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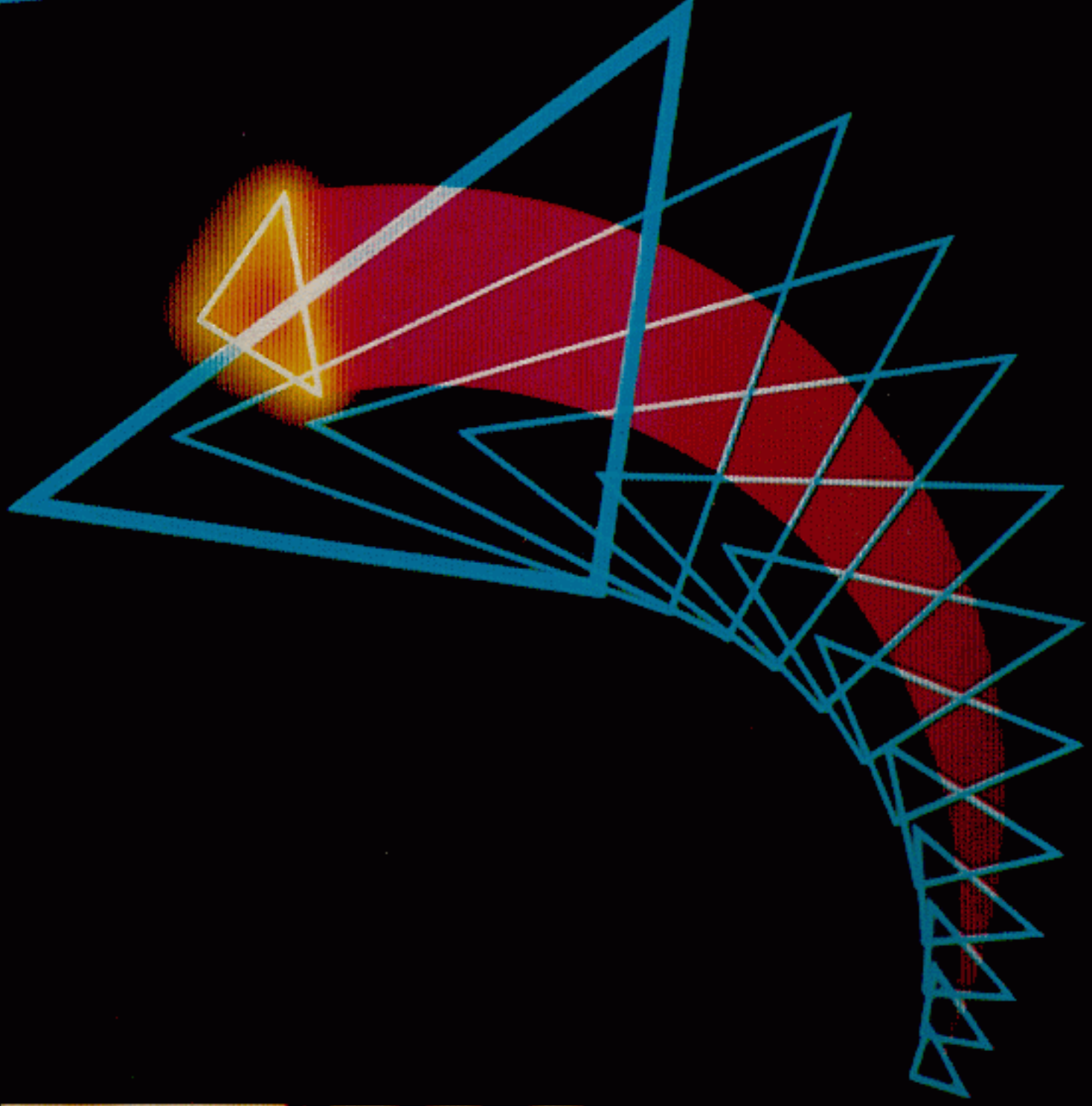
MATH I



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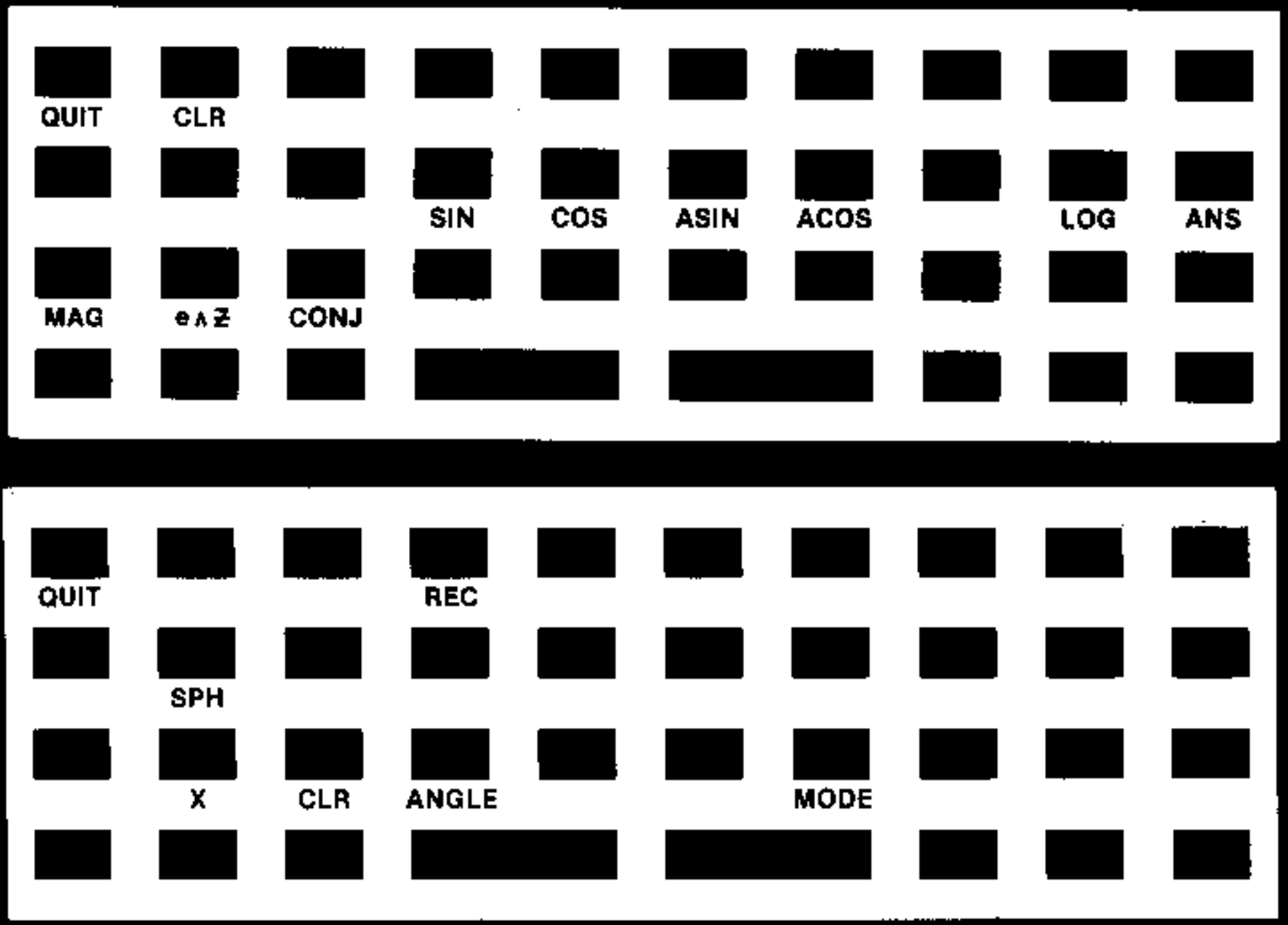
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Math Pak I

Radio Shack®
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FORT WORTH, TEXAS 76102

Table of Contents

Introduction

Math Pak I consists of five programs:

Program	Description
TRIANGLE	Solution of triangles
COMPLEX	Complex arithmetic
VECTOR	Vector arithmetic
ADVMATH	Advanced trigonometry and exponentials
PCALC	Polynomial math and calculus

The functions of these programs are:

TRIANGLE Solves for the three common unknown triangles (side-side-side, side-angle-side, angle-side-angle) and can also solve for triangles based on three Cartesian coordinates. TRIANGLE 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.

COMPLEX Provides for the most common complex number arithmetic operations: addition, subtraction, multiplication, division, magnitude calculation, conjugation, natural logarithms, natural antilogs (e raised to complex powers), sines, cosines, arc sines, and arc cosines. Chain operations are allowed.

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

ADVMATH Provides 24 common trigonometric and hyperbolic functions in degree or radian measure. (Hyperbolic functions must be measured in radian units.) It also provides logarithms to any base, as well as an exponentiation function that can raise negative numbers to positive or integral negative powers. Chain operations are allowed.

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

At the end of each section of the manual are descriptions of the program variables. These may be useful if you want to examine intermediate results.

Backing Up Your Programs

The first thing you should do as owner of the Math Pak I package is make a copy, or backup, of your program tape(s). This assures that you will not lose important program information due to accident or mishap. Detailed instructions for making a backup are in Appendix A.

Using User-Defined Keys

The Pocket Computer-2 gives you a means of customizing the keyboard to fit your specific needs. The keys (F 1) through (F 6) can be defined to automatically perform special functions (such as changing the sign of a number) or represent a constant or other number you frequently use. Using user-defined keys can save time and make entries easier.

For example, in the ADVMATH program, you can quickly calculate e^2 by defining the (F 1) key to represent 2.718281828. When you run the program and are asked for the base number, you may then press (F 1) to generate the constant 2.718281828 instead of typing in the entire number manually.

For detailed instructions on setting up the user-defined keys, please refer to your Pocket Computer-2 Owner's Manual.

Triangle Solutions

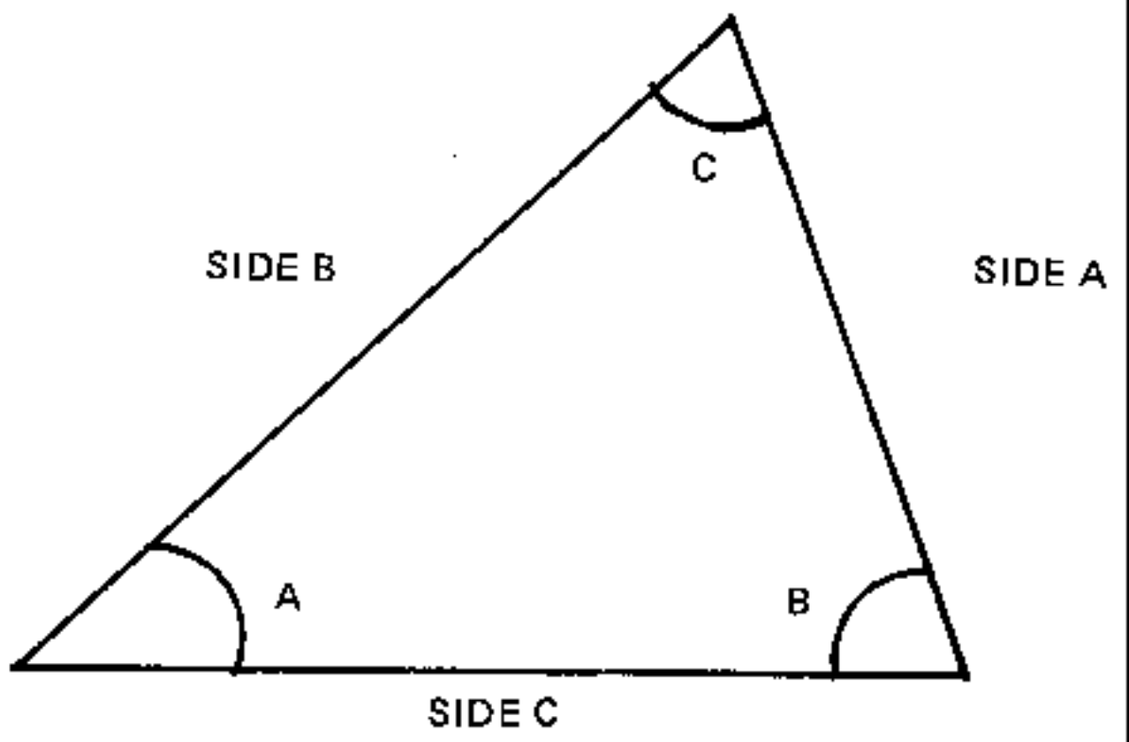
TRIANGLE can solve triangles and test them for certain properties, given any of four data sets:

- The lengths of three sides (SSS, side-side-side)
- The lengths of two sides and the size of the included angle (SAS, side-angle-side)
- The length of one side and the sizes of the angles on each end of that side (ASA, angle-side-angle)
- The locations of the three vertices of a triangle in Cartesian (rectangular) coordinates

When provided with any one of these data sets, the program will calculate all unknown sides and angles, calculate the triangle's area, and test the triangle for equilateral, isoscoles, right, scalene, and/or obtuse properties.

All calculations are carried out at the maximum available precision, which is generally nine or more significant digits. All results are displayed to ten digits, although to allow for the small errors inherent in some functions, sides and angles are rounded to seven digits in logical testing for being right, equilateral, etc.

The three sides of the triangle are A, B, and C. The angle opposite any side has the name of the side, so angle A is opposite side A and lies between sides B and C.



Calculations may be made using any angular units: degrees, radians, or grads. However, if the angular mode is changed, the program must be restarted.

To load the TRIANGLE program, insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to RUN, then type:

(C)(L)(O)(A)(D)(")(T)(R)(I)(A)(N)(G)(L)(E)(")

and press (ENTER). After the prompt sign (>) appears, type: (R)(U)(N) and press (ENTER).

Note: To start the program without losing any data in the Pocket Computer II's memory, or to start over after changing the angular mode, press (DEF)(SPACE) instead of using the RUN command.

The program's name is displayed, along with a copyright notice. Next, the menu appears, corresponding with function keys on the computer directly beneath each option listed on the screen:

TRIANGLE SOLUTIONS
Copr. 1982 Tandy Corp.
SSS SAS ASA 3PT END

To solve a triangle for which the lengths of the three sides are known (SSS), press (F 1).

To solve a triangle for which the lengths of two sides and their included angle are known (SAS), press (F 2).

To solve a triangle for which two angles and the length of their included side is known (ASA), press (F 3).

To solve a triangle for which the vertices' coordinates are known (3PT), press (F 4).

To exit the TRIANGLE program, press (F 5).

After completion of any problem, TRIANGLE will return to the menu, and you may choose another option.

Note: To prevent the display from returning to the menu while you are viewing a solution, press and hold down any key other than (ON) ((BREAK)). The display freezes as long as you hold down the key and returns to the menu when the key is released.

SSS Option

Press F1 to solve a triangle for which the lengths of the three sides are known. The program asks for the sides' lengths, in order A-B-C. Type the lengths of the sides, pressing ENTER after each entry. The display then lists the three angles and the characteristics of the triangle. Afterward, the menu reappears.

SAS Option

Press F2 to solve a triangle for which two sides and their included angle are known. These are assumed to be sides A and C and angle B. The program asks for the length of side A, the angle B, and the length of side C. Type the answers, pressing ENTER after each answer. After solution, the program displays the two unknown angles and the unknown side, the triangle's characteristics, and then returns to the menu.

ASA Option

Press F3 to solve a triangle for which one side and the two angles adjacent to that side are known. These are assumed to be angles A and C and side B. The program first asks for angle A, then side B, and finally angle C. Type the answers, pressing ENTER after each answer. After solution, the program displays the unknown angle and the two unknown sides, the triangle's characteristics, and then returns to the menu.

3 Points Option

Press F4 if the coordinates of a triangle's vertices are known. TRIANGLE assumes the three vertices are called A through C and that each has coordinates (X,Y). Angle A is that associated with vertex A, etc. The program asks for vertex A's X and Y coordinates, vertex B's coordinates, and vertex C's coordinates. Type the answer to each question, pressing ENTER after each answer. The program solves for all three sides and all three angles, and displays the solutions and triangle characteristics before returning to the menu.

Examples

Note: All examples for this section are calculated in DEG mode.

1. Solve a triangle with known side lengths of 8, 6, and 11.

Computer displays:	You type:
>	RUN ENTER
TRIANGLE SOLUTIONS Copr. 1982 Tandy Corp. SSS SAS ASA 3PT END	F1
Side A?__	8 ENTER
Side B?__	6 ENTER
Side C?__	11 ENTER
Angle A = 45.2071663 Angle B = 32.15720861 Angle C = 102.6356251 Area = 23.41874249 Obtuse Scalene SSS SAS ASA 3PT END	

2. Solve a triangle in which side A = 10, side C = 12, and angle B = 45 degrees.

Computer displays:	You type:
SSS SAS ASA 3PT END	F2
Side A?__	10 ENTER
Angle B?__	45 ENTER
Side C?__	12 ENTER
Side B = 8.61941834 Angle A = 55.12133308 Angle C = 79.87866692 Area = 42.42640687 Scalene SSS SAS ASA 3PT END	

3. Solve a triangle with a side of 12.7 and two adjoining angles of 40 degrees and 35 degrees.

Computer displays:	You type:
SSS SAS ASA 3PT END	F3
Angle A?__	40 ENTER
Side B?__	12.7 ENTER
Angle C?__	35 ENTER
Angle B = 105 Side A = 8.451376307 Side C = 7.541387282 Area = 30.78169043 Obtuse Scalene SSS SAS ASA 3PT END	

4. Solve a triangle whose vertices are at points (3,7), (-1.5,7), and (17,-4).

Computer displays:	You type:
SSS SAS ASA 3PT END	F4
Vertex A X-coord?_	3 ENTER
Vertex A Y-coord?_	7 ENTER
Vertex B X-coord?_	- 1 . 5 ENTER
Vertex B Y-coord?_	7 ENTER
Vertex C X-coord?_	1 7 ENTER
Vertex C Y-coord?_	- 4 ENTER
Side A = 21.52324325	
Side B = 17.80449381	
Side C = 4.5	
Angle A = 141.8427735	
Angle B = 30.73548761	
Angle C = 7.421738869	
Area = 24.74999994	
Obtuse	
Scalene	
SSS SAS ASA 3PT END	F5 (to exit the program)
>	

Variable List

A, B, C — Sides A, B, and C
D, E, F — Angles A, B, and C
G, H, I, J, K, L — Vertex Coordinate Holders
  G, H — Vertex A
  I, J — Vertex B
  K, L — Vertex C
N — Logical Value During Testing of Triangle
X — Mode-Constant Right Angle
Y — Mode-Constant 180-Degree Angle
Z — Dummy

Complex Arithmetic

COMPLEX allows complex numbers to be added, subtracted, multiplied, divided, or conjugated. It also allows calculation of natural (base-e) logarithms, natural antilogarithms, sines, cosines, arc sines, and arc cosines. These functions may be used in conjunction with the program's chaining capability to complete almost any calculation using complex numbers.

Note: This program starts and runs **only** in RADIAN mode. All trigonometrical and exponential functions assume radian input and display radian results. Attempting to reset the mode to DEGREE or GRAD will result in inaccuracies in trigonometrical and exponential functions.

To load Complex Arithmetic, set the Remote switch of the Printer/Cassette Interface to ON. Insert the tape in the recorder, and press the "Play" key. Turn the computer on, make sure the mode is set to RUN, then type:

(C)(L)(O)(A)(D)(")(C)(O)(M)(P)(L)(E)(X)(")

and press (ENTER). After the > appears, start the program by typing: (R)(U)(N) and pressing (ENTER).

Note: To start the program without losing any data in the Pocket Computer-2's memory, press (DEF)(SPACE) instead of using the RUN command.

First, the program title and copyright notice will be displayed, and next the command prompt, > Ready, will appear. Select the operation you want to perform by pressing the associated key:

(+) to ADD
(-) to SUBTRACT
(*) to MULTIPLY
(/) to DIVIDE
(C) to CONJUGATE
(Z) to calculate MAGNITUDE
(L) to calculate LOGARITHM
(X) to calculate ANTILOG
(F) to calculate SINE
(G) to calculate COSINE
(H) to calculate ARC SINE
(J) to calculate ARC COSINE
(=) to REDISPLAY LAST ANSWER
(Q) to exit the program

Pressing any other key will display the error message: UNDEFINED OPERATION. To clear this message, press (ENTER). > Ready will appear, and you can choose an option.

COMPLEX uses the rectangular notation convention in the form (A + Bi). The same input routine is used for all operations. The first question is: 1st number real?__. Enter the real portion of the first number.

Next is: 1st number imaginary?__. Reply with the imaginary part of the first number. If the chosen operation is monadic (one that requires only one operand), the Input routine will end at this point.

Note: You may use the result of the last computation as an operand by pressing ENTER in response to 1st number real?__. If this is done, the input routine will load the result of the last computation as the first operand of the new operation and skip to 2nd number real?__.

Next comes 2nd number real?__ and 2nd number imaginary?__. When all data has been entered, the computer will beep once when the answer is ready and display the result with the real portion on the left half of the display and the imaginary portion on the right. Press ENTER to return to the > Ready prompt.

The second number may be kept unchanged, in whole or in part, by pressing ENTER in response to 2nd number real?__ and/or 2nd number imaginary?__. In either case, when ENTER is pressed, the old value of the number asked for will be displayed briefly and retained.

In computing conjugates and magnitudes, only one operand is used. Press ENTER in response to 1st number real?__ to use the last result as the operand. Otherwise, enter the number normally.

When computation is complete, the result will be displayed, with the real portion on the left half of the screen and the imaginary portion on the right. Press ENTER to return to the > Ready prompt.

Examples

1. Add (3 + 4i) and (2 - 1).

Computer displays:	**You type:**
> Ready	+
Add	
1st number real?__	3 ENTER
1st number imaginary?__	4 ENTER
2nd number real?__	2 ENTER
2nd number imaginary?__	- 1 ENTER
5 3	ENTER
> Ready	

2. Divide (2 + i) by (1 - 2).

Computer displays:	You type:
> Ready	/
Divide	
1st number real?__	2 ENTER
1st number imaginary?__	1 ENTER
2nd number real?__	1 ENTER
2nd number imaginary?__	- 2 ENTER
0 1	ENTER
> Ready	

3. You can combine the functions available in this program to perform many other types of calculations. For example, you can raise a complex number to a complex power. Recall that if you take the log of the first number, multiply that by the second, and raise e to the resulting power, you have effectively raised the first number to the power of the second number. The following example shows how this works: raise 1 + 2i to the 2i power.

Computer displays:	You type:
> Ready	L
Logarithm	
1st number real?__	1 ENTER
1st number imaginary?__	2 ENTER
8.047189E-01 1.107148718	ENTER
> Ready	*
Multiply	
1st number real?__	ENTER
2nd number real?__	0 ENTER
2nd number imaginary?__	2 ENTER
-2.214297436 1.609437912	ENTER
> Ready	X
e^Z	
1st number real?__	ENTER
-4.219778E-03 1.091486E-01	ENTER
> Ready	Q (to exit the program)
>	

With this method and the COMPLEX program's easy chaining ability (as demonstrated above), it can complete practically any calculation.

Note: Not all complex math problems have unique answers. Operations such as logarithms have multiple, but equally correct, solutions; hence, when this program conducts extraction of logs or inverse trigonometric functions (which use

logarithms), the answer may not be the obvious one. Usually it will be—but the answer will **always** be a correct one. Just remember that it may not be **the** correct answer for which you've been searching!

Algorithms Used in Computations

The following algorithms are used:

Conjugation: $(A + Bi)^* = (A-Bi)$
Magnitude: $\sqrt{(AA + BB)}$
Addition: $(A + Bi) + (C + Di) = (A + C) + (B + D)i$
Subtraction: $(A + Bi)-(C + Di) = (A-C) + (B-D)i$
Multiplication: $(A + Bi)(C + Di) = (AC-BD) + (AD + BC)i$

$$\text{Division: } (A + Bi) / (C + Di) = \frac{AC + BD}{CC + DD} + \frac{BC-AD}{CC + DD}i$$

e to the z: $e^{(A+Bi)} = e^{A\cos(B)} + e^{A\sin(B)}i$
Sine: $\sin(A + B)) = (\sin(A)(e^{-B} + e^{B})) /$
$2 + (\sin(A)(e^{B} - e^{-B}))) 2i$
Cosine: $\cos(A + Bi) = (\cos(A)(e^{-B} + e^{B})) /$
$2 + (\sin(A)(e^{-B}-e^{B})) 2i$
Arc sine: $\text{asin}(Z) = -i\ \text{Ln}(i(Z + \sqrt{(ZZ-1)}))$
Arc cosine: $\text{acos}(Z) = -i\ \text{Ln}(Z + \sqrt{(ZZ-1)})$

When the result of the last computation is used as an operand, it is used as the first operand (A + Bi in the algorithms).

Variable List

A—New Number Real
B—New Number Imaginary
C—Old Number Real
D—Old Number Imaginary
E, F, G, H—Intermediate Result Holders
I—Error-Present Flag in Extraction of Logs
J—Return Flag for Single-Operand Input
K—Operation Flag in Arc Cosine/Arc Sine Calculation

Vector Arithmetic

This program will perform most common vector operations in three dimensions. It can use either rectangular or spherical coordinates, and in the spherical mode can use radian, degree, or grad units of arc.

To load VECTOR, set the Remote switch of the Printer/Cassette Interface to the ON position. Insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to RUN, then type:

[C][L][O][A][D]["][V][E][C][T][O][R]["]

and press [ENTER]. After the prompt sign (>) appears, type: [R][U][N] and press [ENTER].

Note: To start the program without losing any data in the Pocket Computer-2's memory, press [DEF][SPACE] instead of using the RUN command.

The program will clear itself and start in the rectangular mode. First, you'll see the program title and copyright notice, after which the prompt, > Ready, will appear. Select the desired operation by pressing single keys. The operations are as follows:

[C]—Clear Data
[+]—Add
[-]—Subtract
[.]—Dot Product
[X]—Cross Product
[V]—Angle Computation
[R]—Spherical to Rectangular
[S]—Rectangular to Spherical
[M]—Change Mode
[Q]—End Program

The same input routine is used for all operations. In rectangular mode, the prompts are:

First vector X?__
First vector Y?__
First vector Z?__

In spherical mode, the prompts are:

First vector mag?__
First vector phi?__
First vector theta?__

If needed, the prompts will be repeated for a second vector to be entered.

The program will prompt you for any needed information, display the results (when you press ENTER between each displayed answer), and then return to > Ready. For chained operations, such as a series of additions, press ENTER to answer the first question (First vector X?__ or First vector mag?__). This will load the result of the last operation as the first operand.

Clear

Press C to clear the data used by the program. This will also reset the mode to rectangular.

Add

Press + to add one vector to another.

Subtract

Press - to subtract one vector from another.

Dot Product

Press · to calculate the dot product (also called the scalar or inner product) of two vectors.

Cross Product

Press X to calculate the cross product (also called the vector product) of two vectors.

Angle Computation

Press V to calculate the angle between two vectors.

Spherical to Rectangular Coordinate Conversion

Press R to convert a vector from spherical to rectangular coordinates. This operation is independent of the set mode and does not affect any of the temporary results held by the computer.

Note: This routine will call the input routine for a single vector. You **must** enter the vector you want to convert in response to the FIRST

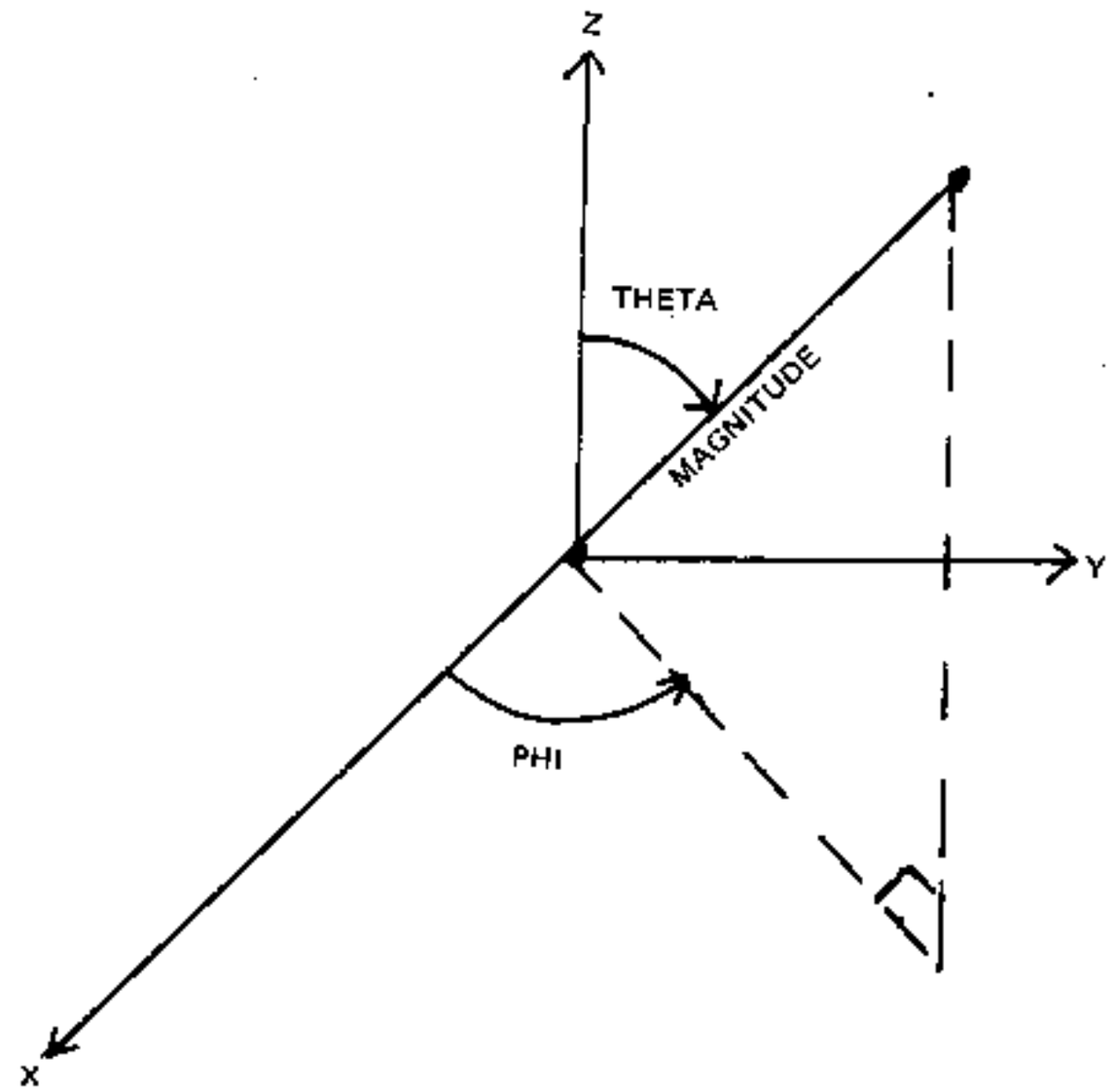
VECTOR statement. A user error here will result in an incorrect answer.

Rectangular to Spherical Coordinate Conversion

Press (S) to convert a vector from rectangular to spherical coordinates. This operation is independent of the set mode and does not affect any of the temporary results held by the computer.

Change Mode

Press (M) to switch modes from rectangular to spherical or spherical to rectangular. The new mode will be displayed briefly. This operation does not affect the contents of the accumulator. In rectangular mode, all input and output is in terms of X, Y, and Z coordinates. In spherical mode, all input and output is in terms of magnitude, phi, and theta, where phi is the counterclockwise angle from the X axis to the projection of the vector on the XY plane and theta is the angle from the Z axis to the vector.



Examples

Note: Examples are all calculated in DEG mode.

1. Add (3x + y - 2Z) and (x + 2y + z).

Computer displays:	You type:
> Ready	[+]
First vector X?__	[3] [ENTER]
First vector Y?__	[1] [ENTER]
First vector Z?__	[-] [2] [ENTER]
Second vector X?__	[1] [ENTER]
Second vector Y?__	[2] [ENTER]
Second vector Z?__	[1] [ENTER]
X = 4	[ENTER]
Y = 3	[ENTER]
Z = -1	[ENTER]
> Ready	

2. Calculate the angle between the previous result and the vector (x + y - 2z).

Computer displays:	You type:
> Ready	[V]
First vector X?__	[ENTER]
Second vector X?__	[1] [ENTER]
Second vector Y?__	[1] [ENTER]
Second vector Z?__	[-] [1] [ENTER]
Angle = 25.06582922	[ENTER]
> Ready	

3. Calculate the cross product of (x + y + z) and (3x - 3y + 2z).

Computer displays:	You type:
> Ready	[X]
First vector X?__	[1] [ENTER]
First vector Y?__	[1] [ENTER]
First vector Z?__	[1] [ENTER]
Second vector X?__	[3] [ENTER]
Second vector Y?__	[-] [3] [ENTER]
Second vector Z?__	[2] [ENTER]
X = 5	[ENTER]
Y = 1	[ENTER]
Z = -6	[ENTER]
> Ready	

4. Convert the previous result to spherical notation.

Computer displays:	You type:
> Ready	S
First vector X?_	5 ENTER
First vector Y?_	1 ENTER
First vector Z?_	- 6 ENTER
Magnitude = 7.874007874	ENTER
Phi = 11.30993247	ENTER
Theta = 139.64089954	ENTER
> Ready	Q (to exit the program)
>	

Variable List

A$—INKEY$ Strobe Holder
A—Vector X in Accumulator
B—Vector Y in Accumulator
C—Vector Z in Accumulator
G, H, I, N, O, P—Temporary Holders for Intermediate Results
J—Current Vector Magnitude
K—Current Vector Phi
L—Current Vector Theta
M—Mode Flag
Q—Return Flag for Single-Vector Input
X—Current Vector X
Y—Current Vector Y
Z—Current Vector Z

Advanced Trigonometry and Exponentiation

This program allows the Pocket Computer-2 to evaluate advanced trigonometric, hyperbolic, and exponential functions.

To load Advanced Trig and Exponentiation, set the Remote switch of the Printer/Cassette Interface to the ON position. Insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to RUN, then type:

(C)(L)(O)(A)(D)(")(A)(D)(V)(M)(A)(T)(H)(")

and press (ENTER). After the prompt sign (>) appears, type: (R)(U)(N) and press (ENTER).

Note: To start the program without losing any data in the Pocket Computer-2's memory, press (DEF)(SPACE) instead of using the RUN command.

The program title and copyright notice will be displayed briefly, followed by: Select function:. Next, you'll see the first line of the menu:

RAD DEG GRAD CLR END

The menu will be displayed line by line. After each line is displayed, press (ENTER) to see the next line, or choose any option you wish by entering its letter code, no matter which menu line you are currently viewing. The menu is as follows:

ADVANCED MATH FUNCTIONS
Copr. 1982 Tandy Corp.
Select function:
RAD DEG GRAD CLR END
SIN COS TAN COT SEC CSC
ASIN ACOS ATAN
ACOT ASEC ACSC
SINH COSH TANH
COTH SECH CSCH
ASINH ACOSH ATANH
ACOTH ASECH ACSCH
LOG X Y

Each menu option stands for a function. The abbreviations and function descriptions follow:

Abbreviation	Function
RAD	Set RADIAN angular mode
DEG	Set DEGREE angular mode
GRAD	Set GRAD angular mode
CLR	Clear data
END	End program
+	Addition
–	Subtraction
*	Multiplication
/	Division
SIN	Sine
COS	Cosine
TAN	Tangent
COT	Cotangent
SEC	Secant
CSC	Cosecant
ASIN	Arc Sine
ACOS	Arc Cosine
ATAN	Arc Tangent
ACOT	Arc Cotangent
ASEC	Arc Secant
ACSC	Arc Cosecant
SINH	Hyperbolic Sine
COSH	Hyperbolic Cosine
TANH	Hyperbolic Tangent
COTH	Hyperbolic Cotangent
SECH	Hyperbolic Secant
CSCH	Hyperbolic Cosecant
ASINH	Arc Hyperbolic Sine
ACOSH	Arc Hyperbolic Cosine
ATANH	Arc Hyperbolic Tangent
ACOTH	Arc Hyperbolic Cotangent
ASECH	Arc Hyperbolic Secant
ACSCH	Arc Hyperbolic Cosecant
LOG	$LOG_y(x)$
X ^ Y	X to the Y

Modes

The 12 circular trig functions may be evaluated in degrees, radians, or grads, as chosen through program options. The 12 hyperbolic functions are always evaluated in radian measure, regardless of the mode. The current mode (DEG, RAD, or GRAD) is displayed near the top left of the Pocket Computer-2's display.

Changing the Mode

Type the code for the mode you desire: (R)(A)(D), (D)(E)(G), or (G)(R)(A)(D), and press (ENTER). The new mode will appear in the top left of the display.

Using the Trigonometric and Hyperbolic Functions

Simply call the function by its abbreviation. The program will ask for the number to be evaluated with the message: Argument?__, and display the answer when calculations are completed. Pressing (ENTER) will end the answer display and return to the menu.

You may reuse the last argument entered by pressing only (ENTER) when asked for the argument. The program will briefly display: Kept and the old argument. You may also use the result of the last computation as the new argument by entering (A) in response to: Argument?__.

Using the Logarithm Function

Call it by typing: (L)(O)(G) and pressing (ENTER). The program will first ask: Argument?__. Reply with the positive number whose logarithm you want, followed by (ENTER). Next, it will ask: Base?__. Answer with a positive number and (ENTER). The program will then perform the required calculations and display the answer.

Exponentiation

This function allows you to raise any positive number to any power and a negative number to a positive or integral negative power. After you type: (X)(A)(Y) and press (ENTER), the program will ask: Argument?__. Enter the number you wish to exponentiate. The next question is: Exponent?__. Reply with the power to which you wish to raise the argument. The program will then display the answer.

Permissible Numerical Ranges for Functions

Entry of an argument for which the function desired cannot be evaluated will cause the program to "beep" three times and display ILLEGAL OPERATION, then return to the menu.

The following list details the numerical range of arguments for which each function is defined:

Function	Range	Undefined Points Within Range
SIN	No Limits	None
COS	No Limits	None
TAN	No Limits	Pi/2 + n Pi
COT	No Limits	n Pi
SEC	No Limits	Pi/2 + n Pi
CSC	No Limits	n Pi
ASIN	ABS(X) < = 1	None
ACOS	ABS(X) < = 1	None
ATAN	No Limits	None
ACOT	No Limits	None
ASEC	ABS(X) > = 1	None
ACSC	ABS(X) > = 1	None
SINH	No Limits	None
COSH	No Limits	None
TANH	No Limits	None
COTH	No Limits	0
SECH	No Limits	None
CSCH	No Limits	0
ASINH	No Limits	None
ACOSH	X > = 1	None
ATANH	ABS(X) < 1	None
ACOTH	ABS(X) > 1	None
ASECH	0 < X < = 1	0
ACSCH	No Limits	0
LOGy(x)	x,y > 0	None
X ^ Y	X>0 or INT(Y) = Y	None

Error Handling

Entry of any undefined operation will result in the display showing: *** ERROR *** after you answer the Argument?__ question. Press ENTER to clear this message and return to the menu.

Attempting to evaluate an impossible function (such as division by zero) will result in a display of: ILLEGAL OPERATION. Press ENTER to return to the menu.

Examples

1. Find the log (base 2) of Pi.

Computer displays:	You type:
Select function:	
RAD DEG GRAD CLR END__	(L)(O)(G)(ENTER)
Argument?__	(SHIFT)(π)
	(ENTER)
Base?__	(2)(ENTER)
1.65149613	(ENTER)
Select function:	

2. Find the arc secant of (1 + log(2)).

Computer displays:	You type:
Select function:	
RAD DEG GRAD CLR END__	(C)(L)(R)(ENTER)
Select function:	
RAD DEG GRAD CLR END	(X)(^)(Y)(ENTER)
Argument?__	(1)(+)(L)(O)(G)
	(()(2)())(ENTER)
Exponent?__	(.)(5)(ENTER)
1.140627019	(ENTER)
Select function:	
RAD DEG GRAD CLR END	(A)(S)(E)(C)
	(ENTER)
Argument?__	(ENTER)
Kept 1.140627019	
28.75109335	(ENTER)
Select function:	
RAD DEG GRAD CLR END	(E)(N)(D)(ENTER)
	(to exit the program)

Variable List

A—Result of last calculation base, in logarithm calculations
B—Parameter carried into current calculation
D$—Dummy used for branching
R, S—Sign flags in exponentiation

Polynomial Math

This program performs basic polynomial math functions with polynomials of up to the ninth order. Operations available include evaluation of the polynomial at a chosen point, calculation of derivatives, calculations of finite integrals, and approximation of a root near a point by Newton's method.

This program handles all polynomials as ninth order using 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 ninth are handled by setting the higher exponent coefficients equal to zero.

Running the Program and Using the Menu

To load PCALC, set the Remote switch of the Printer/Cassette Interface to the ON position. Insert the tape in the recorder and press the "Play" key. Turn the computer on, make sure the mode is set to RUN, then type:

(C)(L)(O)(A)(D)(")(P)(C)(A)(L)(C)(")

and press (ENTER). After the > appears, type: (R)(U)(N) and press (ENTER).

Note: To start the program without losing any data in the Pocket Computer-2's memory, press (DEF) (SPACE) instead of using the RUN command.

The program title and copyright notice will be displayed, then the menu will begin:

```
POLYNOMIAL MATH
Copr. 1982 Tandy Corp.
Select function:
Clear data:  K
Set Coefficients:  C
Evaluate F(x):  F
Differentiate:  D
Integrate:  I
Newtonian root:  R
Exit program:  X
```

As each option is displayed, you may select that option by typing its corresponding letter. You do not have to press Enter to see the next option—it will be displayed automatically. At any time during the menu display, you may choose any menu option, whether or not it is displayed on the screen at that time.

To display the menu at a faster rate, hold down the (SPACE) key while viewing the menu. If the menu reaches the end before you choose an option, it will restart at Select function:.

After execution of any menu option, the program will return to the menu.

Clearing the Data

Press (K). This sets all coefficients to zero. Data cleared will be displayed, then the program will return to the menu.

Setting Coefficients

This allows you to enter or change the coefficients A–J and is the means for entering or changing a polynomial in the program. Press (C) at the menu. The display will show: Coefficient input, then : Exit w/ null, after which it will ask: Exponent? (Ø–9)__. Answer with the exponent whose coefficient you wish to enter or change. PCALC will display the current value of that exponent's coefficient and ask for a new value. Enter the desired value, or press (ENTER) to keep the old (displayed) value. The program will return to: Exponent? (Ø–9)__. When you have finished entering or changing coefficients, press (ENTER) in answer to Exponent? (Ø–9)__, and you will return to the menu.

Evaluating the Polynomial at a Point

This option is selected by entering (F) at the menu. The program will ask: Evaluate F(x) at?__. Reply with the point at which you wish the function to be evaluated. The program will take a few seconds for calculation, then beep and display both x and F(x) in the format: F(x) = . . . Press (ENTER) to end this display and return to the menu.

Evaluating the Derivative of a Polynomial

This option is selected by pressing (D) at the menu. The program will ask: Differentiate F(x) at?__. Reply with the point at which you wish the derivative to be calculated. The program will take a few seconds for calculation, then beep and display x and d/dx F(x) in the format: d/dx F(x) = . . . Press (ENTER) to end the display and return to the menu.

Evaluating the Integral of a Polynomial

This option is selected by pressing (I) at the menu. The program will ask: Integrate from?__. Answer with the lower limit of integration. The next display asks: To?__. Answer with the upper limit of integration. PCALC will calculate for a few seconds, then beep and display the results. Press (ENTER) to end the display and return to the menu.

Approximating a Root Near a Point

Select this option by pressing (R) at the menu. The program will ask: Search near?__. Reply with the point around which you wish to search for a root. The program will make a first approximation of the root, beep, then display the approximate root and actual evaluation of the polynomial at that approximate root. Press (ENTER) to end this display. The display will show: DEF–M if OK, else ENTER. If the approximation is close enough, enter (DEF)(M) to stop the program and return to the menu. Otherwise, press (ENTER) and PCALC will make another approximation and repeat the display.

This option uses Newton's method of root approximation. It will not always converge to a root. The cases in which it will not are:

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

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

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

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

e. 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. It 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: MAX or MIN encountered, then the point and the functions's value at that point. Press (ENTER) to end this display and return to the menu.

Examples

1. Enter the polynomial: $F(x) = 3.2x^3 - x^2 - x + 2$.

Computer displays:	**You type:**
Select function:	
Clear program: K	(K)
Data cleared	
Select function:	(C)
Coefficient input	
Exit w/ null	
Exponent? (0–9)__	(3)(ENTER)
0X ^ 3 New?__	(3)(.)(2)(ENTER)
Exponent? (0–9)__	(2)(ENTER)
0X ^ 2 New?__	(-)(1)(ENTER)
Exponent? (0–9)__	(1)(ENTER)
0X ^ 1 New?__	(-)(1)(ENTER)
Exponent? (0–9)__	(0)(ENTER)
0X ^ 0 New?__	(2)(ENTER)
Exponent? (0–9)__	(ENTER)
Select function:	

2. Evaluate F(x) at x = 4.

Computer displays:	**You type:**
Select function:	(F)
Evaluate F(x) at?__	(4)(ENTER)
F(4) = 186.8	(ENTER)
Select function:	

3. Evaluate d/dx F(x) at 1.

Computer displays:	**You type:**
Select function:	(D)
Differentiate F(x) at?__	(1)(ENTER)
d/dx F(1) = 6.6	(ENTER)
Select function:	

4. Integrate F(x) from 1 to 1.5.

Computer displays:	**You type:**
Select function:	(I)
Integrate from?__	(1)(ENTER)
To?__	(1)(.)(5)(ENTER)
Integral = 2.833333333	(ENTER)
Select function:	

5. Find the root of $F(x) = x^2 - 1$ near 1.5.

Computer displays:	**You type:**
Select function:	(K)
Data cleared	
Select function:	(C)
Coefficient input	
Exit w/ null	
Exponent? (0–9)__	(2)(ENTER)
0X ^ 2 New?__	(1)(ENTER)
Exponent? (0–9)__	(0)(ENTER)
0X ^ 0 New?__	(-)(1)(ENTER)
Exponent? (0–9)__	(ENTER)
Select function:	(R)
Search near?__	(1)(.)(5)(ENTER)
1.083333333 1.736111E-01	(ENTER)
DEF–M if OK, else ENTER	(ENTER)
1.003205128 6.420528E 03	(ENTER)
DEF–M if OK, else ENTER	(ENTER)
1.00000512 1.024002E-05	(ENTER)
DEF–M if OK, else ENTER	(ENTER)
1 0	(ENTER)
DEF–M if OK, else ENTER	(DEF)(M)
Select function:	(X) (to exit the program)
>	

Input Defaults

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

Variable List

A-J—Hold polynomial coefficients for exponents 9-0 (usually addressed as @(i))
A$0—Dummy to hold menu elements
A$—String input holder for branching
M—Evaluation of F(x)
N—Evaluation of d/dx F(x)
O—Temporary result holder during integration
R, S—Sign dummies for exponentiation
V—Point of evaluation and upper limit of integration
W—Lower limit of integration
Z—Dummy

Appendix A—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 Math Pak I should be to make working copies of the original cassette(s) and then put the original(s) 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. Install the computer in the Printer/Cassette Interface, and connect the Printer/Cassette Interface to the cassette recorder. Make sure the Remote switch is OFF.

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. Make a note of the counter number where your saved information will begin, and turn the Remote switch ON. Place the recorder in "Play" mode. Adjust the volume to the setting you have found most effective for making Backups 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 in RUN mode, and type: (C)(L)(O)(A)(D)(") name ("), and press (ENTER). (Name refers to the name of the program to be copied.)

4. When the program has been loaded into the computer and the cassette has stopped, turn the Remote switch OFF, and rewind the recorder to the blank space just prior to the program. Turn the Remote switch ON, and put the recorder into the "Play" mode. Type: (C)(L)(O)(A)(D)(?)(") name (") and press (ENTER).

This is the computer's verifying function. The recorder will compare the cassette program with the program in the computer's memory. If the load 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 load verification, the display will show: ERROR 43. This means that the format of data to be loaded does not match the file format.

If the error message appears on the display, check the recorder volume setting, try the CLOAD function again, and verify the load.

5. When the program has been loaded successfully, remove the cassette and replace it with the cassette which is to receive the program copy. Turn the Remote switch OFF, and either rewind the tape to the beginning, or position it to the point where the copy is to start. Make a note of the counter number where your saved information begins. You should leave from 5-10 seconds of blank space if the copy is to follow another program on the same cassette. Turn the Remote switch ON, and place the recorder in "Record" mode.

6. Make sure that the computer is in the RUN mode. Type: (C)(S)(A)(V)(E)(") name (") and press (ENTER). The recorder will save your program.

7. To make absolutely sure that the program has been saved correctly, use the verification procedure as described in the fourth instruction of this Appendix. 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-2 programs.

8. Back up each program using steps 1 through 7 above.

9. Put the original cassette(s) away in a safe place and use them only for making working copies.

Appendix B—Maintenance

Maintenance of your Pocket Computer-2 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 is 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 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 that pulls the tape and prevent the roller from damaging the tape at the point of contact.

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

7. After removing the computer from the Printer/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 Printer/Cassette Interface.

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