates $\{3\ 4\}$ on level 1, the resulting matrix well be

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 3 & 0 \end{bmatrix}.$$

Press **NXT** to get back to the first page of the main menu.

MAKE Menu

Press **F1-MAKE** to enter the **MAKE** menu. The first command, **F1-CON** will create a matrix with constant values. Place the list with the dimension on level 2 and the desired constant value on level 1, then press **F1-CON**. For example, placing $\{2\ 3\}$ on

level 2 and 3.5 on level 1 will create the matrix $\begin{bmatrix} 3.5 & 3.5 & 3.5 \\ 3.5 & 3.5 & 3.5 \end{bmatrix}$. The next command will

create an identity matrix. Place the desired dimension on level 1 of the stack, press **F2-IDN**, and the requested identity matrix will be created on level 1.

The command F3-TRN will compute the transpose of a matrix. If the matrix has complex elements, it will take the conjugate of those elements.

The next command, F4-RDM, will redimension a matrix according to the following rules. Suppose there is a matrix on level 2 of the stack that is $m \times n$ and the desired new dimension $\{p \ q\}$ is on level 1. The elements of the original matrix are taken starting in the upper left corner, and going across the top row, then the next row, etc. and are placed in the new matrix in the same order. When the elements of a matrix are taken or placed in this order, we say they are being processed in row major order. If pq is less than mn , the trailing elements are lost. If pq is greater than mn , the missing elements are

filled in by zeros. For example, if the original matrix is $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$ and the new dimension is $\{2 \ 4\}$ the resulting new matrix will be $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \end{bmatrix}$. If the new dimension

is $\{4 \ 4\}$ the resulting matrix will be $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$.

With a desired dimension on level 1 of the stack the command F5-RANM will create a random matrix of the desired size. The entries will be integers in the range from -9 to 9 inclusive.

The final command on this page of the menu will return the dimension of the matrix. For example, if there is a 3×4 matrix on level 1 of the stack pressing F6-SIZE will leave $\{3 \ 4\}$ on the stack.

Press NXT for the next page of this menu. Some of these commands are only likely to be used for programming, but they are all presented here for the sake of continuity and completeness.

F1-GET and F2-GETI are used to extract a particular element from the matrix. For GET, the matrix must be on level 2 and the location on level 1. The location can be in the form of coordinates $\{i \ j\}$ or as a single integer called an index. In the latter case the element is picked in row major order. The output is the requested element on level 1 of the stack. For GETI the desired location must be an index and it is selected in row major order. The output leaves the original matrix on level 3, the index increased by 1 is left on level 2, and the desired element is left on level 1.

The F3-PUT and F4-PUTI commands replace a specified element in a matrix with a given value. The matrix must be on level 3, the index (or coordinates in the case of PUT) must be on level 2 and the new value on level one. For PUT the output is the changed matrix on level 1, for PUTI the output is the changed matrix on level 2 and the index increased by 1 on level 1.

The command F5-SUB extracts a sub-matrix of a matrix on level 3 defined by locations on levels 2 and 1. Each location can be a pair of coordinates or an index. The extracted sub-matrix is defined by interpreting the two locations as diagonally opposite corners of the desired sub-matrix. The output is the sub-matrix left on level 1. For

example, with the matrix $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}$ on level 3, 4 on level 2 and {3 2} on level 1,

F5-SUB will output the sub-matrix $\begin{bmatrix} 2 & 3 & 4 \\ 6 & 7 & 8 \\ 10 & 11 & 12 \end{bmatrix}$.

The final command, F6-REPL, replace a portion of a matrix with a given matrix. The original matrix must be on level 3, the location of the upper left corner of the original where the replacement is to be placed, in the form of coordinates or index, must be on level 2, and the replacement must be on level 1. For example, with the matrix

$\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}$ on level 3, {2 2} on level 2 and the matrix $\begin{bmatrix} -6 & -7 \\ -10 & -11 \\ -14 & -15 \end{bmatrix}$ on level 1, the

output will be the matrix $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & -6 & -7 & 8 \\ 9 & -10 & -11 & 12 \\ 13 & -14 & -15 & 16 \end{bmatrix}$ on level 1.

Press NXT to get to the last page of commands in this menu. The first two are the same as \rightarrow DIAG and DIAG \rightarrow found in the main menu and discussed above. With a vector on level 1, the command F3- VANDER will create the Vandermonde matrix that has the given vector as its second column. With a positive integer on level 1, the command F4-HILBE will create the Hilbert matrix of that size. NOTE: To get a better view of a Hilbert matrix you will want the calculator in exact mode when you issue the HILBE command.

Press F6-MATRX to return to the main matrix menu.

NORM Menu

Press F2-NORM to enter this menu. Many of the commands in this menu would be encountered for the first time in a numerical analysis or in a matrix theory course, but elementary linear algebra courses vary significantly in what they cover so these are all included. In each case the input is a matrix on level 1 of the stack. F1-ABS gives the Frobenius norm. F2-SNRM gives the spectral, or ℓ_2 , norm. F3-RNRM gives the row, or ℓ_∞ , norm. F4-CNRM gives the column, or ℓ_1 , norm. F5-SRAD gives the spectral radius. F6-COND gives the condition number. On the next page of this menu F1-RANK gives the rank. F2-DET gives the determinant. F3-TRACE gives the trace. Finally, F4-TRAN gives the transpose of the matrix. It differs from the TRN command found in the MAKE menu in that it does not take the conjugate of complex elements in the matrix.

Press F6-MATRX to return to the main matrix menu.

FACTR Menu

Press F3-FACTR to enter this menu. The only command to be discussed in the menu is the first one. F1-RREF puts a matrix into row reduced echelon form. This is the procedure usually introduced in an elementary linear algebra course for solving systems of linear equations.

Press NXT F6-MATRX to return to the main matrix menu.

ROW Menu

Press F5-ROW to enter this menu. With a matrix on level 1 of the stack, the command F1-→ROW converts the rows of the matrix into vectors which are left in order from top to bottom on the stack and the number of rows is left on level 1 of the stack. With a series of vectors of the same dimension on the stack and a positive integer on level 1 of the stack that gives the number of such vectors, F2-ROW→ combines these vectors into a matrix with the rows in the order of the given vectors. In other words, the command ROW→ reverses the action of →ROW.

With a matrix on level 3, a vector of the appropriate dimension on level 2 and an integer i on level 1, pressing F3-ROW+ will cause the vector to be inserted as a new row i in the matrix. The old row i and all subsequent rows will be moved down one position. The resulting matrix will be left on level 1. With a matrix on level 2 and an integer i on level 1, pressing F4-ROW- will remove row i from the matrix and the rows $i + 1$ and below will be moved up one position. The resulting matrix will be left on level 2 and the removed row will be left as a vector on level 1.

With a matrix on level 3, a constant c on level 2 and a row number i on level 1, pressing F5-RCI will multiply row i by c . With a matrix on level 4, a constant c on level 3, a row number i on level 2 and a row number j on level 1, pressing F6-RCIJ will add c times row i to row j . Press NXT to get to the next page of this menu. With a matrix on level 3, a row number i on level 2 and a row number j on level 1, pressing F1-RSWP will interchange rows i and j .

Press NXT F6-MATRX to return to the main matrix menu.

COL Menu

Press F4-COL to enter this menu. All of the commands in this menu will do for columns what the corresponding row commands mentioned above did for rows.

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