INSTRUCTION MANUAL

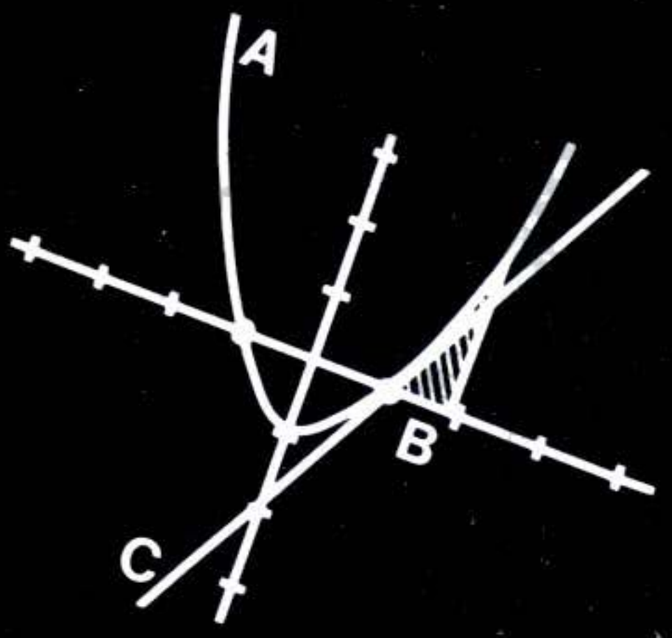
ENGINEERING MATH III

PCALC

A. $F(x) = X^2 - 1$

B. $\int_1^2 F(x)dx = \frac{4}{3}$

C. $\frac{d}{dx} F(1) = 2$



SIMEQ

$3x + 2y - z = 2$

$x - y + 2z = 4$

$-x + 3y + z = 3$

$X = 0.8621$

$Y = 0.6552$

$Z = 1.8966$

CAT. NO. 26-3527

Radio Shack

TRS-80

POCKET COMPUTER SOFTWARE

ENGINEERING MATH III PROGRAM

Engineering Math III

Radio Shack®
A DIVISION OF TANDY CORPORATION
FORT WORTH, TEXAS 76102

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Table of Contents

Introduction

Engineering Math III consists of two programs:

Program	Description
SIMEQ	Linear simultaneous equations
PCALC	Polynomial math and calculus

The functions of the programs are as follows:

SIMEQ solves systems of up to nine linear simultaneous equations for all unknowns. It can also be used to complete a Gaussian reduction of matrices from 2×2 to 9×9.

PCALC provides common polynomial functions and calculus solutions for polynomials to the ninth order. Included are evaluation of the polynomial at any point, calculation of an exact derivative at any point, calculation of an exact integral between any two points, and Newtonian root search.

At the end of each section of the manual, there is a description of the program variables. These may be useful if you want to examine intermediate results. Use the Backup instructions in Appendix B to make a working copy of this tape. See Appendix C for Maintenance instructions.

Simultaneous Equations

This program will solve up to eight simultaneous equations, and can also be used to perform Gaussian reduction on arrays up to 9 × 9. The simultaneous equations are assumed to be linear in the general form:

$$E(1,1)*X(1) + E(1,2)*X(2) + \ ... \ + E(1,n)*X(n) = C(1)$$
$$E(2,1)*X(1) + E(2,2)*X(2) + \ ... \ + E(2,n)*X(n) = C(2)$$
$$\vdots$$
$$E(n,1)*X(1) + E(n,2)*X(2) + \ ... \ + E(n,n)*X(n) = C(n)$$

The variable names E, X, and C are consistent throughout the program with the single exception of the edit routine, in which C(i) is treated as E(i,0). This was done to save memory and to allow both sets of variables to be edited with the same routine.

The following beep codes are used throughout the program:

1 Beep: Awaiting Input
2 Beeps: Solution Completed
3 Beeps: Bad Input or Error

Starting the Program

To load SIMEQ, insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to DEF, then type:
[C][L][O][A][D][″][S][I][M][E][Q][″] and press [ENTER]. After the prompt sign (>) appears, press [SHFT][SPC]. The first display will be the program title: SIMULTANEOUS EQUATIONS. Press [ENTER] and the copyright notice will be displayed briefly before the menu appears:

```
(C) 1981 TANDY CORP.
NEW, LIST, CHG, SOLVE
```

Each function is called by pressing the appropriate shift-letter:

[SHFT][N] for New problem
[SHFT][L] for List data
[SHFT][C] for Change (edit) data
[SHFT][S] for Solve.

Three additional special-purpose commands are not shown:

[SHFT][Z] is used to redisplay the answers after the solution.

(SHFT)(X) is a direct jump from the List function to the editor if an error is found.
(SHFT)(M) is a direct exit from any routine (except SOLVE) straight to the menu.

All are described in detail below.

All seven commands are summarized at the end of these instructions.

Entering a New Set of Commands

Press (SHFT)(N). It is not necessary to clear the program first.

The program will first ask the number of equations to be solved: N? Reply with the appropriate number (from two to eight, inclusive).

Next the program will load the data, asking for rows from top to bottom and each coefficient E(i,j) within a row from left to right. Each constant C(i) is loaded at the end of its row of coefficients E(i,j). The prompt to start a new row is a single beep and brief display of the message: ROW n. The prompt for each E(i,j) in the row is a question mark: ? The prompt for the constant C(i) at the end of the row is: =?

When all rows have been loaded, control will return to the menu.

This routine may be terminated at any prompt by pressing (SHFT)(M).

If a number is not entered for a prompt (by only pressing (ENTER)), it will default to zero.

Listing the Data

You may list the data loaded with the command (SHFT)(L). Data will be displayed in the order it was entered: rows from top to bottom, columns within a row from left to right, and constants at the end of each row. The display format for an array element is: E(I.J.)= ... , the display for a constant is: C(I.)= ... . Each display will be held until you press (ENTER), then the next item will be displayed. After the entire data set has been displayed, you will return to the menu.

It is also possible to jump directly from the list routine to the editor with (SHFT)(X) (see below), to examine the value of a single array element or constant with the editor (described below), and to display the constants alone with the command (SHFT)(Z) (described below).

You may exit this routine (without loss of data) by entering a shift-letter command at any display, including (SHFT)(M) to jump directly back to the menu.

Changing Data (Editing)

This routine is called with the command (SHFT)(C) and it allows any array element E(i,j) or constant C(i) (here addressed as E(i,0)) to be examined and/or changed. On entry it will ask which element is to be changed with the prompt: ELEMENT? Enter a two-digit integer, where the first digit identifies the row and the second the column. (Address a constant by specifying column zero.) For example, E(1,1) is addressed as element 11, E(7,3) as element 73, and C(4) as element 40.

An illegal entry (one that would lie outside the specified bounds of the array or which is not an integer) will be rejected and: ELEMENT? will be repeated.

Once you have identified which element the editor is to work with, the editor will display it in the format: E(I.J.) = ... Press (ENTER) and the editor will ask: NEW VALUE? Here either enter the desired value to make a change, or just press (ENTER) to leave the element unchanged and return to: ELEMENT? If an incorrect entry is made and the element is still known to be wrong, you may return directly to: NEW VALUE? by pressing (SHFT)(X).

This routine is exited normally to the menu by pressing (ENTER), without a numerical entry, in response to: ELEMENT? It may also be exited at any display or input point by entering any other shift-letter command.

The editor may be entered directly from the List function by pressing (SHFT)(X). In this case, the editor will go directly from the display of: E(I.J.) = ... to: NEW VALUE?, then stay in the edit mode until exited normally.

Note: If an incorrect value is entered, you may return directly to: NEW VALUE? by pressing (SHFT)(X) again.

Solving the Equations

Once all the data are correctly loaded, press (SHFT)(S) to solve for each unknown. When all computations are complete, the program will beep twice and start listing the values of the unknowns in the format: X(I.) = ... Each display is held until (ENTER) is pressed, when the program displays the next. When all the unknowns have been listed, DONE will be displayed and control will return to the menu.

Not all sets of simultaneous equations have solutions. In general, these fall into two cases: one in

which there simply is no solution at all, and one in which there is an infinite number of solutions. In either case, the condition will be detected and the program will beep three times and display: UNSOLVABLE. Press [ENTER] to return to the menu.

If you should miss the solution for some reason, the answers may be recovered easily. Turn the computer back "ON" if it has shut itself off during an unused period, then press [SHFT][Z] to redisplay the answers.

Solution time is dependent upon the number of equations to be solved, varying from about 2.5 seconds for two equations to a maximum of about four and a half minutes for eight. If a zero occurs on the diagonal of a reduced row and the program has to swap rows, computation will take longer.

Accuracy in all cases is at least eight significant digits. The internal accuracy limitations of the Pocket Computer (any one operation may have a small inaccuracy in the tenth digit) may allow some error to accumulate during the repeated arithmetic operations involved in the solution. The greatest error will accumulate when many operations are performed, i.e. when large numbers of equations are being solved.

Using the Program to Perform Gaussian Reduction

This may be done easily. Just load in the array with the [SHFT][N] command (the constants C(i) are unimportant in this application), then press [SHFT][S]. Upon completion of the solution, the array will exist in the program in fully reduced (triangular) form and can be listed with [SHFT][L].

Jumping From One Routine to Another

Any routine, except the solution algorithm, may be exited whenever the program is displaying or asking for information. Simply press any of the shift-letter commands. [SHFT][M] will always return directly to the menu.

Accidental Entry of Incorrect Commands

Any routine, except SOLVE, may be exited at any display or input point with [SHFT][M], which will jump directly to the menu without loss or change of any data.

Note: If the Load routine is exited abnormally, the current E(i,j) will be set to zero.

If [SHFT][X] (intended to jump from listing to editing) is used incorrectly, the prompt: NEW VALUE? will still appear, but it is uncertain which element will be edited—it depends on what the program was doing when the command was called. If [SHFT][X] should be pressed accidentally, you may recover without changing any data by either:

a. Pressing [ENTER] in response to: NEW VALUE? to get to: ELEMENT? Then, either press [ENTER] again to get to the menu, or specify a valid element number to edit.

b. Pressing [SHFT][M] to jump directly to the menu.

If [SHFT][Z] (intended to reprint an answer set) is pressed accidentally, the answers listed will be valid **only** if none of the constants have been entered or edited since the last time SOLVE was used. Otherwise, just about anything could be listed. You may jump to the menu with [SHFT][M] when X(1.) is displayed.

If any normal option except [SHFT][S] is called by mistake ([SHFT][N], [SHFT][L], [SHFT][C]), you may return to the menu by pressing [SHFT][M] at the first display.

If [SHFT][S] is pressed accidentally, the program may only be stopped with the [BREAK] key. If you jump to any other routine (including menu display) after use of the [BREAK] key, the data will be destroyed. To complete the solution, type: [C][O][N][T] and press [ENTER]. The solution will go to completion.

If any other shift-command is entered, it will cause an error display (2.....) to appear. This error can be cleared without data loss by first pressing the red [CLR] key, then pressing [SHFT][M] to re-enter the program at the menu.

Sample Use of the Program

Solve the following three simultaneous equations:

$$+3*X1 - 1*X2 - 2*X3 = 1$$
$$-1*X1 + 6*X2 - 3*X3 = 0$$
$$-2*X1 - 3*X2 + 6*X3 = 6$$

The coefficients E(i,j) and constants C(i) would be:

$$+3 \quad -1 \quad -2 \quad +1$$
$$-1 \quad +6 \quad -3 \quad 0$$
$$-2 \quad -3 \quad +6 \quad +6$$

During the solution of these equations, the program dialogue would be:

Computer displays:	**You type:**
	SHFT SPC
SIMULTANEOUS EQUATIONS	ENTER
(C) 1981 TANDY CORP.	Displays briefly
NEW, LIST, CHG, SOLVE	SHFT N
N=?	3 ENTER
(BEEP)	
ROW 1.	Displays briefly
?	3 ENTER
?	− 1 ENTER
?	− 2 ENTER
=?	1 ENTER
(BEEP)	
ROW 2.	Displays briefly
?	− 1 ENTER
? (an error is made)	9 ENTER
?	− 3 ENTER
=?	Ø ENTER
(BEEP)	
ROW 3.	Displays briefly
?	− 2 ENTER
?	− 3 ENTER
?	6 ENTER
=?	6 ENTER

Computer displays:	**You type:**
NEW, LIST, CHG, SOLVE	SHFT L (just to check)
E(1.1.)=3.	ENTER
E(1.2.)=−1.	ENTER
E(1.3.)=−2.	ENTER
C(1.)=1.	ENTER
E(2.1.)=−1.	ENTER
E(2.2.)=9. (error is noted)	ENTER
E(2.3.)=−3.	ENTER
C(2.)=0.	ENTER
E(3.1.)=−2.	ENTER
E(3.2.)=−3.	ENTER
E(3.3.)=6.	ENTER
C(3.)=6.	ENTER
NEW, LIST, CHG, SOLVE	SHFT C (to edit E(2,2))
ELEMENT?	2 2 ENTER
E(2.2.)=9.	ENTER
NEW VALUE?	6 ENTER
ELEMENT?	ENTER
NEW, LIST, CHG, SOLVE	SHFT S (14 seconds delay to solve)
(BEEP-BEEP)	
X(1.)=3.	ENTER
X(2.)=1.999999999	ENTER
X(3.)=3.	ENTER
DONE	ENTER
NEW, LIST, CHG, SOLVE	

Note that X(2) was solved as 1.999999999. The actual solution is 2. Remember that this program gives eight significant digits but the Pocket Computer displays up to ten! Rounding 1.999999999 to eight significant digits gives 2.0000000.

Command Summary

[SHFT][N]—Load new data. Exits to menu after load. If stopped, current element is set to zero, all others are preserved.

[SHFT][L]—List all data. Exits to menu after complete list. If stopped, no data is lost.

[SHFT][C]—Change data. Exits to menu if [ENTER] is pressed in response to ELEMENT? prompt. If stopped, no data is lost.

[SHFT][S]—Solve data. Exits to menu through list-answer routine after solution. Stopped only with [BREAK]. If command other than [C][O][N][T]inue follows [BREAK], data is destroyed.

[SHFT][M]—Direct jump to menu from any point except Solve. Preserves all data except when called from Load, in which case current datum is set to zero and all others are preserved.

[SHFT][Z]—Before solution, lists constants only. After solution, relists answers. If stopped, no data is lost.

[SHFT][X]—From List display, asks NEW VALUE? for item just displayed. From ELEMENT? question in Edit, asks NEW VALUE? for element last edited. If stopped, no data is lost.

Variable List

A-E—Temporary Internal Use (Loop Counters, etc.)
F—Number of Equations to be Solved
G—Dummy to Hold Temporary Subscripts
H—Hold Array Data

Array Indices

$C(i) = A(7 + i)$
$E(i,j) = A(7 + 8i + j)$

Note that $E(i,i) = A(7 + 9i)$
and that if $c = 7 + i$
then $A(i,j) = A(7 + 8i + j) = A(c + 7i + j)$.

This is a faster-executing form.

X(i) are placed in C(i) as they are solved.

Polynomial Math

This program performs basic polynomial math functions with polynomials up to the ninth order. Operations available include evaluation of the polynomial at a chosen point, calculation of its derivative at a point, calculation of its integral between any two points, and approximation of a root near a point by Newton's method.

This program handles all polynomials as ninth order in the following format:

$$Y = JX^9 + IX^8 + HX^7 + GX^6 + FX^5$$
$$+ EX^4 + DX^3 + CX^2 + BX + A$$

Polynomials of order lower than the ninth are handled by setting the higher exponent coefficients equal to zero.

Running the Program and Using the Menu

To load PCALC, insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to DEF, then type: [C][L][O][A][D]["][P][C][A][L][C]["] and press [ENTER]. After the prompt sign (>) appears, press [SHFT][SPC]. The first display will be the program title: POLYNOMIAL MATH. Press [ENTER] and the copyright notice will be displayed briefly before the menu appears:

```
(C) 1981 TANDY CORP.
CLEAR PROGRAM: SHFT-K
SET COEFFICIENTS: SHFT-C
EVALUATE F(X): SHFT-F
EVAL DERIVATIVE: SHFT-D
EVAL INTEGRAL: SHFT-G
SEARCH FOR ROOT: SHFT-S
```

As each option is displayed, you may either press [ENTER] to skip to the next option, or press the appropriate shift letter to execute the displayed option. If the end of the menu is reached, SHFT-Z TO RE-ENTER MENU will be displayed and the program will end. This is to prevent repetitive menu listings being printed if the Pocket Computer has a printer attached. Just press [SHFT][Z] to restart the menu.

After execution of any routine specified in the menu, the program will stop and display the normal BASIC "ready" prompt (>). This means PCALC is ready for your next command. Enter a command, or press (SHFT)(Z) to reprint the menu, or (SHFT)(X) to exit the program.

Note: It is not necessary to cause the menu to display an option in order to execute that option. The computer will recognize a shift-letter command any time program execution is stopped for display or input.

Clearing the Program

Press (SHFT)(K). This sets all coefficients to zero. PROGRAM CLEARED will be displayed, then the program will await the next command.

Setting Coefficients

Press (SHFT)(C). This allows the user to enter or change the coefficients, A through J, and is the means for entering or changing a polynomial in the program. The program will first display: COEFFICIENT INPUT, then: ESCAPE W/ NULL EXPONENT, then ask: EXPONENT? (0-9). Reply with the exponent whose coefficient you wish to enter or change.

Next, the program will ask: COEFFICIENT? Enter the desired coefficient for the selected exponent. As a safety check, the program will display the exponent and coefficient just entered in the format: C.X ^ E., and wait for you to press (ENTER) so it will know you've read the display, then return to the: EXPONENT? (0-9) question for the next data.

When all the coefficients are set as desired, press (ENTER) in response to the: EXPONENT? (0-9) question and the program will stop and await the next command.

Example

Enter the polynomial equation $Y = 3X^2 - X - 6$

Computer displays:	**You type:**
	(SHFT)(SPC)
POLYNOMIAL MATH	(ENTER)
(C) 1981 TANDY CORP.	Displays briefly
SELECT FUNCTION:	Displays briefly
CLEAR PROGRAM: SHFT-K	(SHFT)(K)
PROGRAM CLEARED	(SHFT)(C)
COEFFICIENT INPUT	Displays briefly
ESCAPE W/ NULL EXPONENT	Displays briefly
EXPONENT? (0-9)	(2)(ENTER)
COEFFICIENT?	(3)(ENTER)
3.X ^ 2.	(ENTER)

Computer displays:	You type:
EXPONENT? (0-9)	1 ENTER
COEFFICIENT?	− 1 ENTER
−1.X ^ 1.	ENTER
EXPONENT? (0-9)	Ø ENTER
COEFFICIENT?	− 6 ENTER
−6.X ^ 0.	ENTER
EXPONENT? (0-9)	ENTER

Evaluating the Polynomial at a Point

This option is selected by pressing SHFT F. The program will display: EVALUATE F(X), then ask: EVALUATE AT? Reply with the point at which you wish the function evaluated. The program will take a few seconds for calculations, then beep and display both x and F(x) in the format: F(x.)= ... Press ENTER to end this display, and the program will stop and await the next command.

Example

Evaluate the polynomial just entered at X = 4.

Computer displays:	You type:
	SHFT F
EVALUATE F(X)	Displays briefly
EVALUATE AT?	4 ENTER
(BEEP)	
F(4.)=38.	

Evaluating the Derivative of a Polynomial

This option is selected by pressing SHFT D. The program will display: EVALUATE DERIVATIVE, then ask: EVALUATE AT? Reply with the point at which you wish the derivative to be calculated. The program will take a few seconds for calculations, then beep and display X and D/DX F(x) in the format: D/DX F(x.)= ... Press ENTER to end this display. The computer will await the next command.

Example

Using the same equation as before, evaluate its derivative at X = −1.

Computer displays:	You type:
	SHFT D
EVALUATE DERIVATIVE	Displays briefly
EVALUATE AT?	− 1 ENTER
(BEEP)	
D/DX F(−1.)=−7.	

Evaluating the Integral of a Polynomial

This option is selected with (SHFT)(G). The program will display: EVALUATE INTEGRAL, then ask: LOWER LIMIT and: EVALUATE AT? Reply with the lower limit of integration. Next it will display: UPPER LIMIT and ask: EVALUATE AT? Enter the upper limit of integration. There will be a few seconds delay while calculations are made, then a beep and the results will be displayed. Press (ENTER) to end the display, and the program will stop and await the next command.

Example

Evaluate the integral of the previously entered function from 0 to 4.

Computer displays:	**You type:**
	(SHFT)(G)
EVALUATE INTEGRAL	Displays briefly
LOWER LIMIT	Displays briefly
EVALUATE AT?	(Ø)(ENTER)
UPPER LIMIT	Displays briefly
EVALUATE AT?	(4)(ENTER)
(BEEP)	
INTEGRAL=32.	

Approximating a Root Near a Point

This option is called with (SHFT)(S). The program will display: ROOT SEARCH, then display: START SEARCH FROM: and ask: EVALUATE AT? Reply with the point around which you wish to search for a root. The program will make a first approximation of the root and beep, then display briefly: APPROX ROOT AND F(R):, then display the approximate root and actual evaluation of the polynomial at that approximate root.

Press (ENTER) to end this display, and the program will show: SHFT-X IF OK, ELSE NULL. If the approximation is close enough, press (SHFT)(X) to stop the program and await the next command. Otherwise press (ENTER), and the program will make another approximation and repeat the display.

Note: This option uses Newton's method of root approximation. It will not always converge to a root. The exceptional cases where it won't are:

1. F(x) is positive and the initial point is a minimum. The algorithm will halt.

2. F(x) is negative and the initial point is a maximum. The algorithm will halt.

3. F(x) is negative and the initial point lies below a maximum. The algorithm will converge to the maximum and halt.

4. F(x) is positive and the initial point lies above a minimum. The algorithm will converge to the minimum and halt.

5. The function has no real roots. The algorithm will converge to a maximum if F(x) is negative or a minimum if F(x) is positive.

This algorithm may diverge near a maximum or minimum of a polynomial which has no real roots. This algorithm will converge faster for lower-order polynomials than for higher-order. For first-order functions, the first approximation is exact within machine accuracy.

Newton's method will not work at a maximum or minimum, since the next approximation would entail division by zero. If the program should encounter a zero derivative, it will stop and display briefly: MAX OR MIN ENCOUNTERED, then display the point and the function's value at that point. Press [ENTER] to return to the menu.

Example

Using the previous polynomial, find a root near X = 3.

Computer displays:	**You type:**
	[SHFT][S]
ROOT SEARCH	Displays briefly
START SEARCH FROM:	Displays briefly
EVALUATE AT?	[3][ENTER]
(BEEP)	
APPROX ROOT AND F(R):	Displays briefly
1.941176471 3.363321803	[ENTER]
SHFT-X IF OK, ELSE NULL	[ENTER]
(BEEP)	
APPROX ROOT AND F(R):	Displays briefly
1.625284368 2.99363E-01	[ENTER]
SHFT-X IF OK, ELSE NULL	[ENTER]
(BEEP)	
APPROX ROOT AND F(R):	Displays briefly
1.591078071 3.51021E-03	[ENTER]
SHFT-X IF OK, ELSE NULL	[ENTER]
(BEEP)	
APPROX ROOT AND F(R):	Displays briefly
1.59066735 5.0493E-07	[ENTER]
SHFT-X IF OK, ELSE NULL	[ENTER]
(BEEP)	
APPROX ROOT AND F(R):	Displays briefly
1.590667291 8.6E-10	[ENTER]
SHFT-X IF OK, ELSE NULL	[SHFT][X]

Technical Information

Default Input Values

Exponents: None, exits to menu
Coefficients: Retains old value
All points of evaluation except lower limit of integration: Retain old value
Lower limit of integration: Assumes old upper limit

Variable List

A-J—Coefficients
M—F(x)
N—d/dx F(x)
O—Integral of F(x)
P—Incomplete Calculation Holder
R,S—Sign Flags for Exponentiation of Negative Numbers
U—1st-Iteration Flag in Root Finder
V—Evaluation Parameter and Lower Limit of Integration
W—Lower Limit of Integration
Y—Dummy
Z—Dummy and Counter for Loops

Appendix A

The four Engineering Math packages consist of nine programs designed to handle a variety of algebraic and elementary calculus problems. The contents of the packages are:

Package	Program	Description
Engineering Math I (26-3525)	GAUSS	Gaussian matrix reduction
	MATMUL	Matrix multiplication
	MATINV	Matrix inversion
Engineering Math II (26-3526)	VECTOR	Vector arithmetic
	COMPLEX	Complex arithmetic
	ADVMATH	Advanced trig and exponentials
Engineering Math III (26-3527)	SIMEQ	Linear simultaneous equations
	PCALC	Polynomial math and calculus
Engineering Math IV (26-3528)	TRIANG	Solution of triangles

The functions of the programs are as follows:

GAUSS—Can complete a Guassian reduction of a square matrix from 3 × 3 to 10 × 10, display the reduced matrix, and calculate its determinant.

MATMUL—Will multiply an I × J matrix by a J × K matrix, displaying an I × K matrix as the product. IJ + JK must be less than or equal to 108.

MATINV—Will calculate the inverse of a square matrix, from 3 × 3 to 6 × 6.

VECTOR—Provides all common vector operations in three dimensions in both Cartesian and polar coordinates: addition, subtraction, dot product, cross product, angle between two vectors, and direct conversion of a vector between rectangular and polar coordinate systems. Chain operations are allowed. The mode may be changed between polar and rectangular at any point during program execution without adversely affecting intermediate results.

COMPLEX—Provides for the most common complex number arithmetic operations: addition, subtraction, multiplication, division, calculation of magnitude, conjugation, base-e logarithms, e to complex powers, sines, cosines, arc sines, and arc cosines. Chain operations are allowed.

ADVMATH—Provides 24 common trig functions in degree or radian measure. It also provides logarithms to any base and an exponentiation function which can raise negative numbers to positive or integral negative powers.

SIMEQ—Solves systems of up to nine linear simultaneous equations for all unknowns. It can also be used to complete a Gaussian reduction of matrices from 2×2 to 9×9.

PCALC—Provides common polynomial functions and calculus solutions for polynomials to the ninth order. Included are: evaluation of the polynomial at any point, calculation of an exact derivative at any point, calculation of an exact integral between any two points, and Newtonian root search.

TRIANG—Will solve for the three common unknown triangles (side-side-side, side-angle-side, angle-side-angle) and also can solve from three Cartesian coordinates. TRIANG solves for all sides and angles in any angular unit (degrees, radians, or grads), calculates area, and tests for equilateral, right, Isoscoles, obtuse, and scalene properties.

Appendix B—Making a Backup

A Backup is a tape copy of a program and is an extremely effective method of insuring that an accident or equipment fault will not result in the loss of software. Your first action as owner of the Engineering Math III Package should be to make working copies of the original cassette(s) and then put the originals away in a safe place.

Although it may be possible to make direct copies using two cassette recorders or on cassette duplicating equipment, the most reliable method is to use the computer itself to make the Backups. Also, for frequently used programs, you may wish to put them on separate cassettes for easier loading. Here are step-by-step instructions for making a Backup:

1. Connect the Cassette Interface to the cassette recorder and install the computer in the Cassette Interface.

2. Place the cassette containing the program(s) to be copied in the recorder and either rewind the tape to the beginning or position the tape to a blank area just prior to the desired program. Place the recorder in the "Play" mode. It is recommended that the volume control setting be between 8 and 10 on your recorder. If your recorder has a tone control, set it at maximum treble.

3. Turn on the computer, make sure that it is either in the DEF mode or RUN mode and type in: [C][L][O][A][D][″] name [″] (name refers to the name of the program to be copied). To make absolutely sure that the program has loaded correctly, use the loading verification procedure as described in the sixth instruction of this appendix.

4. When the program has been loaded into the computer and the cassette has stopped, remove the cassette and replace it with the cassette which is to receive the program copy. Either rewind the tape to the beginning or position it to the point where the copy is to start. You should leave about ten seconds of blank space if the copy is to follow another program on the same cassette. Place the recorder in the "Record" mode.

5. Make sure that the computer is in either the DEF or RUN mode and type in: [C][S][A][V][E][″] name [″]. The recorder will save your program.

6. Now rewind the cassette to the blank space just prior to the program, put the recorder into the "Play" mode and type in: [C][L][O][A][D][?][″] name [″].

This is the computer's verifying function. The recorder will start and compare the cassette copy with the program in the computer's memory. If the copy is good, the recorder will stop at the end of the program and the prompt sign (>) will reappear on the display. If an error occurred during the verification, the display will show an error message such as: 5.....

If the error message appears on the display, check the recorder volume setting and try the CLOAD? function once more. If you still get an error, the tape copy is probably damaged. Use the CSAVE function once more and verify the load. It is recommended that you use Radio Shack Supertape or TRS-80 certified cassettes for backing up your Pocket Computer programs.

7. Backup each program using Steps 1 through 6 above.

8. Put the original cassettes away in a safe place and use them only for making working copies.

Appendix C—Maintenance

Maintenance of your Pocket Computer System is not difficult. Attention to the simplest points listed below should provide the best reliability and satisfaction:

1. Keep your program cassettes in their boxes when not in use. Do not expose cassettes to temperature extremes or magnetic fields. Never touch the exposed surface of the tape on the front edge of the cassette.

2. Clean and demagnetize the tape heads in the recorder at regular intervals. Follow the recommendations in the cassette recorder's manual.

3. The most reliable loading and saving is achieved by operating the cassette recorder on AC current, rather than batteries.

4. Use only fresh alkaline-type batteries in the recorder and Cassette Interface when operating your system away from AC current.

5. Always press the recorder's "Stop" key immediately after loading or saving a program. This will release the pressure on the rubber roller which pulls the tape and prevent the roller from developing a permanent "flat" at the point of contact with the tape.

6. Always turn the computer "OFF" before installing it in or removing it from the Cassette Interface.

7. After removing the computer from the Cassette Interface, be sure to reinstall the protective plug to keep dirt out of the connector on the computer. Never touch the exposed parts on the Cassette Interface.

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NOTE: Good data processing procedure dictates that the user test the program, run and test sample sets of data, and run the system in parallel with the system previously in use for a period of time adequate to insure that results of operation of the computer or program are satisfactory.

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