OPERATING MANUAL

11221A MATHEMATICS BLOCK

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(For World-wide Sales and Service Offices see rear of manual.)

TABLE OF CONTENTS

Chapter 1

GENERAL INFORMATION

MATH BLOCK DESCRIPTION

> NOTE
>
> This manual describes only the use of the Math Block in the calculator; for information regarding the calculator, refer to the calculator's Operating and Programming Manual or to the Simplified Operating Instructions.

The HP 11221A Mathematics Plug-in Block (henceforth referred to as the Math Block) provides additional mathematical functions for the HP 9820A and the HP 9821A Calculators. Added functions, shown in Chapter 2, include logarithms, both natural and common; exponential functions; trigonometric and inverse-trigonometric functions (in degrees, radians, or grads), and others. Use of these functions requires no special programming techniques; once the block is installed, its functions become a part of the calculator, in the same way as, for example, the square root function is part of the calculator.

SUPPLIED EQUIPMENT

The following items are supplied with each Math Block:

Operating and Programming Manual;
-hp- Part No. 09820–90017, quantity 1

Mathematics Overlay
-hp- Part No. 7120–1688, quantity 1.

INSPECTION PROCEDURE

The Math Block was carefully inspected, both mechanically and electrically, before it was shipped to you. Inspect the block for physical damage and also check that the supplied equipment, listed above, is present.

To check operation of the block refer to the 'Model 20 System Electrical Inspection Booklet', or the 'Model 21 System Test Instructions booklet' supplied with your calculator. The procedure to install the block in the calculator is given below.

If there is any damage or electrical malfunction, contact your nearest HP Sales and Service Office (addresses are provided at the back of this manual).

MATH BLOCK INSTALLATION

A block will operate installed in any of the numbered slots on top of the calculator. However, any program which is to be loaded from a magnetic card or tape cassette and which also requires the use of a block, dictates that that block be installed in a specific slot – namely the same slot that the block was in when the program was recorded. Before loading any program, always check that program's user instructions, to determine which ROM's should be in which slots for that particular program.

When installed, the Math Block defines the keyblock immediately in front of it, the one which has the same number as the slot in which the Math block is located. An overlay, supplied with each block, can be laid over the defined keyblock to indicate the definition(s) which each key now has.

MATH BLOCK INSTALLATION

(cont'd)

To install the block:

1. Switch the calculator off — if you install a block with the calculator still on, the calculator will continue to operate as if that block were not there. If you do inadvertently leave the calculator on while installing a block, then you must press MEMORY ERASE, to make the calculator 'accept' that block.

2. Unclip the overlay from the Math Block and install it over the selected keyblock, as shown in Figure A. Insert the tab, at the top of the overlay, into the locking slot at the head of the keyblock and press the overlay into place over the keys.

3. Install the block as shown in Figure B; position it vertically (with its label 'right-side up' when viewed from the front of the calculator) over the trap-door of the selected slot. Push the block straight down into the slot until it is firmly seated.

4. The block is now installed; switch the calculator on.

To remove a block, switch the calculator off and pull the block up by the handle. Release the overlay by sliding the latch back (Figure A) and lifting the overlay out; to avoid possibly losing the overlay, always clip it to its block if it is not installed in the calculator.

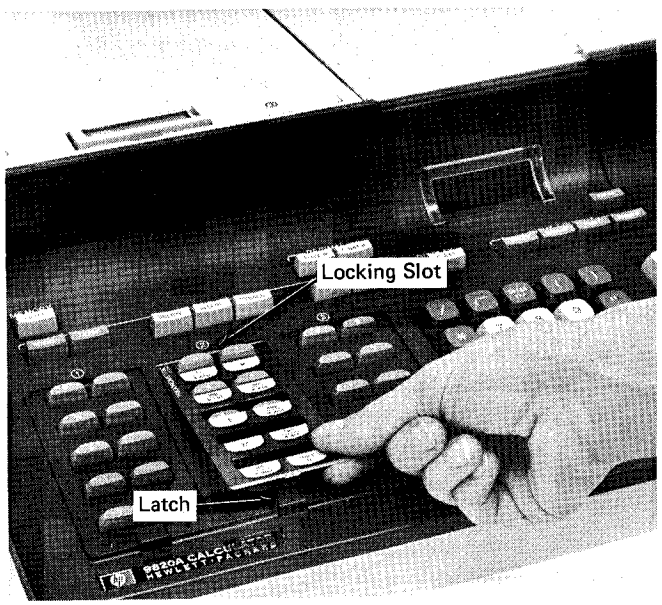


Figure A. Installing the Overlay.

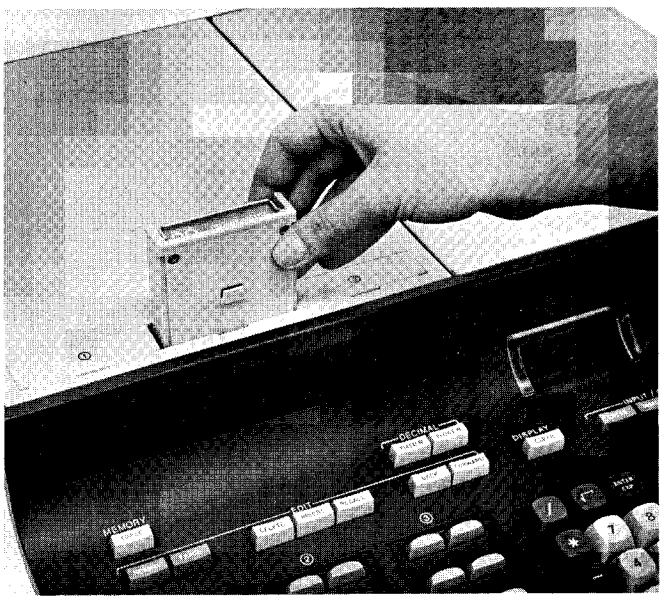


Figure B. Installing A Block.

Chapter 2

DESCRIPTION OF THE FUNCTIONS

INTRODUCTION

The Math Block functions are quite straightforward to use; in most cases they require little explanation. The rules and hierarchy applicable to mathematical operations, as described in the calculator's Operating and Programming Manual, also apply to the operations available with the Math Block. The hierarchy, listed below, is fully discussed in the manual for the calculator.

First: Functions
Exponentiation
Unary Minus
Implied Multiplication
Explicit Multiplication, and Division
Addition and Subtraction, and Unary Plus
Last: Relational Operators

Some plug-in blocks decrease the amount of programmable memory available to the user, by automatically requiring a portion of that memory for their own internal usage — the Math Block has no such requirement and does not affect memory availability.

THE FUNCTIONS

Table 2-1 describes all Math Block Functions. As can be seen from the table, a 'prefix' key (▼) is used to redefine certain other keys. Each key which is to be redefined must be immediately preceded by the 'prefix' key — there is no 'continuous prefix' mode.

When the prefix key is pressed, a triangle appears in the display; when the next key is pressed, the lower of the two mnemonics on that key is substituted for the triangle (ASN is displayed, for example, when the sine key is pressed). The triangle cannot now be recovered by pressing the BACK key — in effect the mnemonic for the two keys (the prefix and the next key), once generated, is treated as if it had been generated by one single key.

Reminder: If the argument of a function is negative, then the argument and its sign must be enclosed in parentheses.

SIN (–40) not SIN –40

2-2 DESCRIPTION OF THE FUNCTIONS

Part of Table 2-1. Math Block Functions.

Function Type	To Calculate these functions . . .	. . . the syntax is;	to obtain the mnemonic . . . (*b* represents blank space)	. . . press these keys
Logarithms and Inverse Logarithms	natural log x ln x $\log_e$ x (e = 2.71828182848)	LN ⟨quantity⟩ or ((expression))	LN*b*	ln / ▼ exp
	e^x $\log_e^{-1}$ x antilog_e x	EXP ⟨quantity⟩ or ((expression))	EXP*b*	▼ ln / ▼ exp
	common log x $\log_{10}$ x	LOG ⟨quantity⟩ or ((expression))	LOG*b*	log / ▼ TN↑
	10^x $\log_{10}^{-1}$ x antilog_{10} x	TN↑ ⟨quantity⟩ or ((expression))	TN↑*b*	▼ log / ▼ TN↑
Circular and Inverse Circular Functions	Select Circular Units	TBL ⟨quantity⟩ quantity = 1 – DEGREES SET 2 – RADIANS SET 3 – GRADS SET	TBL*b*	TABLE N (n)
	Sine x sin x	SIN ⟨quantity⟩ or ((expression))	SIN*b*	sin / ▼ asn
	$\sin^{-1}$ x arc sin x	ASN ⟨quantity⟩ or ((expression))	ASN*b*	▼ sin / ▼ asn
	Cosine x cos x	COS ⟨quantity⟩ or ((expression))	COS*b*	cos / ▼ acs
	$\cos^{-1}$ x arc cos x	ACS ⟨quantity⟩ or ((expression))	ACS*b*	▼ cos / ▼ acs
	Tangent x tan x	TAN ⟨quantity⟩ or ((expression))	TAN*b*	tan / ▼ atn
	$\tan^{-1}$ x arc tan x	ATN ⟨quantity⟩ or ((expression))	ATN*b*	▼ tan / ▼ atn
Miscellaneous Functions	Integer x int x	INT ⟨quantity⟩ or ((expression))	INT*b*	int / ▼ abs
	Absolute value of x |x|	ABS ⟨quantity⟩ or ((expression))	ABS*b*	▼ int / ▼ abs
	Exponentiation "raised to the power of"	⟨quantity⟩ or ((expression)) ↑ ⟨quantity⟩ or ((expression))	↑	↑
	pi π 3.14159265360	⟨constant⟩	π	π
Initialize Program	Clear Data-Storage and Flags	TBL ⟨quantity⟩ quantity = 4 – clear all available R-registers 5 – clear all alphabetic registers 6 – clear all flags	TBL*b*	TABLE N (n)

Part of Table 2-1. Math Block Functions.

Typical Statements	Range of argument (x)	Remarks
LN 6.2; LN A; LN (X-1); -5LN (4(X-1));	$X > 0$	—
EXP .4; EXP B; EXP (-1); 3((EXP A-EXP (-A))/2)→X;	$-225.65 < X < 227.95$	—
LOG 3.1; LOG A; LOG (X-1); -6LOG (4(X-1));	$X > 0$	—
TN↑ .1; TN↑ A; TN↑ (-1); 2((TN↑ B-TN↑ (-B))/2)→X;	$X \leq 99.9999999997$	Because of hierarchy, LOG TN↑2 = LOG(10^2) = 2 while, LOG I0↑2 = (LOG10)^2 = 1.
TBL 1; TBL 2; TBL 3; TBL 0; (displays current units)	—	Once set, units remain set until deliberately changed. At turn-on 'DEGREES SET' is automatically assumed.
SIN 30; SIN B; SIN (-45); A↑2((1-COS B)↑2+(SIN B)↑2)→C	$\|X\| \leq 1 \times 10^{11}$	—
ASN .707; ASN (-.3);	$\|X\| \leq 1$	Calculates principal value only: $\theta = \sin^{-1} x$; $-90° \leq \theta \leq +90°$
COS 30; COS A; COS (-45); A↑2((1-SIN B)↑2+(COS B)↑2)→C;	$\|X\| \leq 1 \times 10^{11}$	—
ACS .317; ACS (-.5);	$\|X\| \leq 1$	Calculates principal value only: $\theta = \cos^{-1} x$; $0° \leq \theta \leq +180°$
TAN 60; TAN B; TAN (-30); A↑2((1-COS B)↑2+(TAN B)↑2)→C;	$\|X\| \leq 1 \times 10^{11}$	—
ATN .531; ATN (-.2);	$\|X\| < 10^{99}$	Calculates principal value only: $\theta = \tan^{-1} x$; $-90° \leq \theta \leq +90°$
INT 4.6; INT A; INT (-7.2); INT (A/B+1.03);	—	The integer function finds the integer of the absolute value of the argument and maintains the mantissa sign.
ABS (-4); ABS A; ABS (A/B+1.03);	—	Sets value positive without otherwise changing the value.
5↑2; 5↑(-2); (A+B)↑(X/Y-3);	For A↑B if A < 0, then B must be an integer	-2 ↑ 4 is equal to -16; (-2) ↑ 4 is equal to +16. (See TN↑)
2πA; 180B/π→C;	—	—
TBL 4; clears all available R-registers. TBL 5; clears registers A, B, C, X, Y and Z. TBL 6; Clears flags 0 through 15	—	See 'Select Circular Units' for TBL 0, 1, 2, 3. TBL 7, 8, 9 not used.

ERROR SUMMARY

Summary of maximum errors of Math Block functions.

a. Errors are expressed as absolute errors unless stated otherwise:

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

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

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

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

1.	LN		$\pm 7 \times 10^{-11}$ ±1/20 visible count
2.	EXP (e^X)	$X < 2.3$	relative error = $\pm 9 \times 10^{-11}$
		$X < 23$	relative error = $\pm 3 \times 10^{-10}$
		$X < 230$	relative error = $\pm 24 \times 10^{-10}$
3.	LOG		$\pm 3 \times 10^{-11}$ ±1/8 visible count
4.	TN↑ (10^X)	X is an integer	no error
		X is not an integer	error depends on LN and EXP

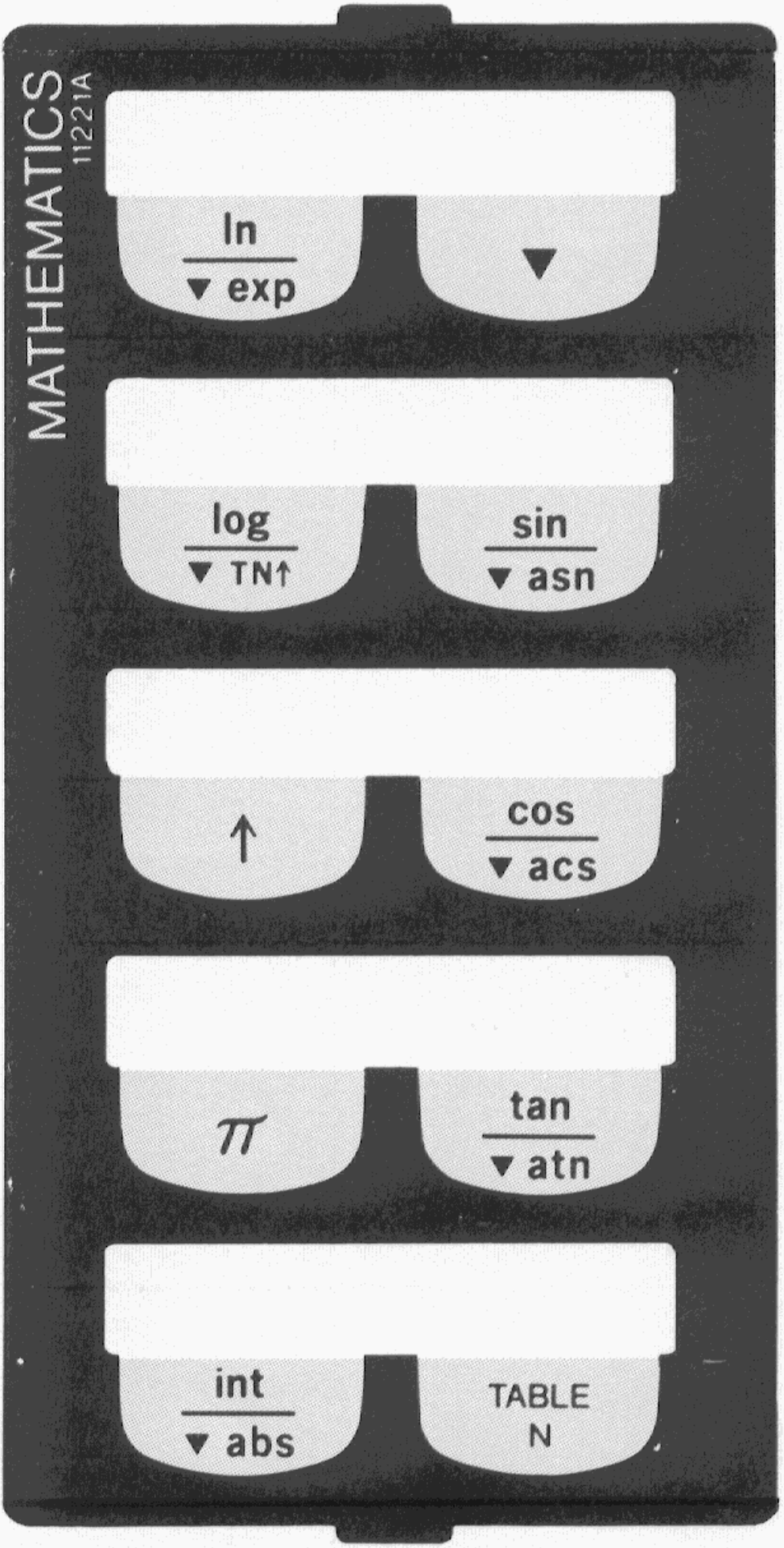
[TN↑ is computed as follows: $A = TN\uparrow\ x = e^{(x \ln 10)}$]

5.	SIN θ	$\theta < 1$ rad	±1 visible count
	1 rad $\leq$	$\theta < \pi$	$\pm 12 \times 10^{-11}$
	$\pi \leq$	$\theta < 2\pi$	$\pm 31 \times 10^{-11}$
	$2\pi \leq$	θ	$\pm 18 \times 10^{-10} \times 10^{(\text{no. of decades of circles})}$
6.	COS θ	$\theta < 1$ rad	$\pm 4 \times 10^{-11}$
	1 rad $\leq$	$\theta < \pi$	$\pm 9 \times 10^{-11}$
	$\pi \leq$	$\theta < 2\pi$	$\pm 28 \times 10^{-11}$
	$2\pi \leq$	θ	$\pm 18 \times 10^{-10} \times 10^{(\text{no. of decades of circles})}$
7.	TAN θ	$\theta < 1$ rad	±1½ visible count
	1 rad $\leq$	$\theta < \pi$	±½ (exp of answer) $\pm 2 \times 10^{-10}$ (visible counts)
	$\pi \leq$	$\theta < 2\pi$	±1 × exp of answer $\pm 3 \times 10^{-10}$ (visible counts)
	$2\pi \leq$	θ	±5 × 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
8.	SIN^{-1} (a)	$a < .707$	±½ visible count
		$a > .707$	rad $\pm 10^{-10}$
9.	COS^{-1} (a)	$a < .707$	±½ visible count $\pm 10^{-11}$
		$a > .707$	rad $\pm 10^{-10}$
			deg $\pm 70 \times 10^{-10}$

ERROR SUMMARY

10.	TAN^{-1} (a)	radians	±1/10 visible count
		degrees	±¼ visible count
11.	↑ (x^y)		Error depends upon accuracy of LN and EXP

[↑ is computed as follows: $A = x \uparrow y = e^{(y \ln x)}$]


MATHEMATICS
11221A
ln
▼ exp
▼
log
▼ TN↑
sin
▼ asn
↑
cos
▼ acs
π
tan
▼ atn
int
▼ abs
TABLE
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