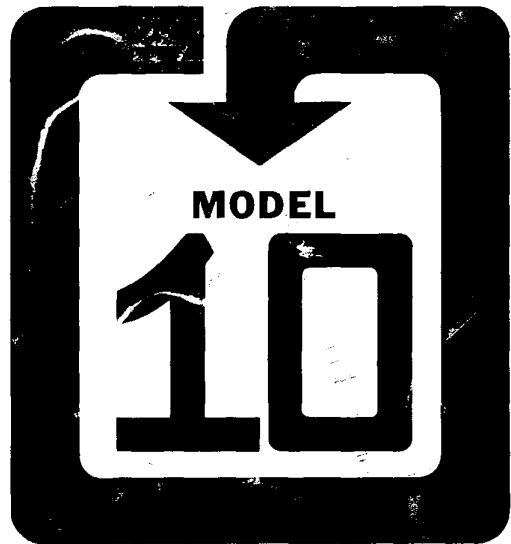
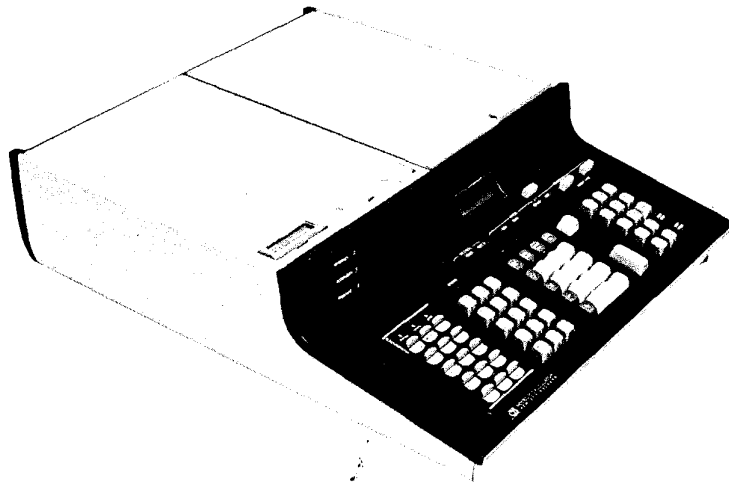




**HEWLETT-PACKARD 9810A CALCULATOR
MATHEMATICS BLOCK**

OPERATING MANUAL

MODEL 9810A CALCULATOR SHOWN WITH THE MATH BLOCK



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TABLE OF CONTENTS

CHAPTER 1: GENERAL INFORMATION

INTRODUCTION TO YOUR MATH BLOCK

Math Block User's Guide	1-1
Compatibility With Other ROM's	1-1
Equipment Supplied	1-1
Installation Procedure	1-2
Electrical Inspection	1-3

CHAPTER 2: MATH BLOCK OPERATION

INTRODUCTION

Illegal Math Operations	2-1
-------------------------	-----

SPECIFYING TRIGONOMETRIC UNITS

2-2

TRIGONOMETRIC FUNCTIONS

SINE	2-3
COSINE	2-3
TANGENT	2-3
Inverse Functions	2-3

LOGARITHMIC AND EXPONENTIAL FUNCTIONS

Common Logarithm	2-4
Antilog, Base 10	2-4
Natural Logarithm	2-5
Antilog, Base e	2-5
X^Y	2-5

VECTOR ARITHMETIC

TO POLAR	2-6
TO RECTANGULAR	2-7
ACCUMULATE +	2-8
ACCUMULATE -	2-9
RECALL	2-9

SPECIAL FUNCTIONS

Angle Conversion	2-12
Rounding A Number	2-13
Calculate X Factorial	2-14
Y	2-14
Plotter Scaling	2-15

PROGRAMMING FEATURES

Definable Function	2-21
Clearing Storage Registers	2-22
Iterative Subroutines (Do-Loops)	2-22
Iterative Label Subroutines	2-25

APPENDIX

MATH BLOCK USER'S GUIDE

SALES AND SERVICE OFFICES

INTRODUCTION TO YOUR MATH BLOCK

The 11210A Mathematics Block (Math Block) consists of the Mathematics Read-Only-Memory (Math ROM), which plugs into your 9810A Calculator, and the Math Overlay, which snaps into place over the left block of calculator keys.

The Math Block adds 26 mathematical and programming functions to your Model 10 Calculator. These functions can be executed by pressing either a single key or a combination of the TABLE or ARC keys and one of several other keys. Each of the Math Block functions are described in the following chapter.

NOTE

Please follow the Installation Procedure beginning on page 1-2 when plugging in the Math ROM.

An abbreviated list of Math Block operations is located in the back of this manual. This list may be removed and kept in the plastic envelope located in the flap on top of your Calculator.

**MATH BLOCK
USER'S GUIDE**

The Math Block must be plugged into ROM SLOT 1, therefore it may be used concurrently with those ROM's which are useable in ROM Slot 2 or 3. Other ROM's which are useable in ROM Slot 1 cannot be used with the Math Block. Your 9810A Operating Manual lists other ROM's.

**COMPATIBILITY
WITH OTHER
ROM'S**

The Math Block consists of the equipment listed in Table 1.

Table 1. Equipment Supplied

PART NO.	QUANTITY	DESCRIPTION
11210A	1	MATHEMATICS ROM
7120-2774	1	MATH OVERLAY
09810-90024	1	MAGNETIC CARD - Math Block Exerciser
09810-90002	2	OPERATING MANUAL
09810-90071	2	MATH BLOCK USER'S GUIDE

**EQUIPMENT
SUPPLIED**

INSTALLATION
PROCEDURE

The following procedure should be used to install your Math Block.

CAUTION

THE MATH ROM MUST BE INSTALLED ONLY
IN ROM SLOT 1.

CALCULATOR POWER SHOULD BE OFF WHEN
INSTALLING OR REMOVING ANY ROM.

LINE

1. SWITCH: OFF 
2. If another ROM is plugged into ROM SLOT 1, remove the ROM. Also, remove the key overlay, which is snapped over the left block of calculator keys. The key overlay should be attached to the removed ROM when it is not in use.
3. Snap the Math overlay, which is attached to the front of your Math ROM, over the left block of calculator keys. The overlay is snapped into place by: inserting the upper locking tab into the small slot above the left block, then pressing the overlay down into place on the keyboard.
4. Position the Math ROM over ROM SLOT 1 (see Figure 1) such that the ROM label is readable from the front of your calculator. Push the ROM straight down into the slot until it is firmly seated.
5. SWITCH: **LINE**
 ON

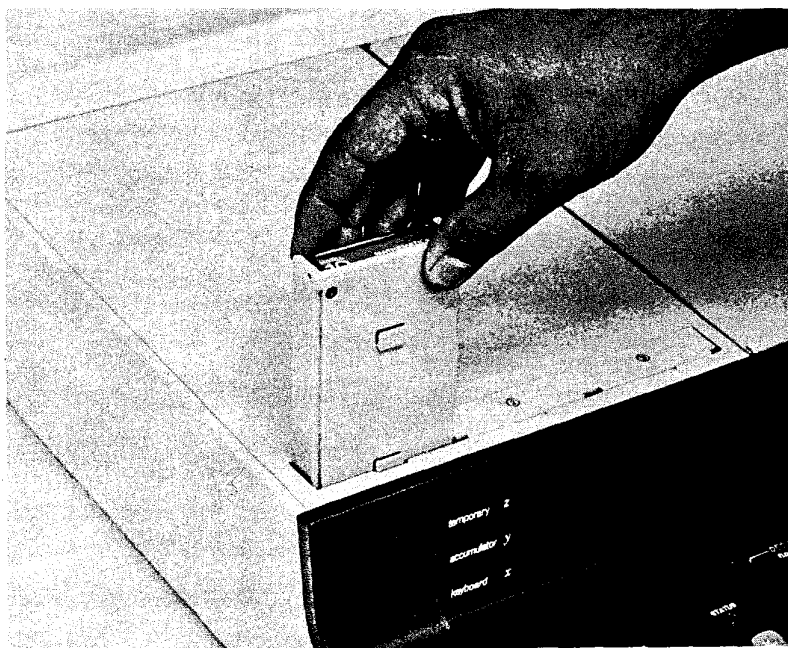


Figure 1. Math Block Installation

NOTE

An abnormal calculator display may result from plugging in or unplugging a ROM while the calculator's power is ON. This display may be cleared by switching the calculator OFF, and leaving it off for a few seconds before switching it ON.

To verify your Math Block's electrical performance, proceed to the next section.

The following procedure should be used to verify the electrical performance of your Math Block.

ELECTRICAL INSPECTION

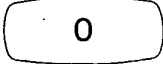
NOTE

This procedure assumes that the Math Block has been properly installed.

The magnetic card supplied with your Math Block contains two programs for exercising ROM's in the 9810A. Side 2 contains the Math Block Exerciser, and Side 1 contains a program for exercising the Printer Alpha ROM.

To exercise the Math Block:

SWITCH:  ON

PRESS:     

PRESS: 

Insert side 2 of the magnetic card into the upper card reader slot. After the program has been loaded (the calculator display will return).

PRESS:  

**ELECTRICAL
INSPECTION
(continued)**

Correct exerciser operation is indicated by a calculator display which flashes on at about 5 second intervals. The first display should appear as shown below.

temporary	z	/ .
accumulator	y	/ .
keyboard	x	/ .

The numbers displayed should increment by 1 for each successive display (i.e. 2, 3, 4, 5). When 5's are displayed the display cycle is complete. One cycle is sufficient to check Math Block operation; however, the display cycles will repeat until the STOP key is pressed. Each light above the left block of keys should light at least once during one display cycle.

If the exerciser does not operate as described above, repeat the entire inspection procedure. If the exerciser still fails to operate correctly, remove the Math ROM from your calculator and verify calculator performance by running the Exerciser Program described in Chapter 1 of the 9810A Operating Manual.

If the calculator operates correctly, but the Math Block Exerciser cannot be successfully run, contact your nearest -hp- Sales and Service Office for assistance.

INTRODUCTION

This chapter describes the added keyboard and programming operations which are available when the Math Block is plugged into the Model 10 calculator. Individual keyboard operations are grouped into separate sections according to their related mathematical functions (i.e. trigonometric functions, exponential functions, etc.). The last section of this chapter describes Math Block operations which are essentially programming features, although all the Math Block operations can be programmed.

The STATUS light will indicate a mathematically illegal operation, when performed either from the keyboard or a program. A list of illegal math operations is in the APPENDIX. Also listed in the APPENDIX is a range of arguments and a summary of calculator errors when performing Math Block operations.

The examples following keyboard descriptions should be performed in order to obtain a good understanding of Math Block operation; however, the examples and text printed in purple are optional reading since they consist of material previously given. Unless indicated otherwise, all examples in this chapter assume that your calculator is set in the RUN mode.

ILLEGAL MATH OPERATIONS

NOTE

The discussion accompanying example programs in this section assumes the reader is familiar with Model 10 programming procedures.

SPECIFYING TRIGONOMETRIC UNITS

The units to be used in problems involving trigonometric function or vector arithmetic are easily selected according to the procedure listed in Table 2. The units specified, either degrees, radians, or grads, are indicated by the appropriate light above the Math key-block.

Table 2. Specifying Units

TO SPECIFY:	PRESS:	INDICATION:		
		① degrees	② radians	③ grads
DEGREES	 1	●	○	○
RADIANS	 2	○	●	○
GRADS	 3	○	○	●

NOTE

If units are not specified after the calculator is turned on, the calculator will automatically select degrees when the first trigonometric or coordinate conversion key is executed.

TRIGONOMETRIC FUNCTIONS

The circular functions of angles having an absolute magnitude less than 10^{11} may be computed by using the keys listed below. When evaluating angles greater than the above limit, refer to the APPENDIX for a summation of calculator error. The inverse circular functions are computed within the range of principal values of each function:

$$\begin{aligned} -90^\circ &\leq \sin^{-1} X \leq 90^\circ \\ 0^\circ &\leq \cos^{-1} X \leq 180^\circ \\ -90^\circ &\leq \tan^{-1} X \leq 90^\circ \end{aligned}$$

For instance: $\cos 150^\circ = \cos 210^\circ = \cos 510^\circ = (\text{etc.}) = -.866$

But: $\cos^{-1} -.866 = 150^\circ$

TRIGONOMETRIC FUNCTIONS

NOTE

The STATUS light will indicate an attempted calculation which is beyond the above range of inverse circular functions.



Calculates the Sine of the X-register contents and inserts the result in X.



Calculates the Cosine of the X-register contents and inserts the result in X.



Calculates the Tangent of the X-register contents and inserts the result in X.



When followed by a trigonometric key, will calculate the respective inverse circular function of the X-register contents and insert the result in the X-register.

EXAMPLE:

Calculate $\sin^{-1} 0.5$

PRESS:

PRESS: (Set degrees)

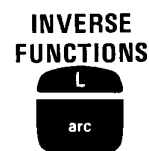
PRESS:

DISPLAY: 30.0000 → x (Degrees)

To calculate the sine 30° :

PRESS:

DISPLAY: .5000 → x



LOGARITHMIC AND EXPONENTIAL FUNCTIONS

The following keys add logarithmic and additional exponential functions to your Model 10.

COMMON LOGARITHM



4

Calculates the logarithm, to base 10 (common logarithm), of the X-register contents and displays the result in X.

ANTILOG, BASE 10



5

Raises 10 to the power indicated by the X-register contents and displays the result in X (i.e. 10^x or $\log_{10}^{-1} x$).

EXAMPLE:

Raise 10 to the power 0.69897

PRESS:  

PRESS:      

PRESS:  

DISPLAY: 5.0000000 → x

To take the $\log_{10}$ of 5

PRESS:  

DISPLAY: .6989700 → x

LOGARITHMIC AND EXPONENTIAL FUNCTIONS



Calculates the logarithm, to base e (natural logarithm), of the X-register contents and displays the result in X.

NATURAL
LOGARITHM



Raises e (2.718....) to the power indicated by the X-register contents and displays the result in X. (i.e. $\ln^{-1}x$).

ANTILOG,
BASE e



EXAMPLE:

$$\sqrt[5]{32}$$

PRESS: **Float**

PRESS: **3** **2** **ln x** **↑**

PRESS: **5** **÷** **↓** **e^x**

DISPLAY: 2.00000000 00 → x



Raises the X-register contents to the power indicated by the Y-register contents. The result is displayed in the X-register, and the Y-register contents remain unchanged.



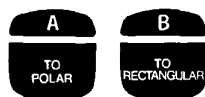
EXAMPLE:

Find $19^{1.6}$

PRESS: **Float** **1** **•** **6** **↑**

PRESS: **1** **9** **x^y**

DISPLAY: 1.111746476 02 → x

COORDINATE
CONVERSION

VECTOR ARITHMETIC

The vector keys provide capability for performing complex and vector arithmetic with single keystroke operation.



Converts rectangular coordinates, consisting of x and y components in the X- and Y-registers respectively, to polar coordinates. The final display is:

temporary	z	
accumulator	y	(angle θ)
keyboard	x	(radius R)

$$\theta = \tan^{-1} \frac{y}{x}$$

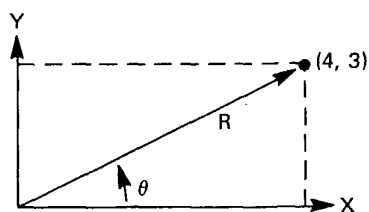
$$R = \sqrt{x^2 + y^2}$$

When converting from rectangular (cartesian) to polar coordinates, the calculated angle θ will be within the range:

$$-180^\circ \leq \theta \leq 180^\circ$$

EXAMPLE:

Convert the coordinates 4, 3 (x, y) to polar degree form.



PRESS: (Set Degrees)

PRESS:

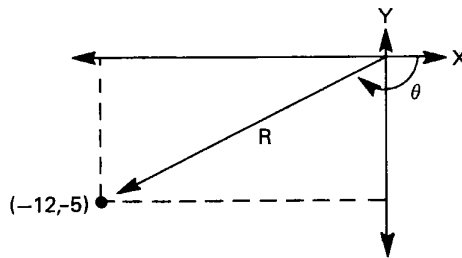
PRESS:

DISPLAY: 36.870 $\rightarrow y$ (θ°)
5.000 $\rightarrow x$ (R)

VECTOR ARITHMETIC

EXAMPLE:

Convert the coordinates $-12, -5$ (x, y) to polar radian form.



PRESS: K
TABLE 2 FIX () 3 (Set radians)

PRESS: CHG SIGN 5 ↑ CHG SIGN 1 2

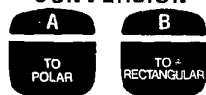
PRESS: A
TO POLAR

DISPLAY: $-2.747 \rightarrow y$ (θ , in radians)
 $13.000 \rightarrow x$ (R)



Converts polar coordinates, when the radius (R) and the angle (θ) are in the X- and Y-registers respectively, to rectangular coordinates. The final display is:

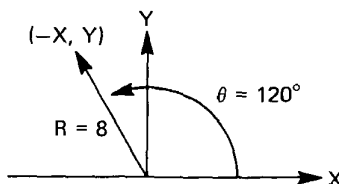
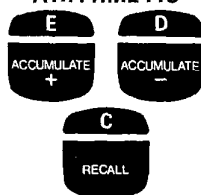
temporary	z		
accumulator	y	(Y component)	$Y = R \sin \theta$
keyboard	x	(X component)	$X = R \cos \theta$

COORDINATE
CONVERSION

(continued)

VECTOR ARITHMETIC

EXAMPLE:

 $R = 8, \theta = 120^\circ$ (or -240°): convert to rectangular form.PRESS: **FIX ()** **3** **K** **1**PRESS: **1** **2** **0** **↑** **8**PRESS: **B**
TO
RECTANGULARDISPLAY: $6.928 \rightarrow Y$ (Y component)
 $-4.000 \rightarrow X$ (X component)VECTOR
ARITHMETIC

ACCUMULATE +, ACCUMULATE -, and RECALL are storage and recall keys which are associated with the *a* and *b* data storage registers. These keys provide complete capabilities for vector addition and subtraction.

NOTE

The *a* and *b* registers are cleared by the CLEAR key, thus CLEAR instructions should be used carefully when using these registers.



Adds (simultaneously) the contents of the X- and *a* -registers together and the contents of the Y- and *b* -registers together. The sums are entered in the *a* - and *b* -registers respectively, while the X- and Y-registers remain unchanged.

Thus:

$$\begin{aligned} b + Y &\rightarrow b \\ a + X &\rightarrow a \end{aligned}$$

VECTOR ARITHMETIC



Subtracts (simultaneously) the contents of the X-register from the a -register contents and the contents of the Y-register from the b -register contents. The remainders are entered in a - and b -registers respectively, while the X- and Y-registers remain unchanged.

Thus:

$$\begin{aligned} b - Y &\rightarrow b \\ a - X &\rightarrow a \end{aligned}$$



Recalls the contents of the a -register to the X-register and the contents of the b -register to the Y-register. The contents of the a - and b -registers remain unchanged.

Thus:

$$\begin{aligned} b &\rightarrow Y \\ a &\rightarrow X \end{aligned}$$

The following examples demonstrate the use of the vector arithmetic keys.

EXAMPLE:

Vector addition

$$(2x + 3y) + (4x + 5y) - (3x - 6y) = 3x + 14y$$

PRESS:  

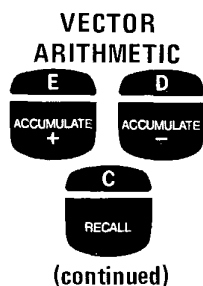
Clear a - and b -registers:

PRESS: 

or

PRESS: *  

*This operation clears the a - and b -registers but does not affect the FLAG or the Z-register contents.

**VECTOR ARITHMETIC**

Enter the first term:

PRESS:

RESULT: $0 + 3 = 3 \rightarrow b$
 $0 + 2 = 2 \rightarrow a$

Enter the second term and add:

PRESS:

RESULT: $3 + 5 = 8 \rightarrow b$
 $2 + 4 = 6 \rightarrow a$

Enter the last term and subtract:

PRESS:

RESULT: $8 - (-6) = 14 \rightarrow b$
 $6 - 3 = 3 \rightarrow a$

Display result in X- and Y-registers:

PRESS:

DISPLAY: $14.000 \rightarrow y$
 $3.000 \rightarrow x$

EXAMPLE:

Multiplication of complex numbers

$$(3 + j4)(-2 + j3) = -18 + j1$$

where: $j = \sqrt{-1}$

This type of problem (containing complex terms) is best solved in the calculator by the following method:

1. convert the quantities in parentheses to polar form ($R \angle \theta$),
2. multiply the R quantities using logarithms and add the angles,
3. convert the result back to rectangular form.

VECTOR ARITHMETIC

Clear the a - and b -registers:

PRESS: 

Enter $(3 + j4)$ and convert to the polar form $(R_1 \angle \theta_1)$:

PRESS:    

Take the $\log_e$ of R_1 and store $\ln R_1$ in the a -register and $\angle \theta_1$ in the b -register:

PRESS:  

Enter $(-2 + j3)$ and convert to the polar form:

PRESS:     

Take the $\log_e$ of R_2 and add $\ln R_2$ and $\angle \theta_2$ to b - and a -registers respectively:

PRESS:  

Take the $\log^{-1}$ ($\ln R_1 + \ln R_2$):

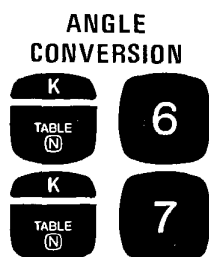
PRESS:  

Convert the result (R in X and $\angle \theta$ in Y) back to rectangular form:

PRESS: 

DISPLAY: $1.000 \rightarrow y (j)$
 $-1.000 \rightarrow x$

The preceding procedure may be changed to division of complex numbers (i.e. $[3 + j4]/[-2 + j3]$) by changing the second ACCUMULATE + instruction to an ACCUMULATE - instruction.



SPECIAL FUNCTIONS

The TABLE key is also used in performing the following mathematical operations: angle conversion, plotter scaling, rounding a number to a specified power of ten, and calculating X factorial (X!).



6

Converts an angle expressed in degrees, minutes, and seconds to decimal degrees. The angle must be entered into the calculator as follows:

temporary	Z	D	(degrees)
accumulator	Y	M	(minutes)
keyboard	X	S	(seconds)

The result in decimal degrees appear in X; the Y- and Z-registers are cleared.



7

Converts an angle expressed in decimal degrees to degrees, minutes, and seconds. The angle to be converted must be entered into the X-register, and the resulting angle appears as in the previous display.

EXAMPLE:

Angle conversion.

$$45^{\circ} 30' 3'' = 45.50083^{\circ}$$

PRESS:

PRESS:

PRESS:

DISPLAY: 45.50083 → X (decimal angle)

To convert back to degrees, minutes, seconds:

PRESS:

DISPLAY: 45.00000 → Z (D)
30.00000 → Y (M)
3.00000 → X (S)

SPECIAL FUNCTIONS

When converting angles, the inverse conversion may not always recover the exact original angle. This is due to the round-off error inherent in the calculator's 12-digit numeric capability.

To observe this error:

PRESS: **FLOAT**

DISPLAY: 4.500000000 01 → *z*
 3.000000000 01 → *y*
 2.999999880 00 → *x*



9

Will round the number in the Y-register to the power of ten indicated by the integer value of the number in the X-register. The rounded number appears in X, while the Y-register remains unchanged.

EXAMPLE:

Round 5610.0 to 10^2 (or nearest 100).

PRESS: **FIX ()** **3**

PRESS: **5** **6** **1** **0** **↑**

To enter a power of ten (10^2) and round the number:

PRESS: **2** **K** **9**

DISPLAY: 5610. → *y*
 5600.000 → *x* (Y rounded)

To round the number in Y to another power of ten (10^4):

PRESS: **4** **K** **9**

DISPLAY: 5610.000 → *y*
 10000.000 → *x* (Y rounded)

ROUNDING
A NUMBER



9

ROUNDING A NUMBER



(continued)

SPECIAL FUNCTIONS

A fractional number may be rounded by entering a negative number into the X-register.

EXAMPLE:

Round 0.025 to the 10^{-2} or nearest $\frac{1}{100}$.

PRESS:

PRESS:

DISPLAY: 0.025 $\rightarrow$ y
0.030 $\rightarrow$ x (Y rounded)

CALCULATE X FACTORIAL



Will replace the X register contents with X!.

Where: $0 \leq \text{int } |X| \leq 69$.

EXAMPLE:

Calculate 7!

PRESS:

DISPLAY: 5040.0 $\rightarrow$ x

ABSOLUTE VALUE OF Y



Sets the Y-register contents positive without affecting the sign of the exponent; the X- and Z-registers remain unchanged.

SPECIAL FUNCTIONS

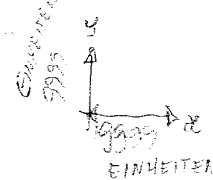
A problem usually encountered when writing a calculator/plotter program* is that of scaling the available X and Y problem-variables to X_{plot} and Y_{plot} coordinates which the plotter can use. The plotter scaling function to be described, simplifies this typical plotting problem.

PLOTTER SCALING

K **TABLE** **Ⓢ** **FMT** Replaces X and Y plotter problem-variables which are entered in corresponding X- and Y-registers, with computed X_{plot} and Y_{plot} coordinates. X_{plot} and Y_{plot} coordinates are each simultaneously calculated by the equations:

$$X_{plot} = \frac{9999}{X_{max} - X_{min}} [X_{var} - X_{min}]$$

$$Y_{plot} = \frac{9999}{Y_{max} - Y_{min}} [Y_{var} - Y_{min}]$$



K **TABLE** **Ⓢ** **FMT**

Where: X_{var} and Y_{var} = entered problem-variables
 X_{max} , X_{min} = problem variable range
 Y_{max} , Y_{min} = problem variable range
 9999 = maximum unit range of X-Y plotter

The problem-variable range must be predetermined and entered into data registers 001 to 004 according to the following table:

Table 3. Variable Range Storage

PROBLEM-VARIABLE RANGE:	STORE IN REGISTER:
X_{min} —————→	001
X_{max} —————→	002
Y_{min} —————→	003
Y_{max} —————→	004

The stored variable range limits are automatically assumed as being the graph limits. Thus, by setting the lower left and upper right graph limit controls on the calculator plotter, the graph is calibrated to any required size and grid dimension (units per inch on graph).

*A plotting problem involves the following basic steps:

1. determine the problem-variable ranges.
2. determine the graph calibration (i.e. problem-units per inch on graph).
3. convert problem-variables to X_{plot} and Y_{plot} coordinates for graphing.
4. Write a program to calculate and plot coordinates.

**PLOTTER
SCALING
(continued)**

SPECIAL FUNCTIONS

With a Model 9862A Plotter connected in your 9800 System, an $\uparrow$ or $\downarrow$ instruction following TABLE, FMT will cause the plotter to plot computed X_{plot} and Y_{plot} coordinates.

NOTE

The plotter scaling function does not *require* the use of a plotter. Sets of computed coordinates may be printed (or hand copied) and manually graphed. However, if a plotter is not used the $\uparrow$ or $\downarrow$ instruction should be retained in the procedure, since unwanted operations may result if another instruction follows TABLE, FMT.

The following example demonstrates the use of the plotter scaling function. This example assumes the use of an X-Y Plotter; however, the note on Page 2-20, suggests how the program may be modified for use without a plotter or printer.

EXAMPLE:

Plot the parabola: $y = x^2$

Where: $-5 \leq X \leq 10$

NOTE

If a plotter is to be used, 10 X 15 inch paper should be positioned on the platen.

Determine the problem variable range:

X_{var} range = X_{max} , X_{min} = 10, -5 (given above)

Y_{var} range = Y_{max} , Y_{min} = 100, 0 (by substitution)

Enter the above range limits into registers 001 through 004 according to Table 3. The STOP key will be used to terminate each short-form address.

PRESS: RUN FIX () 0 CLEAR

PRESS: CHG SIGN 5 $x \rightarrow ()$ 1 STOP

SPECIAL FUNCTIONS

PRESS: 1 0 $x \rightarrow ()$ 2 STOP

PRESS: 0 $x \rightarrow ()$ 3 STOP

PRESS: 1 0 0

PRESS: $x \rightarrow ()$ 4 STOP

By setting the graph limits controls on the Calculator Plotter, the grid can be calibrated to any desired size plot. This example will generate a full size (10 X 15 inch or 25 X 38 cm) plot, therefore, the graph limits are set to the lower-left and upper-right corners of the paper. This procedure results in the following calibrated plotter grid:

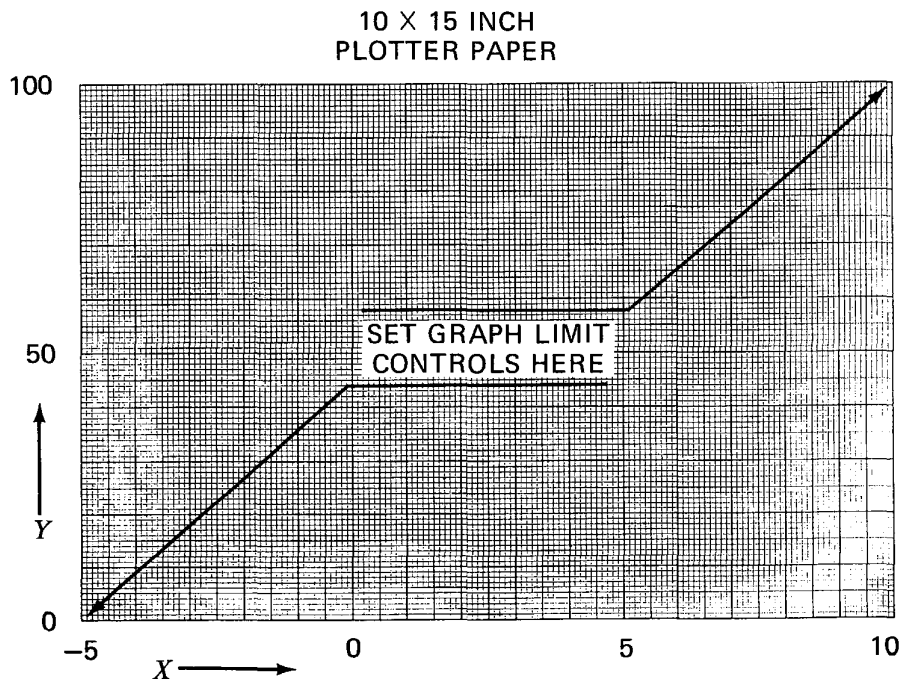
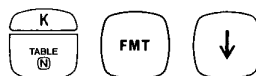


Figure 2. Resulting Grid Calibration

PLOTTER SCALING (continued)

SPECIAL FUNCTIONS

By entering individual sets of X and Y variables and pressing



the plotter will plot each set of computed coordinates. However, a program can easily be written to compute X and Y variables and plot the computed X_{plot} and Y_{plot} coordinates.

The following program is one method of plotting a parabola of $y = x^2$.

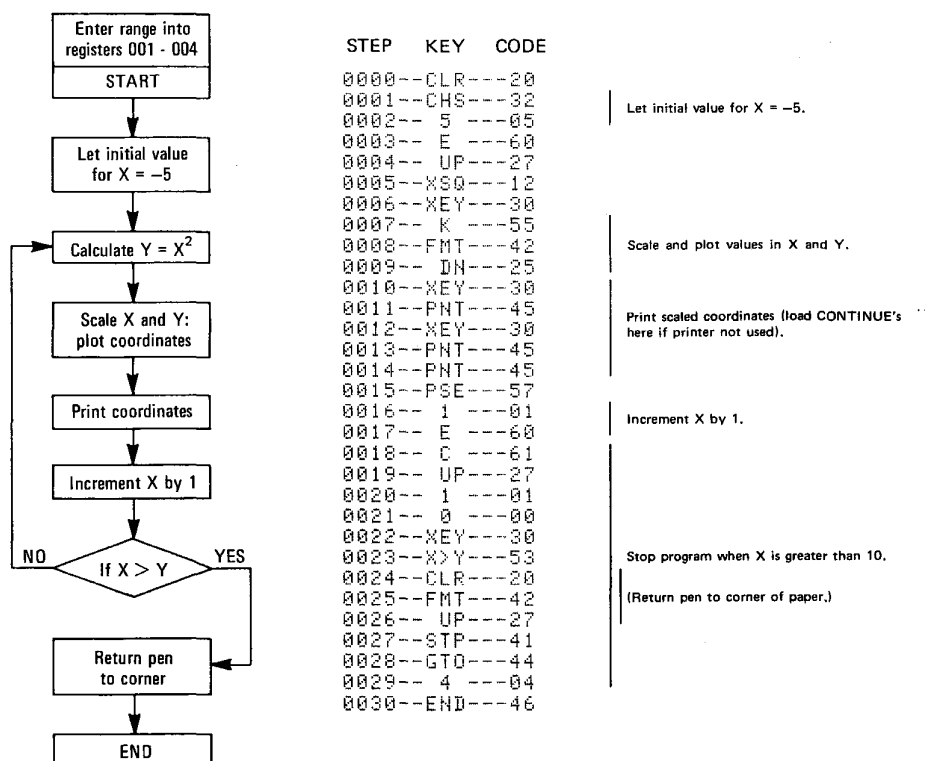


Figure 3. Sample Plotter Program

To load and run the program:

PRESS: **RUN** **END** **FIX ()** **0** **PRGM**

PRESS: (The keys in the above program beginning with step 0000.)

SPECIAL FUNCTIONS

PRESS:

RUN

END

CONTINUE

HARD COPY:

2500.

0.

1600.

667.

900.

1333.

400.

2000.

100.

2666.

0.

3333.

100.

4000.

400.

4666.

900.

5333.

1600.

5999.

2500.

6666.

3600.

7333.

4900.

7999.

6399.

8666.

8099.

9332.

9999.

9999.

PLOTTER
SCALING
(continued)

SPECIAL FUNCTIONS

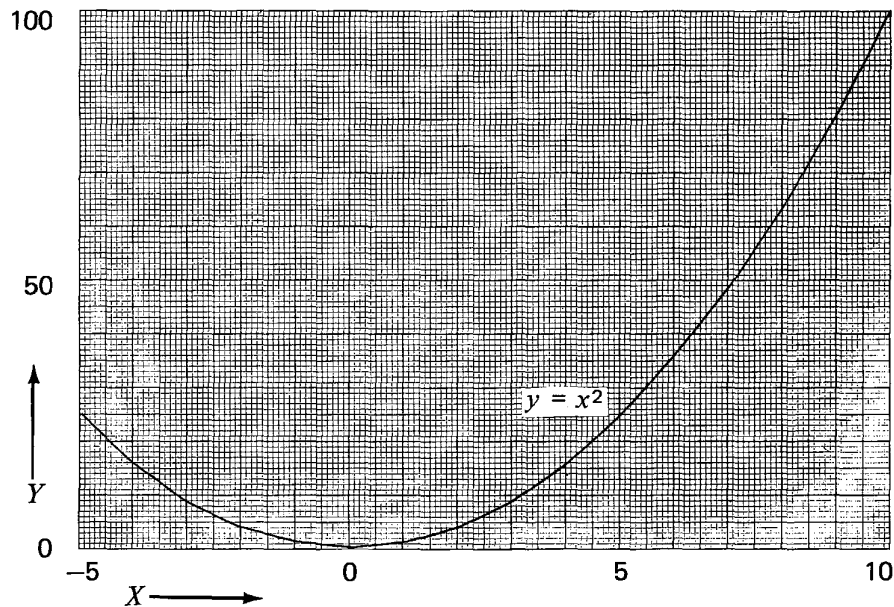


Figure 4. Completed Plot

If a plotter is not available, plotter coordinates can still be computed using the plotter scaling function. This program will run correctly without a plotter connected in your 9800 System.

If your 9800 System does not contain a printer or plotter, steps 0010 through 0015 may be replaced by PAUSE instructions. During program operation each set of computed coordinates will flash on the display long enough for the operator to press PAUSE (stopping the program) in order to hand copy each set of computed coordinates for future graphing.

PROGRAMMING FEATURES

This section describes the special program-related functions which the Math Block adds to your Model 10.

 Is used to label and 'call' an often used function which is stored in your Model 10. The definable function may be executed at any time from the keyboard by pressing the DEFINABLE key, or it may be 'called' in a program by inserting the DEFINABLE (key) instruction.

The definable function is programmed similarly to a 'LABEL' subroutine; it is executed as a normal subroutine, except that it may be 'called' by a single keystroke or program step.

DEFINABLE FUNCTION



NOTE

The definable function should be stored near the end of the program memory to avoid accidental erasure from subsequent programming operations.

The following subroutine* is written as a definable function. Notice that the function must begin with LBL, DEFINABLE and its last step must be SUB/RETURN.

0490--LBL---	51	Definable Function address
0491-- F ---	16	
0492-- J ---	75	
0493-- UP---	27	
0494--1/X---	17	Keys of function:
0495-- + ---	33	may be any number of steps.
0496-- 2 ---	02	
0497--DIV---	35	
0498--S/R---	77	Terminates function.
0499-- 0 ---	00	

Figure 5. Programmed Definable Function

If the function were stored in your Model 10, you could use it anytime by pressing the DEFINABLE key.

*This subroutine computes the hyperbolic cosine of the X-register contents (cosh X) and places the result in the Y-register.

CLEARING
STORAGE
REGISTERS

PROGRAMMING FEATURES



will clear all numerical storage registers without affecting the *a* and *b* registers or the X, Y, and Z registers or the flag.

ITERATIVE
SUBROUTINES
(DO-LOOPS)

A programmed subroutine may be repeated *n* number of times by inserting the following keys at the end of the subroutine:



Where: (r) may be any key from 0 to 9 corresponding to the data storage register (reg. 000 through 009) that contains *n*; and *n* is equal to the absolute, integer value of the contents of the register designated. If $n < 1$ the subroutine will execute at least one time.

After the subroutine has been repeated '*n*' times, the program exits from the subroutine* and resumes normal program execution at the step following the subroutine 'call instructions'. The branching instructions which 'call' the iterative subroutine *must* contain 6 program steps; if less than 6 steps are used, the program will probably not execute properly, but it will return to the correct step after exiting the subroutine.

The following program demonstrates the use of an iterative subroutine. The program is a register scanner, since it prints (or displays) the address and the contents of all data registers from the register number entered by the operator at the beginning of the program to register 000.

This program is written for use with a Model 10 containing a printer (Option 004). If your Model 10 does not have a printer, the note on Page 2-25 describes how to modify this program for the basic Model 10.

*The subroutine may be exited anytime before being repeating '*n*' times by clearing the register containing '*n*'.

PROGRAMMING FEATURES

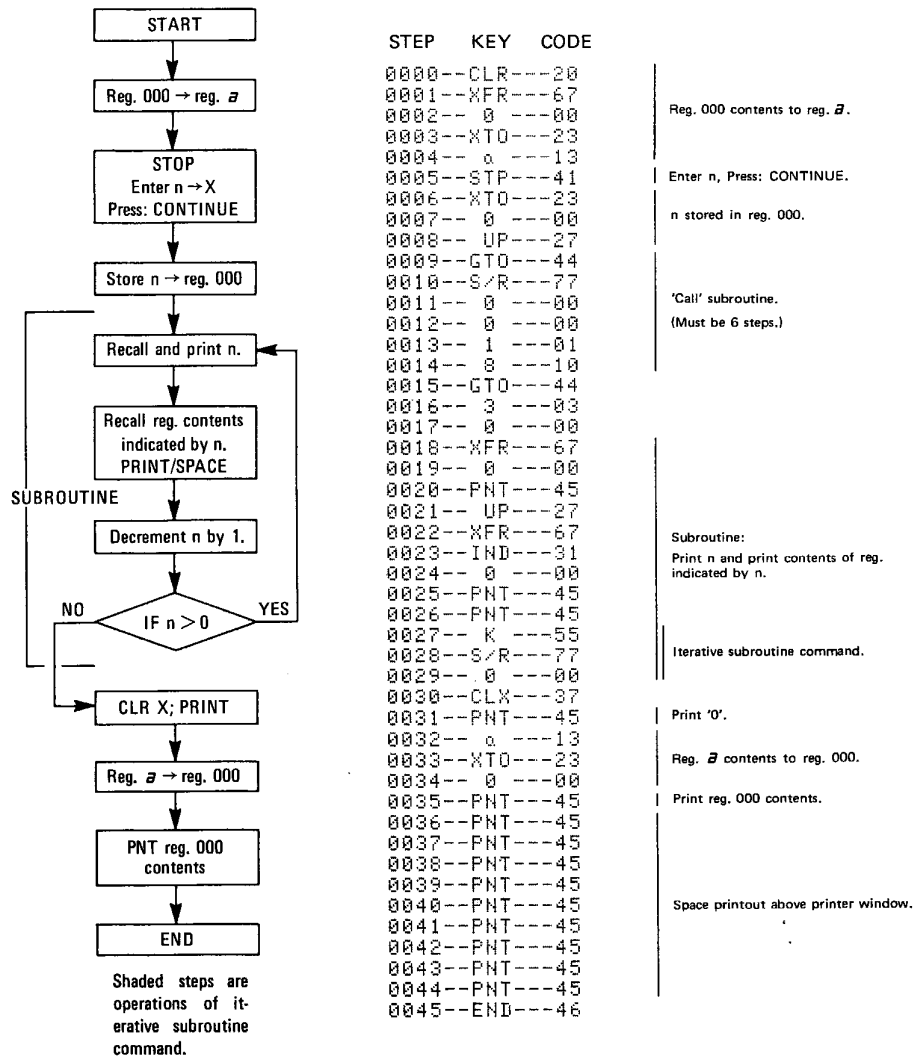


Figure 6. Iterative Subroutine Program

After loading the program at step 0000:

PRESS:

RUN

FLOAT

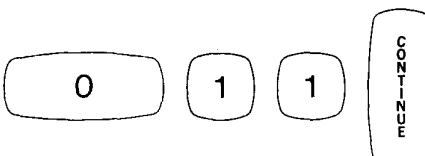
END

CONTINUE

ITERATIVE
SUBROUTINES
(DO-LOOPS)
(continued)

PROGRAMMING FEATURES

To enter n (any valid* data register address) into the X-register and run the program:

PRESS: 

SAMPLE PRINTOUT:

reg. 011 (n) → 1.1000000000 01
content of reg. 011 → 4.945154556 01

1.0000000000	01
2.8300000000	00
9.0000000000	00
5.7800000000	01
8.0000000000	00
5.782239183	01
7.0000000000	00
1.3388300000	-02
6.0000000000	00
3.854003524	-01
5.0000000000	00
2.717540519	01
4.0000000000	00
1.0000000000	-89
3.0000000000	00
1.543843393	01
2.0000000000	00
3.141592654	00
1.0000000000	00
5.5500000000	01
0.0000000000	00
3.0000000000	00

*A valid register address is any three-digit number between 000 and 048 (or 000 to 108 if your calculator contains Option 001). If an invalid register address is entered, the STATUS light and a printout of the entered address will indicate the incorrect entry. The entry may be short-form addressed.

PROGRAMMING FEATURES

Notice in the program, that the iterative subroutine requires the exclusive use of a storage register (register 000 in the preceding program), since the number (n) originally in the specified register is decremented to 0 during execution of the iterative subroutine.

NOTE

The preceding program may be modified for use in a Model 10 without a printer by replacing all PRINT instructions except Steps 0026 and 0031 with CONTINUE's. Insert an $\uparrow$ instruction in step 0031. Program operation is the same as with a printer except that each time CONTINUE is pressed the data displayed in X- and Y-registers correspond to one set of data in the sample hard copy (see Page 2-24).

The iterative subroutine feature may be added to a 'LABEL' subroutine, but when the LABEL subroutine is 'called' (during a program) the call instructions *must* contain 6 program steps. The following partial program shows how to call the LABEL π iterative subroutine.

ITERATIVE LABEL SUBROUTINES

```
0200-- + ---33
0201--CNT---47
0202--CNT---47
0203--GTO---44
0204--S/R---77
0205--LBL---51
0206--  $\pi$  ---56
0207-- - ---34
```

Call subroutine.

(CONTINUE's must be entered
before 'GO TO' step.)

Return from subroutine.

Figure 7. Iterative 'LABEL' Subroutine

APPENDIX

RANGE OF CALCULATION: $\pm 10^{-98}$ to $\pm 9.999999999 \times 10^{98}$

RANGE OF ARGUMENTS for trigonometric, logarithmic and exponential functions:

SIN X, COS X, TAN X:	$ X \leq 1 \times 10^{11}$
SIN ⁻¹ X:	$ X \leq 1$
COS ⁻¹ X:	$ X \leq 1$
TAN ⁻¹ X:	$ X < 10^{99}$
ln X:	$X > 0$
e ^X :	$-225.65 < X < 227.95$
LOGX:	$X > 0$
10 ^X :	$ X < 10^{99}$
X!:	$0 \leq \text{int} X \leq 69$

ERROR SUMMARY: Summary of maximum errors of Math Block functions.

a. Errors are expressed as absolute errors:

$$\text{Absolute error} = |f(X) - \hat{f}(X)|$$

$$\text{Relative error} = \frac{|f(X) - \hat{f}(X)|}{f(X)}$$

where $f(X)$ = exact value

$\hat{f}(X)$ = calculated value

b. One 'visible count' is one count in the tenth digit.

1. SIN θ	$\theta < 1 \text{ rad}$	$\pm 1 \text{ visible count}$
	$1 \text{ rad} \leq \theta < \pi$	$\pm 12 \times 10^{-11}$
	$\pi \leq \theta < 2\pi$	$\pm 31 \times 10^{-11}$
	$2\pi \leq \theta$	$\pm 18 \times 10^{-10} \times 10^{(\text{no. of decades of circles})}$
2. COS θ	$\theta < 1 \text{ rad}$	$\pm 4 \times 10^{-11}$
	$1 \text{ rad} \leq \theta < \pi$	$\pm 9 \times 10^{-11}$
	$\pi \leq \theta < 2\pi$	$\pm 28 \times 10^{-11}$
	$2\pi \leq \theta$	$\pm 18 \times 10^{-10} \times 10^{(\text{no. of decades of circles})}$
3. TAN θ	$\theta < 1 \text{ rad}$	$\pm 1\frac{1}{2} \text{ visible count}$
	$1 \text{ rad} \leq \theta < \pi$	$\pm \frac{1}{2} \text{ (exp of answer)}$
		$\pm 2 \times 10^{-10} \text{ (visible counts)}$
	$\pi \leq \theta < 2\pi$	$\pm 1 \times \text{exp of answer}$
		$\pm 3 \times 10^{-10} \text{ (visible counts)}$
	$2\pi \leq \theta$	$\pm 5 \times \text{exp of answer} \times 10^{(\text{no. of decades of circles})}$
		$\pm 31 \times 10^{-10} \times 10^{(\text{no. of decades of circles})}$
		visible counts
4. SIN ⁻¹ (a)	$a < .707$	$\pm \frac{1}{2} \text{ visible count}$
SIN ⁻¹ (a)	$a > .707$	rad $\pm 10^{-10}$

-



TABLE. FMT when computed coordinates exceed range limits

MATH BLOCK OPERATIONS

KEY	RESULTS/COMMENTS
	COORDINATE CONVERSION: POLAR COORDINATES
	RECTANGULAR COORDINATES $\theta \rightarrow Y$ $R \rightarrow X$
	$b \rightarrow Y$ $a \rightarrow X$
	$b - Y \rightarrow b$ $a - X \rightarrow a$
	$b + Y \rightarrow b$ $a + X \rightarrow a$
	EXECUTES SPECIAL SUBROUTINE, SEE PAGE 2-21*.
	$ Y \rightarrow Y$
	$X^Y \rightarrow X$
	NATURAL LOG (X) $\rightarrow X$
	(2.718..RAISED TO CONTENTS OF X) $\rightarrow X$
	USE TO PREFIX ANY KEY BELOW IN ORDER TO COMPUTE RESPECTIVE INVERSE CIRCULAR FUNCTION.
	$\sin X \rightarrow X$
	$\cos X \rightarrow X$
	$\tan X \rightarrow X$

KEY(S)	RESULTS/COMMENTS						
	PREFIXES THE FOLLOWING OPERATIONS (NOT AVAILABLE WITH A SINGLE KEY).						
		SETS DEGREES					
		SETS RADIANS					
		SETS GRADS					
		COMMON LOG(X) $\rightarrow$ X					
		$10^x \rightarrow$ X					
ANGLE CONVERSION:							
		D,M,S $\rightarrow$ DECIMAL DEGREES					
		DECIMAL DEGREES $\rightarrow$ D,M,S					
		<table><tr><td>D $\rightarrow$ Z</td></tr><tr><td>M $\rightarrow$ Y</td></tr><tr><td>S $\rightarrow$ X</td></tr><tr><td>Dec. $\rightarrow$ X</td></tr><tr><td>Deg. $\rightarrow$ X</td></tr></table>	D $\rightarrow$ Z	M $\rightarrow$ Y	S $\rightarrow$ X	Dec. $\rightarrow$ X	Deg. $\rightarrow$ X
D $\rightarrow$ Z							
M $\rightarrow$ Y							
S $\rightarrow$ X							
Dec. $\rightarrow$ X							
Deg. $\rightarrow$ X							
		X FACTORIAL $\rightarrow$ X $0 \leq \text{int } X \leq 69$					
		(Y ROUNDED TO POWER OF 10 INDICATED BY CONTENTS OF X) $\rightarrow$ X					
		PLOTTER SCALING FUNCTION, SEE PAGE 2-15*.					
		CLEAR ALL NUMERIC REGISTERS'					
		'DO-LOOP' SUBROUTINE, SEE PAGE 2-22*.					

* For further information on any of these operations, see the Math Block Operating Manual.

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HP MODEL 2010A CALCULATOR MAIN BLOCK



OPERATING MANUAL



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