SQUEEZING THE MOST OUT OF CASIO

FX-570ES CALCULATOR FOR MATRIX COMPTATION IN NUMERICAL METHODS

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Abstract
In most examinations, scientific calculator is used to do calculation. As compared to Casio fx-570MS, Casio fx-570ES calculator is more users friendly. The display of the n x m matrix is more natural which is exactly in their mathematical form. This natural textbook display will avoid confusion among students as Casio fx-570MS only shows one line expression. In this paper, a collection of keystroke sequences is illustrated to highlight its features of matrix computation. Once the students can utilize their calculator throughout matrix computation in numerical methods, they can expand their ability to any other problems involving matrix in a similar pattern for any subjects in undergraduate level.
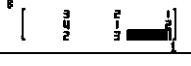
Introduction

When using calculator in a classroom, almost immediately in a picture of a mind is a graphing calculator with all the accessories attached to the big screen display. However, it is not practical if student cannot bring and use the graphing calculator anywhere because it is costly, bulky and heavy. In an examination hall with a large number of students taking numerical method, only a handheld calculator is allowed. As fx-570MS calculator (Guerrero-García & Santos-Palomo, 2008; Tay, 2006) promotes only one line display and soon become outdated, the Casio fx-570ES is an everyday calculator which student can afford to buy. Students need to get the maximum benefit out of this calculator. Not to make the full use of this calculator is such a waste. It can be used in almost all subjects in a university which need calculator. With the help of Casio fx-570ES emulator, lecturers can easily display their keystroke sequences from their laptop in the classroom.
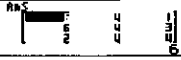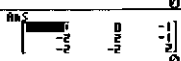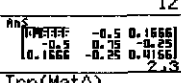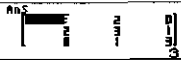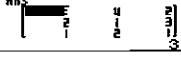
In numerical method, matrix is used in topics such as system of linear equations, eigenvalue-eigenvector, boundary value problem (BVP) in ordinary differential equation (ODE), partial differential equation (PDE) and finite element method (FEM). Not to forget the manual calculation of matrix which was introduced in linear algebra, student will still need a step further using their calculator in solving matrix. With Casio fx-570ES calculator display of the n x m matrix exactly in their mathematical form, students will reduce the amount of time spending in solving related problems.

Matrix
Keystroke sequences of casio fx-570ES for the basic operation of two matrices, A and B.

$$\text{Let} \quad A = \begin{bmatrix} 3 & 2 & 0 \\ 2 & 3 & 1 \\ 0 & 1 & 3 \end{bmatrix} \quad \text{and} \quad B = \begin{bmatrix} 3 & 2 & 1 \\ 4 & 1 & 2 \\ 2 & 3 & 1 \end{bmatrix} \text{. Find } A+B, A-B, AxB, A^{-1}, A^{T} \text{ and } B^{T}.$$

Activity	Keystroke	Calculator Display
Input 3x3 matrix A	[MODE] [6] [1] [1] [3] [=] [2] [=] [0] [=] [2] [=] [3] [=] [1] [=] [0] [=] [1] [=] [3] [=]	
	Press [AC] button to clear screen	
Input 3x3 matrix B	[SHIFT] [4] [1] [2] [1] [3] [=] [2] [=] [1] [=] [4] [=] [1] [=] [2] [=] [2] [=] [3] [=] [1] [=]	
	Press [AC] button to clear screen	
Adding matrix A and B	[SHIFT] [4] [3] [+] [SHIFT] [4] [4]	MatA+MatB

	[÷]	Ans (matrix display)
Press [AC] button to clear screen		
Subtracting matrix A and B	[SHIFT][4][3][−][SHIFT][4][4]	MatA-MatB 0
	[÷]	Ans (matrix display)
Press [AC] button to clear screen		
Multiplying matrix A and B	[SHIFT][4][3][×][SHIFT][4][4]	MatA×MatB 0
	[÷]	Ans (matrix display)
Press [AC] button to clear screen		
Checking if A^{-1} exist, determinant is nonzero.	[SHIFT][4][7][SHIFT][4][3][)][=]	det(MatA) 12
A^{-1}	[SHIFT][4][3][x^{-1}][=]	Ans (matrix display)
The transpose of matrix A, A^T	[SHIFT][4][8][SHIFT][4][3][)]	Trn(MatA) 0
	[÷]	Ans (matrix display)
B^T	[SHIFT][4][8][SHIFT][4][4][)][=]	Ans (matrix display)

System of linear equations

Gauss Elimination Method

Suppose the task is to solve the linear system below by Gauss Elimination method. The keystrokes sequences in Casio fx-570ES is the same as Casio fx-570MS (Tay, 2006), therefore, the keystroke will not be discussed:
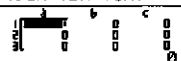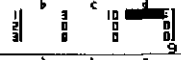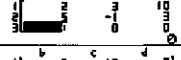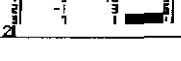
$$2x_1 + 3x_2 + 10x_3 = 9$$
$$5x_1 - x_2 + 3x_3 = 6$$
$$4x_1 + 7x_2 + x_3 = 2$$

According to Tay (2006), the answer should be as

$$x = \begin{pmatrix} 0.660 \\ -0.210 \\ 0.831 \end{pmatrix}$$

Student can use direct solution of 3x3 matrix using Casio fx-570ES for comparing their answer in solving system of linear equations in numerical methods.

Activity	Keystroke	Calculator Display
Entering the linear system	[MODE][5]	1: anX+bnY=Cn 2: anX+bnY+CnZ=dn 3: aX2+bX+C=0 4: aX3+bX2+cX+d=0
	[2]	(matrix display)
First row	[2][=][3][=][1][0][=][9]	(matrix display)
Second row	[=][5][=][(−)][1][=][3][=][6][=]	(matrix display)
Third row	[4][=][7][=][1][=][2]	(matrix display)

	$\div$ $=$	$X=$ $\frac{242}{367}$
	$\div$	$Y=$ $-\frac{77}{367}$
	$\div$	$Z=$ $\frac{305}{367}$

The answer is $\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \frac{242}{367} \\ \frac{-77}{367} \\ \frac{305}{367} \end{pmatrix} = \begin{pmatrix} 0.660 \\ -0.210 \\ 0.831 \end{pmatrix}$ which is the same as $x = \begin{pmatrix} 0.660 \\ -0.210 \\ 0.831 \end{pmatrix}$.

Cholesky Method

To solve the system of linear equations below by Cholesky method, the matrix should be shown first as positive definite.

$$\begin{pmatrix} 3 & 1 & 0 \\ 1 & 3 & -1 \\ 0 & -1 & 3 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \\ 4 \end{pmatrix}$$

In solving the above equations using Cholesky Method, matrix $A = \begin{pmatrix} 3 & 1 & 0 \\ 1 & 3 & -1 \\ 0 & -1 & 3 \end{pmatrix}$ must be symmetric

positive-definite. Theorem: A symmetric matrix A is positive definite if and only if each of its leading principal submatrices has a positive determinant.

Activity	Keystroke	Calculator Display
det $(3)=3>0$		
$\det \begin{pmatrix} 3 & 1 \\ 1 & 3 \end{pmatrix} = 8>0$	[MODE] [6] [1] [5] [3] [=] [1] [=] [1] [=] [3] [=] [SHIFT] [4] [7] [SHIFT] [4] [3] [)] [=]	$^{\wedge}[\quad \vdots \quad \blacksquare]$ 8
$\det \begin{pmatrix} 3 & 1 & 0 \\ 1 & 3 & -1 \\ 0 & -1 & 3 \end{pmatrix} = 21>0$	[MODE] [6] [1] [1] [3] [=] [1] [=] [0] [=] [1] [=] [3] [=] [(-)] [1] [=] [0] [=] [(-)] [1] [=] [3] [=] [SHIFT] [4] [7] [SHIFT] [4] [3] [)] [=]	$^{\wedge}[\quad \vdots \quad \vdots \quad \blacksquare]$ 21

It is shown that the 3x3 matrix above is symmetric positive-definite.

From $A = LL^T$, solve for L and L^T.

$$\begin{pmatrix} 3 & 1 & 0 \\ 1 & 3 & -1 \\ 0 & -1 & 3 \end{pmatrix} = \begin{pmatrix} a & 0 & 0 \\ b & c & 0 \\ d & e & f \end{pmatrix} \begin{pmatrix} a & b & d \\ 0 & c & e \\ 0 & 0 & f \end{pmatrix} = \begin{pmatrix} a^2 & ab & ad \\ ab & b^2+c^2 & bd+ce \\ ad & bd+ce & d^2+e^2+f^2 \end{pmatrix}$$

Activity	Keystroke	Calculator Display
Compare element by element $a^2 = 3, a = ?$	[MODE] [1] [SHIFT] [MODE] [1] [ALPHA] [)] [x^2] [ALPHA] [CALC] [3]	$X^2=3\vert$
$a^2 = 3, a = X$	[ALPHA] [CALC]	Solve for X 0
	[$\div$]	$X^2=3$ X= 1.732050808 L−R= 0
$ab = 1, b = ?$	[ALPHA] [)] [ALPHA] [(-)] [ALPHA] [CALC] [1]	$XA=1\vert$
$a = X, b = A$	[ALPHA] [CALC]	A? 0.5773502692

$ad = 0, d = 0$	Manually	0
		0
$b^2 + c^2 = 3, c = ?$ $c = B$	[ALPHA] [•••] [ALPHA] [CALC] [√■] [3] [─] [ALPHA] [(─)] [CALC] [=]	$B = \sqrt{3 - A^2}$ $\frac{2\sqrt{6}}{3}$
$bd + ce = -1, d = 0, e = -1$ $e = D$	[ALPHA] [sin] [ALPHA] [CALC] [(─)] [1] [÷] [ALPHA] [•••] [=]	$D = -1 \div B$ $-\frac{\sqrt{6}}{4}$
$d^2 + e^2 + f^2 = 3, f = ?$ $f = M$	[ALPHA] [M+] [ALPHA] [CALC] [√■] [3] [─] [ALPHA] [sin] [x^2] [CALC] [=]	$M = \sqrt{3 - D^2}$ $\frac{\sqrt{42}}{4}$

From $LY = b$, solve Y by forward substitution:

$$\begin{pmatrix} 1.732 & 0 & 0 \\ 0.577 & \frac{2\sqrt{6}}{3} & 0 \\ 0 & -\frac{\sqrt{6}}{4} & \frac{\sqrt{42}}{4} \end{pmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{pmatrix} 1 \\ 2 \\ 4 \end{pmatrix}$$

Using direct solution from Casio fx-570ES,

$$y = \begin{pmatrix} 0.577 \\ 1.021 \\ 2.855 \end{pmatrix}$$

From $L^T x = Y$, solve x by backward substitution:

$$\begin{pmatrix} 1.732 & 0.577 & 0 \\ 0 & \frac{2\sqrt{6}}{3} & -\frac{\sqrt{6}}{4} \\ 0 & 0 & \frac{\sqrt{42}}{4} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 0.577 \\ 1.021 \\ 2.855 \end{pmatrix}$$

Using direct solution from Casio fx-570ES,

$$x = \begin{pmatrix} -0.096 \\ 1.286 \\ 1.762 \end{pmatrix}$$

Advantages and Shortcomes of Casio fx-570ES calculator

Casio fx-570ES calculator helps educators and students in solving numerical methods. Its helps to reduce the amount of time spend in solving the tasks given in the class. Even though it is designed for a system of maximum 3x3 matrix, it helps student a lot in the examination hall. For more than 3x3 matrix, student should use other resources such as EXCEL, MATHCAD, MAPLE, MATLAB, MATHEMATICA or C Programming. Hence users can extend the concept presented here to a system of n linear equations.

Conclusion

Several examples of solving matrix in numerical methods are shown in this paper. As some of the keystrokes sequences for Casio fx-570ES are the same as Casio fx-570MS in the book written by Tay, (2006), the steps to solve specific topic are not described. For future research on squeezing the most out of Casio fx-570ES calculator, more topics on numerical method will be studied.

References

Tay, K.G. (2006). *How To Use Calculator Casio FX-570MS In Numerical Methods*. Batu Pahat: Penerbit KUiTTHO.

Guerrero-García, P. & Santos-Palomo. Á. (2008, June). *Squeezing the most out of the casio fx-570ms for electrical/electronics engineers*. Paper presented at the Proceedings of the International Conference on Computational and Mathematical Methods in Science and Engineering, Spain.

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