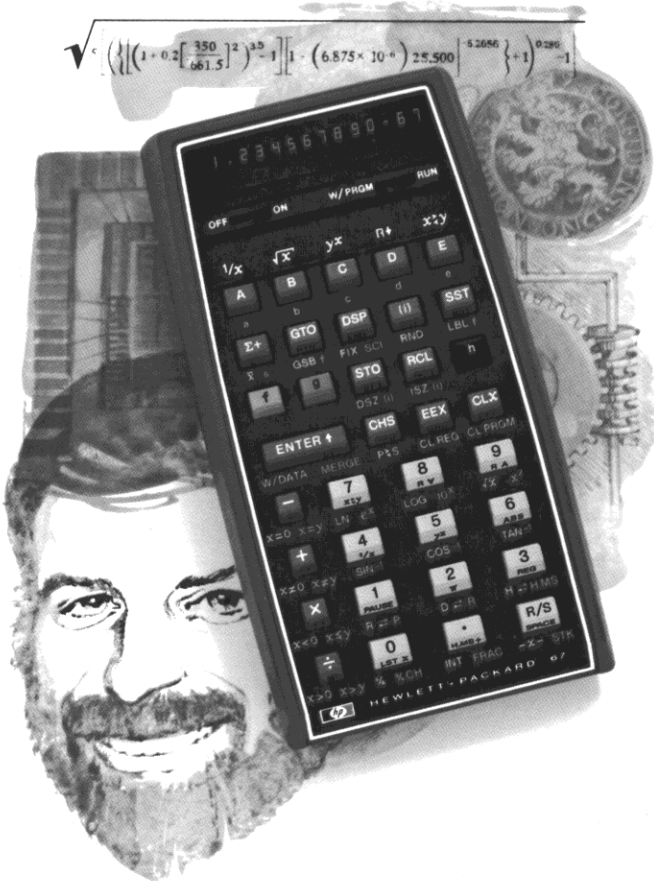
HEWLETT-PACKARD

HP-67

Owner's Handbook and Programming Guide



"The success and prosperity of our company will be assured only if we offer our customers superior products that fill real needs and provide lasting value, and that are supported by a wide variety of useful services, both before and after sale."

Statement of Corporate Objectives.
Hewlett-Packard

When Messrs. Hewlett and Packard founded our company in 1939, we offered one superior product, an audio oscillator. Today, we offer more than 3,000 quality products, designed and built for some of the world's most discerning customers.

Since we introduced our first scientific calculator in 1967, we've sold over a million world-wide, both pocket and desktop models. Their owners include Nobel laureates, astronauts, mountain climbers, businessmen, doctors, students, and housewives.

Each of our calculators is precision crafted and designed to solve the problems its owner can expect to encounter throughout a working lifetime.

HP calculators fill real needs. And they provide lasting value.

HEWLETT hp PACKARD

HP-67
Programmable Pocket Calculator

Owner's Handbook and Programming Guide

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Contents

Lunar Module model on page 122 courtesy of NASA, AMES Research Center.

The HP-67 Programmable Pocket Calculator

Function Key Index

Manual RUN Mode. W/PRGM-RUN switch W/PRGM RUN set to RUN.

Function keys pressed from the keyboard execute individual functions as they are pressed. Input numbers and answers are displayed. All function *keys* listed below operate either from the keyboard or as recorded instructions in a program.

OFF ON Power switch **(page 27).**

W/PRGM RUN Program mode switch **(page 124).**

Default Functions

1/x √x yˣ R↓ x≷y

Default functions. Operate only in manual RUN mode when no instructions have been loaded into program memory. Duplicated by other functions on calculator for programming or manual use **(page 131).**

Prefix Keys

f Pressed before function key, selects gold function printed below key **(page 28).**

g Pressed before function key, selects blue function printed below key **(page 28).**

h Pressed before function key, selects black function printed on slanted key face **(page 28).**

Digit Entry

ENTER↑ Enters a copy of number in displayed X-register into Y-register. Used to separate numbers **(page 58).**

CHS Changes sign of number or exponent of 10 in displayed X-register **(page 29).**

EEX Enter exponent. After pressing, next numbers keyed in are exponents of 10 **(page 48).**

0 through 9 Digit keys **(page 28).**

STK Automatic stack review. Flashes contents of stack in order T, Z, Y, X, with blinking decimal point **(page 56).**

Number Alteration

ABS Gives absolute value of number in displayed X-register **(page 86).**

INT Leaves only integer portion of number in displayed X-register by truncating fractional portion **(page 86).**

FRAC Leaves only fractional portion of number in displayed X-register by truncating integer portion **(page 87).**

RND Rounds mantissa of 10-digit number in X-register to actual value seen in the display **(page 85).**

Number Manipulation

R↑ Rolls up contents of stack for viewing in displayed X-register **(page 55).**

R↓ Rolls down contents of stack for viewing in displayed X-register **(page 54).**

x≷y Exchanges contents of X- and Y-registers of stack **(page 55).**

CL x Clears contents of displayed X-register to zero **(page 29).**

Percentage

% Computes x% of y **(page 90).**

%CH Computes percent of change from number in Y-register to number in displayed X-register **(page 91).**

Storage

STO Store. Followed by address key, stores displayed number in primary storage register (R_0 through R_9, R_A through R_E) specified. Also used to perform storage register arithmetic **(page 72).**

RCL Recall. Followed by address key, recalls number from primary storage register (R_0 through R_9, R_A through R_E) specified into the displayed X-register **(page 72).**

CL REG Clears contents of all primary storage registers (R_0 through R_9, R_A through R_E, I) to zero **(page 79).**

LST x Recalls number displayed before the previous operation back into the displayed X-register **(page 67).**

P⇄S Primary exchange secondary. Exchanges contents of primary storage registers R_0 through R_9 with contents of protected secondary storage registers R_{S0} through R_{S9} **(page 74).**

REG Automatic register review. Flashes contents of storage registers in order R_0 through R_9, R_A through R_E, I; register address appears in display preceding contents of storage register **(page 77).**

Display Control

FIX Selects fixed point display **(page 44).**

SCI Selects scientific notation display **(page 43).**

ENG Selects engineering notation display **(page 46).**

DSP Followed by number key, selects number of displayed digits **(page 42).**

Mathematics

N! Computes factorial of number in displayed X-register **(page 88).**

1/x Computes reciprocal of number in displayed X-register **(page 87).**

x^2 Computes square of number in displayed X-register **(page 89).**

$\sqrt{x}$ Computes square root of number in displayed X-register **(page 89).**

π Places value of pi (3.141592654) into displayed X-register **(page 89).**

+ − × ÷ Arithmetic operators **(page 32).**

Statistics

Σ+ Accumulates numbers from X- and Y-registers into secondary storage registers R_{S4} through R_{S9} **(page 107).**

Σ− Subtracts x and y values from storage registers R_{S4} through R_{S9} for correcting or subtracting Σ+ accumulation entries **(page 116).**

x̄ Computes mean (average) of x and y values accumulated by Σ+ **(page 111).**

s Computes sample standard deviations of x and y values accumulated by Σ+ **(page 113).**

Polar/Rectangular Conversion

→P Converts x, y rectangular coordinates placed in X- and Y-registers to polar magnitude r and angle θ **(page 99).**

R→ Converts polar magnitude r and angle θ in X- and Y-registers to rectangular x and y coordinates **(page 100).**

Flags

SF Set flag. Followed by flag designator (0, 1, 2, or 3), sets flag true **(page 255).**

CF Clear flag. Followed by flag designator (0, 1, 2, or 3), clears flag **(page 255).**

Trigonometry

[→H.MS] Converts decimal hours or degrees to *hours, minutes, seconds* or *degrees, minutes, seconds* **(page 94).**

[H→] Converts *hours, minutes, seconds* or *degrees, minutes, seconds* to decimal degrees **(page 94).**

[H.MS+] Adds *hours, minutes, seconds,* or *degrees, minutes, seconds* in Y-register to those in displayed X-register **(page 96).**

[SIN⁻¹] [COS⁻¹] [TAN⁻¹] Computes arc sine, arc cosine, or arc tangent of number in displayed X-register **(page 93).**

[SIN] [COS] [TAN] Computes sine, cosine, or tangent of value in displayed X-register **(page 93).**

[→R] Converts degrees to radians **(page 92).**

[D→] Converts radians to degrees **(page 92).**

[DEG] Sets decimal degrees mode for trigonometric functions **(page 93).**

[RAD] Sets radians mode for trigonometric functions **(page 93).**

[GRD] Sets grads mode for trigonometric functions **(page 93).**

Indirect Control

[STO I] Store-I. Stores number in I-register **(page 73).**

[RCL I] Recall-I. Recalls number from I-register **(page 73).**

[(i)] When preceded by [DSP], [GTO], [GSB], [STO] or [RCL], the address or control value for that function is specified by the current number in **I** **(page 223).**

[ISZ] Increment and skip if zero. Adds 1 to contents of **I**. Skips one step if contents are then zero **(page 215).**

[ISZ (i)] Increment (i) and skip if zero. Adds 1 to contents of storage register specified by value in **I**. Skips one step if contents are then zero **(page 238).**

[DSZ] Decrement **I** and skip if zero. Subtracts 1 from contents of **I**. Skips one step if contents are then zero **(page 215).**

[DSZ(i)] Decrement (i) and skip if zero. Subtracts 1 from contents of storage register specified by value in **I**. Skips one step if contents are then zero **(page 238).**

[X≷I] Exchanges contents of displayed X-register with those of **I**-register **(page 214).**

Logarithmic and Exponential

[y^x] Raises number in Y-register to power of number in displayed X-register **(page 104).**

[10^x] Common antilogarithm. Raises 10 to power of number in displayed X-register **(page 103).**

[e^x] Natural antilogarithm. Raises e (2.718281828) to power of number in displayed X-register **(page 103).**

[LOG] Computes common logarithm (base 10) of number in displayed X-register **(page 103).**

[LN] Computes natural logarithm (base e, 2.718...) of number in displayed X-register **(page 103).**

Magnetic Card Control

[W/DATA] If a magnetic card is passed through the card reader immediately after this operation, the contents of the storage registers are recorded on the card **(page 279).**

[MERGE] Merges, rather than overwrites, data or program from magnetic card with data or program in calculator **(page 275).**

The HP-67

Automatic Memory Stack

Registers

T 0.00
Z 0.00
Y 0.00

Program Memory

000	
001	84
002	84
003	84
004	84
005	84
220	84
221	84
222	84
223	84
224	84

Displayed X. 0.00

LAST X

Addressable Storage Registers

Primary Registers

	(i) Address
I	25
R_f	24
R_D	23
R_C	22
R_B	21
R_A	20
R_9	9
R_8	8
R_7	7
R_6	6
R_5	5
R_4	4
R_3	3
R_2	2
R_1	1
R_0	0

Protected Secondary Registers

	(i) Address
R_{59} n	19
R_{58} $\sum xy$	18
R_{57} $\sum y^2$	17
R_{56} $\sum y$	16
R_{55} $\sum x^2$	15
R_{54} $\sum x$	14
R_{53}	13
R_{52}	12
R_{51}	11
R_{50}	10

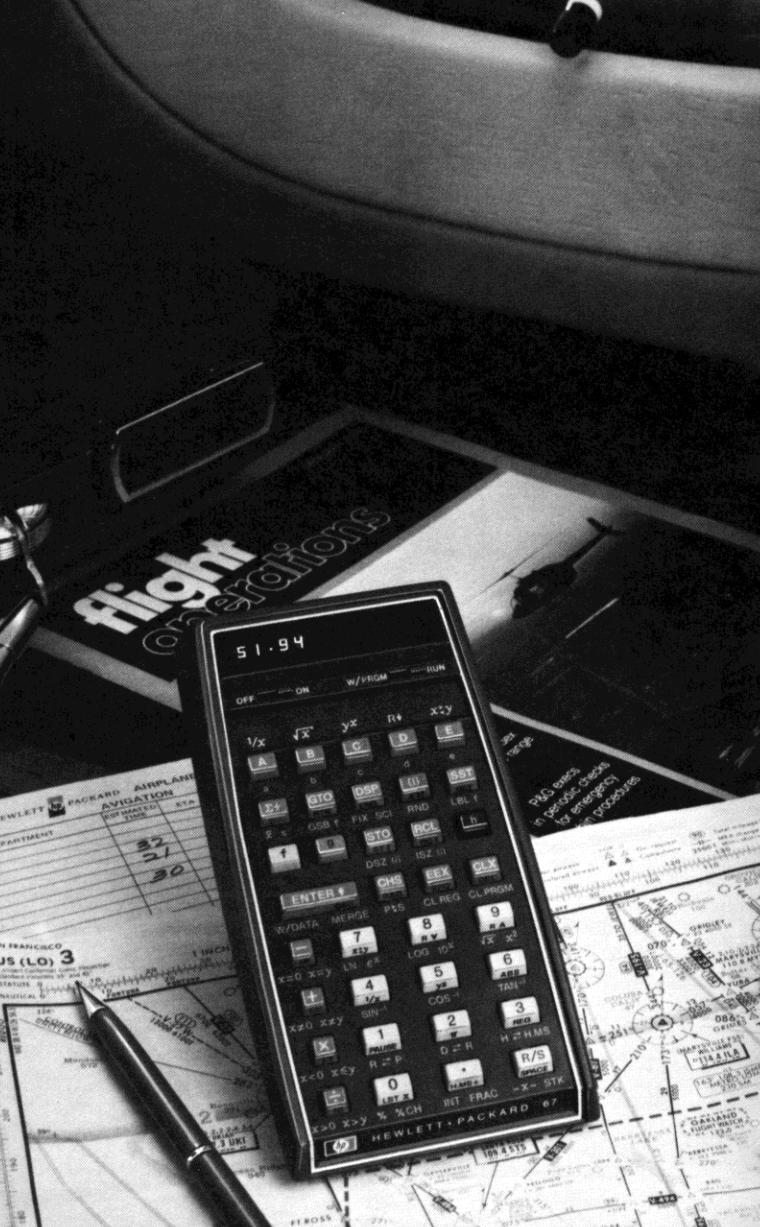
Programming Key Index

PROGRAM Mode	Automatic RUN Mode	
W/PRGM-RUN switch set to W/PRGM W/PRGM ▮▮▮ RUN All function keys except the 5 default keys and the functions shown below are loaded into program memory when pressed. Program memory contents recorded upon magnetic card when card passed through card reader.	PRGM-RUN switch W/PRGM ▮▮▮ RUN set to RUN. Function keys may be executed as part of a recorded program or individually by pressing from the keyboard. Input numbers and answers are displayed by the calculator, except where indicated. Data or instructions loaded from magnetic card into calculator when card is passed through card reader.	
Active keys: In PROGRAM mode only five operations are active. These operations are used to help record programs, and cannot themselves be recorded in program memory.	**Pressed from keyboard:** A B C D E a b c d e User-definable keys. Cause calculator to search downward through program memory to first designated label and begin execution there. **(page 137).**	**Executed as a recorded program instruction:** A B C D E 0 1 2 3 4 5 6 7 8 9 Label designators. When preceded by LBL, define beginning of routine. When preceded by GTO or GSB, cause calculator to stop execution, search downward through program memory to first designated label, and resume execution there **(page 133).** a b c d e Label designators. Operate exactly as label designators listed above, except they are preceded only by LBL f, GTO, and GSB f **(page 133).**

PROGRAM Mode	Automatic RUN Mode	
Active keys:	**Pressed from the keyboard:**	**Executed as a recorded program instruction:**
GTO Go to. Followed by • n n n positions calculator to step n n n of program memory. No instructions are executed **(page 157).**	GTO Go to. Followed by • n n n sets calculator to step n n n of program memory without executing instructions. Followed by label designator (A through E, f a through f e, 0 through 9) or (i), causes calculator to search downward through program memory to first designated label and stop there **(page179).**	GTO Go to. Followed by label designator (A through E, f a through f e, 0 through 9) or (i), causes calculator to stop execution, search through program memory to first designated label, and resume execution there **(page 179).**
	GSB GSB f Go to subroutine. Followed by label designator, (A through E, a through e, 0 through 9, (i)), causes calculator to start executing instructions, beginning with designated label **(page 207).**	GSB GSB f Go to subroutine. Followed by label designator (A through E, a through e, 0 through 9) or (i), causes calculator to search through program memory to first designated label and execute that section of program memory as a subroutine **(page 197).**
	RTN Return. Sets calculator to step 000 of program memory **(page 152).**	RTN Return. If executed as a result of pressing a label designator or execution of a GTO instruction, stops execution and returns control to keyboard. If executed as a result of a GSB instruction, returns control to next step after the GSB instruction **(page 134).**

PROGRAM Mode	Automatic RUN Mode	
Active keys:	**Pressed from keyboard:**	**Executed as a recorded program instruction:**
[CLPRGM] Clear program. Clears program memory to all [R/S] instructions, sets calculator to step 000, clears all flags, and specifies FIX 2 and DEGREE modes **(page 132).**	[CLPRGM] After [f] prefix key, cancels that key. After other keys, does nothing. Does not disturb program memory or calculator status **(page 147).**	[PAUSE] Stops program execution and transfers control to keyboard for 1 second, then resumes program execution **(page 172).**
[BST] Back step. Moves calculator back one step in program memory **(page 158).**	[BST] Back step. Sets calculator to and displays step number and keycode of previous program memory step when pressed; displays original contents of X-register when released. No instructions are executed **(page 158).**	[x≠y] [x=y] [x>y] [x≤y] [x≠0] [x=0] [x>0] [x<0] Conditionals. Each tests value in X-register against 0 or value in Y-register as indicated. If true, calculator executes instruction in next step of program memory. If false, calculator skips one step before resuming execution **(page 186).**
[SST] Single step. Moves calculator forward one step of program memory **(page 155).**	[SST] Single step. Displays step number and keycode of current program memory step when pressed; executes instruction, displays result, and moves calculator to next step when released **(page 152).**	[F?] If flag true. Followed by flag designator (0, 1, 2, or 3), tests designated flag. If flag is set (true) the calculator executes the instruction in the next step of program memory. If flag is cleared (false), calculator skips one step before resuming execution. [F?] clears flags F2 and F3 after test **(page 255).**

PROGRAM Mode	Automatic RUN Mode	
Active keys:	**Pressed from the keyboard:**	**Executed as a recorded program instruction:**
		[-x-] Flash X. Pauses to display contents of X-register for 5 seconds. Used to write down answers or to interface programs with HP-97 Programmable Printing Calculator **(page 172).**
		[SPACE] Executed as no operation in HP-67. Used to interface programs with HP-97 Programmable Printing Calculator **(page 304).**
	[R/S] Run/stop. Begins execution from current step of program memory. Stops execution if program is running **(page 169).**	[R/S] Run/stop. Stops program execution **(page 169).**
[DEL] Delete. Deletes current instruction from program memory. All subsequent instructions moved up one step **(page 161).**	[DEL] After [h] prefix key, cancels that key. After other keys, does nothing. Does not disturb program memory or calculator status **(page 161).**	
	Any key. Pressing any key on the keyboard stops execution of a running program.	


flight operations
51.94
OFF ON W/PRGM RUN
HEWLETT-PACKARD 67

Meet the HP-67

Congratulations!

With your purchase of the HP-67 Programmable Pocket Calculator, you have acquired a truly versatile and unique calculating instrument. Using the Hewlett-Packard RPN logic system that slices with ease through the most difficult equations, the HP-67 is without parallel:

As a scientific calculator. As a scientific calculator, the HP-67 features a multiple-entry keyboard with each of the 35 keys controlling up to four separate operations, ensuring maximum computing power in a pocket instrument.

As a problem-solving machine. Anyone who can follow simple step-by-step instructions can use the prerecorded magnetic cards in the Standard Pac and the optional application pacs from the areas of engineering, mathematics, finance, statistics, medicine, and many other fields. Immediately!

As a personal programmable calculator. The HP-67 is so easy to program and use that it requires no prior programming experience or knowledge of arcane programming languages. Yet even the most sophisticated computer experts marvel at the programming features of the HP-67:

- Magnetic cards that record data or programs—permanently.
- 26 data storage registers.
- 224 steps of program memory.
- Fully merged prefix and function keys that mean more programming per step.
- Easy-to-use editing features for correcting and modifying programs.
- Powerful unconditional and conditional branching.
- Three levels of subroutines, four flags, 20 easily-accessed labels.
- Indirect addressing.

And in addition, the HP-67 can be operated from its rechargeable battery pack for *complete portability,* anywhere.

Now let's take a closer look at the HP-67 to see how easy it is to use, whether we solve a problem manually, use one of the sophisticated prerecorded programs from the Standard Pac, or even write our own program.

Manual Problem Solving

To get the feel of your HP-67, try a few simple calculations. First, set the switches that are located at the top of the keyboard as follows:

Set the OFF-ON switch OFF ▮▮▮ ON to ON.
Set the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

To solve:	Press:	Display:
$5 + 6 = 11$	5 ENTER↑ 6 +	11.00
$8 \div 2 = 4$	8 ENTER↑ 2 ÷	4.00
$7 - 4 = 3$	7 ENTER↑ 4 −	3.00
$9 \times 8 = 72$	9 ENTER↑ 8 ×	72.00
$\frac{1}{5} = 0.20$	5 h 1/x	0.20
Sine of $30° = 0.50$	3 0 f SIN	0.50

Now let's try something a little more involved. To calculate the surface area of a sphere, the formula $A = \pi d^2$ can be used, where:

A is the surface area of the sphere,
d is the diameter of the sphere,
π is the value of pi, 3.141592654.

Ganymede, one of Jupiter's 12 moons, has a diameter of 3200 miles. You can use the HP-67 to manually compute the area of Ganymede. Merely press the following keys in order:

Press	Display	
3 2 0 0	3200.	Diameter of Ganymede.
g x^2	10240000.00	Square of the diameter.
h π	3.14	The quantity π.
×	32169908.78	Area of Ganymede in square miles.

As you will see, these same keystrokes can be used to write a *program* for the HP-67 that will solve for the area of *any* sphere. But first let's look at a prerecorded program, one of the fifteen in the Standard Pac shipped with your calculator.

Running a Prerecorded Program

The Standard Pac shipped with your calculator contains 15 prerecorded magnetic cards, and each card contains a program. By using cards from the Standard Pac (or from any of the optional application pacs, available in areas like finance, statistics, mathematics, engineering, or medicine) you can use your HP-67 to perform extremely complex calculations just by following the cookbook-style directions in each pac. Let's try running one of these programs now.

1. Select the Calendar Functions program from the Standard Pac card case.

2. Ensure that the W/PRGM-RUN switch W/PRGM RUN is set to RUN.

3. Insert side 1 of the Calendar Functions card, printed side up, into the card reader slot on the right of the calculator as shown. When the card is partially into the slot, a motor engages and passes the card through the calculator and out a similiar slot on the left of the calculator. Let the card move freely.

4. The calculator display should read Crd to prompt you that side 2 of the card must be read in.
5. Now insert side 2 of the calendar functions card, again face up, into the card reader slot on the right side of the calculator and permit it to pass through the card reader to the rear of the calculator.
6. If after either pass of the card through the card reader, the display shows Error, that side of the card did not read properly. Press CLx, then insert that side of the card into the card reader slot and let it pass through again.
7. When both sides of the card have been read properly, the display will again show the previous answer.
8. Insert the card into the window slot, as shown. The markings on the card should be directly over the keys marked A B C D E. The markings, or mnemonics, on the card now identify the function of each of these five keys.

You are now ready to use the program.

Example: How many days are there between September 3, 1944 and November 21, 1975?

Solution: The figure on the next page duplicates the user instructions for the Calendar Functions program. These instructions can also be found in the *HP-67 Standard Pac,* just as can the instructions for the other 14 programs in the pac.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	For day of the week calculations			
	go to step 6.			
3	Input two of the following:			
	First date (mm.ddyyyy)	DT_1	A	Day #$_1$
	Second date (mm.ddyyyy)	DT_2	B	Day #$_2$
	Days between dates	DAYS	C	Days
	or weeks between dates*	WKS. DYS	D	Days
4	Calculate one of the following:			
	First date		A	DT_1
	Second date		B	DT_2
	Days between dates		C	Days
	Weeks between dates		D	WKS. DYS
5	For a new case go to step 2.			
6	Input date and calculate day			
	of the week (0 = Sunday,			
	6 = Saturday).	DT	E	DOW
7	For a new case go to step 2.			
	*Either days between dates or			
	weeks between dates, but not			
	both, may be input in step 3.			

To solve the problem, just follow the User Instructions, beginning with step 1. Since you have already performed step 1, and you do not wish to perform step 2, you continue on to step 3. There you input the first date in the format mm.ddyyyy. (This means you key in the date as the month, from 00 to 12, then a decimal point, then the day as dd, and finally the year as yyyy.) Thus, to key in September 3, 1944:

Press	**Display**
09.031944	*09.031944*

Reading across the line, you can see that after you input the first date (DT_1), you are directed under the Keys heading to press [A].

Press	Display	
[A]	2431337.	Julian day number (number of days since the inception of the Julian calendar).

Now follow the instructions for the second date (DT_2) which is November 21, 1975.

Press	Display	
11.211975	11.211975	
[B]	2442738.	(Julian day number used by astronomers.)

Now you move to step 4, which gives the key you press for calculation. You can see that to calculate the days between dates, you press [C].

Press	Display
[C]	11401.

The number of days between September 3, 1944 and November 21, 1975 is 11401.

You can run the program again as often as you like. With the calendar program, you can calculate the days between dates, the weeks between dates, or even the day of the week on which any date falls.

You have seen from this example how simple it is to use your HP-67. You can begin using your Standard Pac, or any of the optional applications pacs, right *now*. All you have to do to begin taking advantage of the calculating power and programmability of the HP-67 is follow simple instructions like these.

Your Own Program

Earlier, you calculated the surface area of Ganymede, one of Jupiter's 12 moons. Now, if you wanted the surface area of *each* moon, you could repeat that procedure 12 times, using a different value for the diameter *d* each time. An easier and faster method, however, is to create a *program* that will calculate the surface area of a sphere from its diameter, instead of pressing all the keys for each moon.

To calculate the area of a sphere using a program, you should first *create* the program, then you must *load* the program into the calculator, and finally you *run* the program to calculate each answer. If you want to save the program, you can *record* it permanently on a magnetic card.

Creating the Program. You have already created it! A program is nothing more than the series of keystrokes you would execute to solve the same problem manually. Two additional operations, a *label* and a *return* are used to define the beginning and end of the program.

Loading the Program. To load the keystrokes of the program into the calculator:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM *(program)*.

Press f CLX (CL PRGM) to clear the calculator.

Press the following keys in order. (When you are loading a program, the display gives you information that you will find useful later, but which you can ignore for now.)

f SST (LBL) A — Defines the beginning of the program.

g 9 (R↓) h 2 (P) × (P?) — These are the same keys you pressed to solve the problem manually.

h GTO (RTN) — Defines the end of the program.

The calculator will now remember this keystroke sequence.

Running the Program. To run the program to find the area of any sphere from its diameter:

1. Slide the W/PRGM-RUN switch W/PRGM RUN back to RUN.
2. Key in the value of the diameter.
3. Press A to run the program.

When you press A, the sequence of keystrokes you loaded is automatically executed by the calculator, giving you the same answer you would have obtained manually.

For example, to calculate the area of Ganymede, with a diameter of 3200 miles:

Press	Display	
3200	3200.	
A	32169908.78	Square miles.

With the program you have loaded, you can now calculate the area of any of Jupiter's moons—in fact, of *any* sphere—using its diameter. You have only to leave the calculator in RUN mode and key in the diameter of each sphere for which you want the area, then press A. For example, to compute the surface area of Jupiter's moon Io, with a diameter of 2310 miles:

Press	Display	
2310 A	16763852.56	Square miles.

For the moons Europa, diameter 1950 miles, and Callisto, diameter 3220 miles:

Press	Display	
1950 A	11945906.07	Area of Europa in square miles.
3220 A	32573289.27	Area of Callisto in square miles.

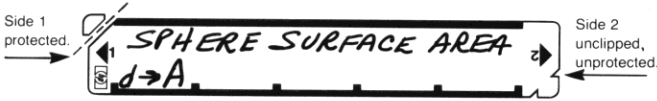
Programming the HP-67 is *that* easy! The calculator remembers a series of keystrokes and then executes it at the press of a single key. In fact the HP-67 can remember up to 224 separate operations (and many more keystrokes, since many operations require two or three keystrokes) and execute them at the press of one of the label keys. By using, say, label A for one program, label B for another, etc., your calculator can contain many different programs at one time.

Recording the Program. Just as the programs in the Standard Pac have been permanently recorded on magnetic cards, so you can record your program on a magnetic card. To record your program:

1. Select a blank, unprotected (unclipped) magnetic card.

2. Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.
3. Insert side 1 of the card into the right card reader slot on the calculator. Permit the card to pass through the card reader to the left of the calculator. Since your program contains fewer than 113 instructions, you need to pass only one side of the card through the card reader. Your program is now recorded on the magnetic card.
4. Be sure to mark the card so you don't forget what program is on the card and what keys control the program. The marked card might look like this when you are through:

5. The program now on the card will remain there until you record another program over it. To save the program permanently, so that no other program can be recorded on the card, clip the corner of the card nearest side 1:



That's all there is to it! You can reuse the program as often as you like—merely pass the card through the card reader with the W/PRGM-RUN switch set to RUN each time you want to load this program into the calculator.

Using this Handbook

New to Hewlett-Packard Calculators? Part One of this handbook has been designed to teach you to use your HP-67 as a powerful scientific calculator. By working through these sections of the handbook, you'll learn every function that you can use to calculate answers manually, and you'll come to appreciate the calculating efficiency of the Hewlett-Packard logic system with RPN. And since the programmability of the HP-67 stems from its ability to remember a series of manual keystrokes, Part One, Using Your HP-67 Calculator, is invaluable in laying the groundwork for Part Two, Programming The HP-67.

Previous HP User? If you've already used Hewlett-Packard pocket or desktop calculators with RPN, you may want to turn directly to Part Two, Programming The HP-67. Later, though, you will undoubtedly wish to peruse Part One at your leisure in order to discover the many calculating advantages of the HP-67.

Whether an old hand or a novice, you'll find the Function and Key Index on pages 8–13 invaluable as a quick reference guide, a programming guide, or even to illustrate the features of the HP-67 to your friends.

Part One

Using Your HP-67 Pocket Calculator


OFF ON W/PRGM RUN
1/x √x y^x
ENTER↑
W/DATA MERGE P↕S CL REG CL PRGM
HEWLETT-PACKARD
HALT

Section 1

Getting Started

Your HP-67 is shipped fully assembled, including a battery. You can begin using your calculator immediately by connecting the cord from the ac adapter/recharger and plugging the charger into an ac outlet. If you want to use your HP-67 on battery power alone, you should charge the battery for 14 hours first. Whether you operate from battery power or from power supplied by the charger, *the battery pack must always be in the calculator.*

To begin:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Slide the OFF-ON switch OFF ON to ON.

Display

Numbers that you key into the calculator and intermediate and final answers are always seen in the bright red display. When you first turn the calculator ON, the display is set to 0.00 to show you that all zeros are present there.

Keyboard

Each key on the keyboard can perform as many as four different functions. One function is indicated on the flat plane of the key face, while another is printed in black on the slanted face of the key. A third and a fourth function may be indicated by printed symbols in gold and blue, respectively, below the key.

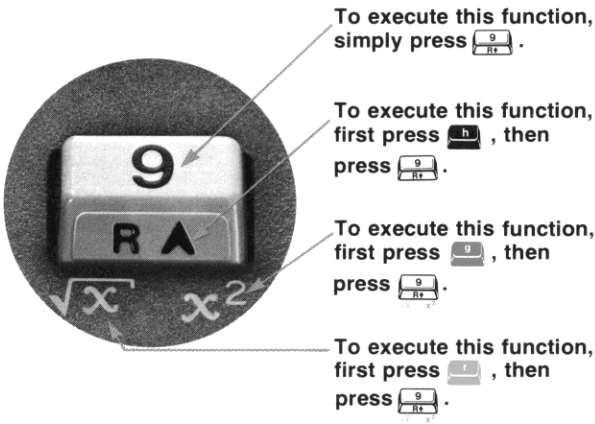
There are three *prefix* keys, f , g , and h . By pressing one of these prefix keys before pressing a function key, you select the function printed on the slanted key face or one of the functions printed in gold or blue below the function key.

To select the function printed on the flat plane of a function key, press the key.

To select the function printed in black on the slanted key face, first press the black h prefix key. Then press the function key.

To select the function printed in gold below the function key, first press the gold f prefix key. Then press the function key.

To select the function printed in blue below the function key, first press the blue g prefix key. Then press the function key.



In this handbook, the selected key function will appear in the appropriate color, outlined by a box, like this: [R↓], [√x], [x²].

Keying In Numbers

Key in numbers by pressing the number keys in sequence, just as though you were writing on a piece of paper. The decimal point must be keyed in if it is part of the number (unless it is to be right of the last digit).

Example:

Key in 148.84
by pressing the keys
[1] [4] [8] [•] [8] [4]

Display
148.84

The resultant number 148.84 is seen in the display.

Negative Numbers

To key in a negative number, press the keys for the number, then press CHS *(change sign)*. The number, preceded by a minus (−) sign, will appear in the display. For example, to change the sign of the number now in the display:

Press	Display
CHS	-148.84

You can change the sign of either a negative or a positive nonzero number in the display. For example, to change the sign of the -148.84 now in the display back to positive:

Press	Display
CHS	148.84

Notice that only negative numbers are given a sign in the display.

Clearing

You can clear any numbers that are in the display by pressing CL x *(clear X)*. This key erases the number in the display and replaces it with 0.00

Press	Display
CL x	0.00

If you make a mistake while keying in a number, clear the entire number string by pressing CL x. Then key in the correct number.

Functions

In spite of the dozens of functions available on the HP-67 keyboard, you will find the calculator functions simple to operate by using a single, all-encompassing rule: *When you press a function key, the calculator immediately executes the function written on the key.*

> Pressing a function key causes the calculator to immediately perform that function.

For example, to calculate the square of 148.84, merely:

Press	Display
148.84	148.84
g x^2	22153.35

To calculate the square root of the number now in the display:

Press	Display
f $\sqrt{x}$	148.84

Notice that you did not use the $\sqrt{x}$ function directly over the B key to calculate the square root. The five functions above the A, B, C, D, and E keys are known as *default* functions. When you first turn the HP-67 ON, these default functions are present in the calculator, and you can select any of them by simply pressing the appropriate key (A through E). However, as soon as you begin keying in a program, the default functions are lost, and the top row keys (A through E) are used to select programs or routines within programs. The only way to restore the default functions to the calculator is to clear the calculator of all programs, either by turning it OFF, then ON, or by pressing f CL PRGM with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM.

Each of the five default functions is duplicated by another key on the keyboard. For example, you can select the square root function either with the default function $\sqrt{x}$ or by pressing f $\sqrt{x}$. When the default functions are operational, you can use a default function by pressing only one keystroke. In this handbook, however, we normally show the prefixed function instead of the default function.

Whether selected as a default function or as a prefixed function, [√x] is an example of a one-number function; that is, a key that operates upon a single number. All function keys in the HP-67 operate upon either one number or two numbers at a time (except for statistics keys like [Σ+] and [s]—more about these later).

> Function keys operate upon either one number or two numbers.

One-Number Functions

To use any one-number function key:

1. Key in the number.
2. Press the function key (or press the prefix key, then the function key).

For example, to use the one-number function [1/x] key, you first key in the number represented by x, then press the function key. To calculate ¼, key in 4 (the x-number) and press [h] [1/x].

Press	Display
4	4.
[h] [1/x]	0.25

Now try these other one-number function problems. Remember, *first key in the number, then press the function:*

$\frac{1}{25}$	=	0.04
$\sqrt{2500}$	=	50.00
10^5	=	100000.00 (Use the [10^x] key.)
$\sqrt{3204100}$	=	1790.00
log 12.58925411	=	1.10
71^2	=	5041.00

Two-Number Functions

Two-number functions are functions that must have two numbers present in order for the operation to be performed. [+], [−], [×], and [÷] are examples of two-number function keys. You cannot add, subtract, multiply, or divide unless there are two numbers present in the calculator. Two-number functions work the same way as one-number functions—that is, the operation occurs when the function key is pressed. Therefore, *both numbers must be in the calculator before the function key is pressed.*

When more than one number must be keyed into the calculator before performing an operation, the [ENTER↑] key is used to separate the two numbers.

> Use the [ENTER↑] key whenever more than one number must be keyed into the calculator before pressing a function.

If you key in only one number, you never need to press [ENTER↑]. To place two numbers into the calculator and perform an operation:

1. Key in the first number.
2. Press [ENTER↑] to separate the first number from the second.
3. Key in the second number.
4. Press the function key to perform the operation.

For example, to add 12 and 3:

Press	
12	The first number.
[ENTER↑]	Separates the first number from the second.
3	The second number.
[+]	The function.

The answer, | *15.00* | , is displayed.

Other arithmetic functions are performed the same way:

To perform	Press	Display
12 − 3	12 ENTER↑ 3 −	9.00
12 × 3	12 ENTER↑ 3 ×	36.00
12 ÷ 3	12 ENTER↑ 3 ÷	4.00

The y^x key is also a two-number operation. It is used to raise numbers to powers, and you can use it in the same simple way that you use every other two-number function key:

1. Key in the first number.
2. Press ENTER↑ to separate the first number from the second.
3. Key in the second number (power).
4. Perform the operation (press h y^x).

When working with any function key (including y^x), you should remember that the displayed number is always designated by x on the function key symbols.

> The number displayed is always x.

So $\sqrt{x}$ means square root of the displayed number, $1/x$ means $\frac{1}{\text{displayed number}}$, etc.

Thus, to calculate 3^6:

Press	Display	
3	3.	
ENTER↑	3.00	
6	6.	x, the displayed number, is now six.
h y^x	729.00	The answer.

Now try the following problems using the [y^x] key, keeping in mind the simple rules for two-number functions:

16^4 (16 to the 4th power) = 65536.00

81^2 (81 squared) = 6561.00 (You could also have done this as a one-number function using [x²].)

$225^{.5}$ (Square root of 225) = 15.00 (You could also have done this as a one-number function using [√x].)

2^{16} (2 to the 16th power) = 65536.00

$16^{.25}$ (4th root of 16) = 2.00

Chain Calculations

The speed and simplicity of operation of the Hewlett-Packard logic system become most apparent during chain calculations. Even during the longest of calculations, you still perform only one operation at a time, and you see the results as you calculate—the Hewlett-Packard automatic memory stack stores up to four intermediate results inside the calculator until you need them, then inserts them into the calculation. This system makes the process of working through a problem as natural as it would be if you were working it out with pencil and paper, but the calculator takes care of the hard part.

For example, solve $(12 + 3) \times 7$.

If you were working the problem with a pencil and paper, you would first calculate the intermediate result of $(12 + 3)$...

$$(12 + 3) \times 7 =$$

15

...and then you would multiply the intermediate result by 7.

$$(12 + 3) \times 7 = 105$$

15 x 7 = 105

You work through the problem exactly the same way with the HP-67, one operation at a time. You solve for the intermediate result first...

$$(12 + 3)$$

Press	Display	
12	12.	
ENTER↑	12.00	
3	3.	
+	15.00	Intermediate result.

...and then solve for the final answer. You don't need to press ENTER↑ to store the intermediate result—the HP-67 automatically stores it inside the calculator when you key in the next number. To continue...

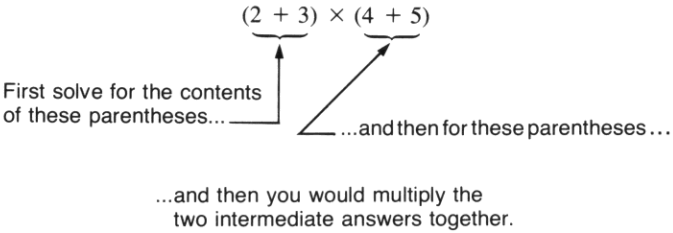
Press	Display	
7	7.	The intermediate result from the preceding operation is automatically stored inside the calculator when you key in this number.
×	105.00	Pressing the function key multiplies the new number and the intermediate result, giving you the final answer.

Now try these problems. Notice that for each problem you only have to press ENTER↑ to insert a pair of numbers into the calculator—each subsequent operation is performed using a new number and an automatically stored intermediate result.

To solve	Press	Display
$\frac{(2 + 3)}{10}$	2	
	ENTER↑	
	3	
	+	
	10	
	÷	0.50

To solve	Press	Display
$3\ (16 - 4)$	16	
	ENTER↑	
	4	
	−	
	3	
	×	36.00
$\frac{14 + 7 + 3 - 2}{4}$	14	
	ENTER↑	
	7	
	+	
	3	
	+	
	2	
	−	
	4	
	÷	5.50

Problems that are even more complicated can be solved in the same simple manner, using the automatic storage of intermediate results. For example, to solve $(2 + 3) \times (4 + 5)$ with a pencil and paper, you would:



You work through the problem the same way with the HP-67. First you solve for the intermediate result of (2 + 3)....

Press	Display	
2	2.	
ENTER↑	2.00	
3	3	
+	5.00	Intermediate result.

Then add 4 and 5:

(Since you must now key in another *pair* of numbers before you can perform a function, you use the ENTER↑ key again to separate the first number of the pair from the second.)

Procedure	Press	Display
~~(2+3)~~ × ~~(4+5)~~ 5 9	4 ENTER↑ 5 +	9.00

Then multiply the intermediate answers together for the final answer:

Procedure	Press	Display
~~(2+3)~~ × ~~(4+5)~~ 5 × 9	×	45.00

Notice that you didn't need to write down or key in the intermediate answers from inside the parentheses before you multiplied—the HP-67 automatically stacked up the intermediate results inside the calculator for you and brought them out on a last-in, first-out basis when it was time to multiply.

No matter how complicated a problem may look, it can always be reduced to a series of one- and two-number operations. Just work through the problem in the same logical order you would use if you were working it with a pencil and paper.

For example, to solve:

$$\frac{(9 + 8) \times (7 + 2)}{(4 \times 5)}$$

Press	Display	
9 ENTER↑ 8 +	17.00	Intermediate result of (9 + 8).
7 ENTER↑ 2 +	9.00	Intermediate result of (7 + 2).
×	153.00	(9 + 8) multiplied by (7 + 2).
4 ENTER↑ 5 ×	20.00	Intermediate result of (4 × 5).
÷	7.65	The final answer.

Now try these problems. Remember to work through them as you would with a pencil and paper, but don't worry about intermediate answers—they're handled automatically by the calculator.

$(2 \times 3) + (4 \times 5) =$ 26.00

$$\frac{(14 + 12) \times (18 - 12)}{(9 - 7)} = 78.00$$

$$\frac{\sqrt{16.38 \times 5}}{.05} = 181.00$$

$4 \times (17 - 12) \div (10 - 5) =$ 4.00

$\sqrt{(2 + 3) \times (4 + 5)} + \sqrt{(6 + 7) \times (8 + 9)} =$ 21.57

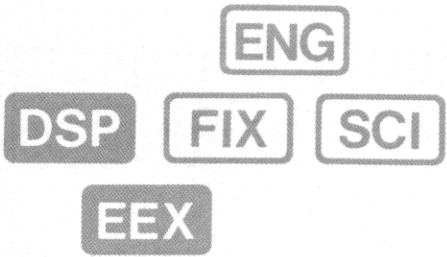
A Word about the HP-67

Now that you've learned how to use the calculator, you can begin to fully appreciate the benefits of the Hewlett-Packard logic system. With this system, you enter numbers using a parenthesis-free, unambiguous method called RPN (Reverse Polish Notation).

It is this unique system that gives you all these calculating advantages whether you're writing keystrokes for an HP-67 program or using the HP-67 under manual control:

- You never have to work with more than one function at a time. The HP-67 cuts problems down to size instead of making them more complex.
- Pressing a function key immediately executes the function. You work naturally through complicated problems, with fewer keystrokes and less time spent.
- Intermediate results appear as they are calculated. There are no "hidden" calculations, and you can check each step as you go.
- Intermediate results are automatically handled. You don't have to write down long intermediate answers when you work a problem.
- Intermediate answers are automatically inserted into the problem on a last-in, first-out basis. You don't have to remember where they are and then summon them.
- You can calculate in the same order that you do with pencil and paper. You don't have to think the problem through ahead of time.

The HP system takes a few minutes to learn. But you'll be amply rewarded by the ease with which the HP-67 solves the longest most complex equations. With HP, the investment of a few moments of learning yields a lifetime of mathematical dividends.


ENG
DSP
FIX
SCI
EEX

Section 2

Display Control

In the HP-67, you can select many different rounding options for display of numbers. When you first turn on the HP-67, for example, the calculator "wakes up" with numbers appearing rounded to two decimal places. Thus, the fixed constant π, which is actually in the calculator as 3.141592654, will *appear in the display* as 3.14 (unless you tell the calculator to display the number rounded to a greater or lesser number of decimal places).

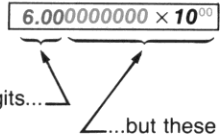
Although a number is normally shown to only two decimal places, the HP-67 always computes internally using each number as a 10-digit mantissa and a two-digit exponent of 10. For example, when you compute 2 × 3, you *see* the answer to only two decimal places:

Press	Display
2 ENTER↑ 3 ×	6.00

However, inside the calculator all numbers have 10-digit mantissas and two-digit exponents of 10. So the HP-67 *actually* calculates using full 10-digit numbers:

$$2.000000000 \times 10^{00} \text{ ENTER↑ } 3.000000000 \times 10^{00} \times$$

yields an answer that is actually carried to full 10 digits internally:



Display Control Keys

There are four keys, FIX, SCI, ENG, and DSP that allow you to control the manner in which numbers appear in the display in the HP-67. DSP followed by a number key changes the number of displayed digits without changing the format. FIX displays numbers in fixed decimal point format, while SCI permits you to see numbers in scientific notation format. ENG displays numbers in engineering notation, with exponents of 10 shown in multiples of three (e.g., 10^{3}, 10^{-6}, 10^{15}).

No matter which format or how many displayed digits you choose, these display control keys alter only the *manner* in which a number is displayed in the HP-67. The actual number itself is not altered by any of the display control keys. No matter what type of display you select, the HP-67 always calculates internally with numbers consisting of full 10-digit mantissas multiplied by 10 raised to a two-digit exponent.

Display Number Changes

The DSP (*display*) key followed by a number key specifies the *number* of digits that your HP-67 will display. For example, when you turn the HP-67 ON, it "wakes up" with two digits displayed after the decimal point. Using the DSP key and the appropriate number key (0–9), you can display up to nine digits after the decimal point. For example:

Press	Display	
(Turn the calculator OFF, then ON.)	0.00	Calculator "wakes up" with two digits shown after the decimal point.
DSP 4	0.0000	Four digits shown after decimal point.
DSP 9	0.000000000	Nine digits shown after decimal point.
DSP 2	0.00	Two digits shown after decimal point.

In the next few pages, you will see how the DSP and number keys are used in conjunction with FIX, SCI, and ENG to display numbers in any of a wide variety of formats.

Scientific Notation Display

In scientific notation each number is displayed with a single digit to the left of the decimal point followed by a specified number of digits (up to nine) to the right of the decimal point and multiplied by a power of 10. Scientific notation is particularly useful when working with very large or small numbers.

Scientific Notation Display

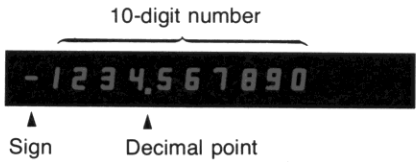
Scientific notation is selected by pressing g [SCI]. The DSP key followed by a digit key is then used to specify the number of decimal places to which the number is rounded. The display is left-justified and includes trailing zeros within the setting selected by the DSP key. To change the number of places displayed after the decimal point, use the DSP key followed by the appropriate number key. For example:

Press	Display	
(Turn the calculator OFF, then ON.)	0.00	Calculator "wakes up" with two places displayed after the decimal point.
123.4567	123.4567	
g [SCI]	1.23 02	Displays 1.23×10^2. Two decimal places shown after decimal point.

DSP 4	1.2346 02	Displays 1.2346×10^2. Notice that the display rounds if the first *hidden* mantissa digit is 5 or greater.
DSP 7	1.2345670 02	Displays 1.2345670×10^2.
DSP 9	1.234567000 02	Displays 1.234567000×10^2.
DSP 4	1.2346 02	Displays 1.2346×10^2.

Fixed Point Display

When you first turn the HP-67 ON, the display you see is FIX 2—that is, fixed point display with two decimal places shown. In fixed point display, numbers are shown with a fixed number of displayed digits after the decimal point. The number begins at the left side of the display and includes trailing zeros within the setting selected. You can select fixed point display from the keyboard by using the FIX function.



Fixed Point Display

After you have specified fixed point format, you can use the DSP key followed by the appropriate number key (0–9) to select the number of places to which the display is rounded. For example:

Press	Display	
123.4567	123.4567	
f FIX	123.4567	Display is rounded to the four decimal places you specified earlier.

DSP 0	123.	
DSP 7	123.4567000	
DSP 1	123.5	Notice that the display rounds if the first *hidden* digit is 5 or greater.
DSP 2	123.46	Normal FIX 2 display.

Engineering Notation Display

Engineering notation allows all numbers to be shown with exponents of 10 that are multiples of three (e.g., 10^{3}, 10^{-6}, 10^{12}).

One significant digit always present.

Specified significant digits after the first one.

Exponent of 10 always a multiple of three.

Engineering Notation Display

Engineering notation is particularly useful in scientific and engineering calculations, where units of measure are often specified in multiples of three. See the prefix chart below.

Multiplier	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Engineering notation is selected by pressing h [ENG]. The first significant digit is *always* present in the display. When you press [DSP] followed by a number key, you specify the number of *additional* displayed digits after the first one. The decimal point always appears in the display. For example:

Press	Display	
.000012345	.000012345	
h [ENG]	12.3 -06	Engineering notation display. Since you had specified [DSP] 2 in the previous example, the number appears here rounded off to two significant digits after the omnipresent first one. Power of 10 is proper multiple of three.
[DSP] 3	12.35 -06	Display is rounded off to third significant digit after the first one.
[DSP] 9	12.34500000-06	
[DSP] 0	10. -06	Display rounded off to first significant digit.

Notice that rounding can occur to the *left* of the decimal point, as in the case of [ENG] 0 specified above.

When engineering notation has been selected, the decimal point shifts to show the mantissa as units, tens, or hundreds in order to maintain the exponent of 10 as a multiple of three. For example, multiplying the number now in the calculator by 10 causes the decimal point to shift to the right without altering the exponent of 10:

Press	Display	
[DSP] 2	12.3 -06	ENG 2 display.
10 ×	123. -06	ENG 2 display.

However, multiplying again by 10 causes the exponent to shift to another multiple of three and the decimal point to move to the units position. Since you specified ENG 2 earlier, the HP-67 maintains two significant digits after the first one when you multiply by 10:

Press	Display	
10 ×	1.23 -03	Decimal point shifts. Power of 10 shifts to 10^{-3}. Display maintains two significant digits after the first one.

Automatic Display Switching

The HP-67 switches the display from fixed point notation to full scientific notation (SCI 9) whenever the number is too large or too small to be seen with a fixed decimal point. This feature keeps you from missing unexpectedly large or small answers. For example, if you try to solve $(.05)^3$ in normal FIX 2 display, the answer is automatically shown in scientific notation.

Press	Display	
CLx f FIX	0.00	Normal FIX 2 display.
.05 ENTER↑	0.05	
3 h y^x	1.250000000-04	Display automatically switched to SCI 9 to show answer.

After automatically switching from fixed to scientific, when a new number is keyed in or CLx is pressed the display automatically reverts back to the fixed point display originally selected.

The HP-67 also switches to scientific notation if the answer is too large ($\geq 10^{10}$) for fixed point display. For example, the display will not switch from fixed if you solve 1582000 × 1842:

Press	Display	
1582000 ENTER↑	1582000.00	
1842 ×	2914044000.	Fixed point format.

However, if you multiply the result by 10, the answer is too large for fixed point notation, and the calculator display switches automatically to scientific notation:

Press	Display	
10 ×	2.914044000 10	Scientific notation format.

Notice that automatic switching is between fixed and scientific notation display modes only—engineering notation display must be selected from the keyboard.

Keying In Exponents of Ten

You can key in numbers multiplied by powers of 10 by pressing EEX *(enter exponent of 10)* followed by number keys to specify the exponent of 10. For example, to key in 15.6 trillion (15.6×10^{12}), and multiply it by 25:

Press	Display	
15.6	15.6	
EEX	15.6 00	
12	15.6 12	(This means 15.6×10^{12}.)

Now Press	Display
ENTER↑	1.560000000 13
25 ×	3.900000000 14

You can save time when keying in exact powers of 10 by merely pressing EEX and then pressing the desired power of 10. For example, key in 1 million (10^6) and divide by 52.

Press	Display	
EEX	1. 00	You do not have to key in the number 1 before pressing EEX when the number is an exact power of 10.
6	1. 06	
ENTER↑	1000000.00	Since you have not specified scientific notation, the number reverts to fixed point notation when you press ENTER↑.
52 ÷	19230.77	

To see your answer in scientific notation with six decimal places:

Press	Display
g SCI DSP 6	1.923077 04

To key in negative exponents of 10, key in the number, press EEX, press CHS to make the exponent negative, then key in the power of 10. For example, key in Planck's constant (h)—roughly, 6.625×10^{-27} erg sec.—and multiply it by 50.

Press	Display	
CLx	0.000000 00	
f FIX DSP 2	0.00	
6.625 EEX	6.625 00	
CHS	6.625 -00	
27	6.625 -27	
ENTER↑	6.625000000-27	
50 ×	3.312500000-25	Erg sec.

Calculator Overflow

When the number in the display would be greater than 9.999999999 $\times 10^{99}$, the HP-67 displays all 9's to indicate that the problem has exceeded the calculator's range. For example, if you solve $(1 \times 10^{49}) \times (1 \times 10^{50})$, the HP-67 will display the answer:

Press	Display
CLx	0.00
EEX 49 ENTER↑	1.000000000 49
EEX 50 ×	1.000000000 99

But if you attempt to multiply the above result by 100, the HP-67 display indicates overflow by showing you all 9's:

Press	Display	
100 ×	9.999999999 99	Overflow indication.

Error Display

If you happen to key in an improper operation (or if a magnetic card fails to read properly) the word Error will appear in the display.

For example, if you attempt to calculate the square root of –4, the HP-67 will recognize it as an improper operation:

Press	Display
4 CHS	-4.
f √x	Error

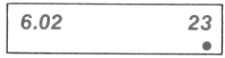
Pressing any key clears the error and is *not* executed. The number that was in the display before the error-causing function is returned to the display so that you can see it.

Press	Display
CL x	-4.00

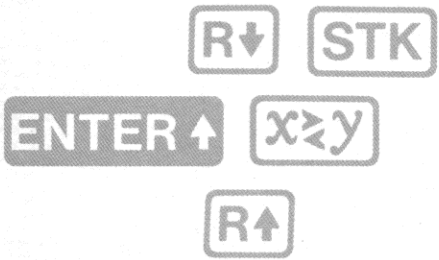
All those operations that cause an error condition are listed in appendix C.

Low Power Display

When you are operating the HP-67 from battery power, a red lamp inside the display will glow to warn you that the battery is close to discharge.



You must then connect the ac adapter/recharger to the calculator and operate from ac power, or you must substitute a fully charged battery pack for the one that is in the calculator. Refer to appendix B for descriptions of these operations.


R↓
STK
ENTER↑
x≷y
R↑

Section 3

The Automatic Memory Stack

The Stack

Automatic storage of intermediate results is the reason that the HP-67 slides so easily through the most complex equations. And automatic storage is made possible by the Hewlett-Packard automatic memory stack.

Initial Display

When you first switch the calculator ON, the display shows 0.00 in RUN mode. This represents the contents of the display or "X-register."

Set the W/PRGM-RUN switch W/PRGM RUN **to RUN.**

Switch the HP-67 OFF, then ON.

Basically, numbers are stored and manipulated in the machine "registers." Each number, no matter how few digits (e.g., 0, 1, or 5) or how many (e.g., 3.141592654, −23.28362, or $2.87148907 \times 10^{27}$), occupies one entire register.

The displayed X-register, which is the only visible register, is one of four registers inside the calculator that are positioned to form the automatic memory stack. We label these registers X, Y, Z, and T. They are "stacked" one on top of the other with the displayed X-register on the bottom. When the calculator is switched ON, these four registers are cleared to zero.

Name	Register	
T	0.00	
Z	0.00	
Y	0.00	
X	0.00	Always displayed.

Manipulating Stack Contents

The R↓ *(roll down)*, R↑ *(roll up)*, and x≷y *(x exchange y)* keys allow you to review the stack contents or to shift data within the stack for computation at any time.

Reviewing the Stack

To see how the R↓ key works, first load the stack with numbers 1 through 4 by pressing:

4 ENTER↑ 3 ENTER↑ 2 ENTER↑ 1

The numbers that you keyed in are now loaded into the stack, and its contents look like this:

T	4.00
Z	3.00
Y	2.00
X	1.

Display.

When you press h R↓, the stack contents shift downward one register. So the last number that you have keyed in will be rotated around to the T-register when you press h R↓. When you press h R↓ again, the stack contents again roll downward one register.

When you press h R↓, the stack contents are rotated...

...from this...			...to this.		
T	4.00		T	1.00	
Z	3.00		Z	4.00	
Y	2.00		Y	3.00	
X	1.	Display.	X	2.00	Display.

Notice that the *contents* of the registers are shifted. The actual registers themselves maintain their positions. The contents of the X-register are always displayed, so 2.00 is now visible.

Press h R↓ again and the stack contents are shifted...

...from this...			...to this.		
T	1.00		T	2.00	
Z	4.00		Z	1.00	
Y	3.00		Y	4.00	
X	2.00	Display.	X	3.00	Display.

Press h R↓ twice more...and the stack shifts...

...through this...			...back to the start again.		
T	3.00		T	4.00	
Z	2.00		Z	3.00	
Y	1.00		Y	2.00	
X	4.00	Display.	X	1.00	Display.

Once again the number 1.00 is in the displayed X-register. Four presses of h R↓ roll the stack down four times, returning the contents of the stack to their original registers.

You can also manipulate the stack contents using h R↓ *(roll up)*. This key rolls the stack contents *up* instead of down, but it otherwise operates in the same manner as h R↓.

Exchanging x and y

The x⇄y (*x exchange y*) key exchanges the contents of the X- and the Y-registers without affecting the Z- and T-registers. If you press h x⇄y with data intact from the previous example, the numbers in the X- and Y-registers will be changed...

	...from this...		...to this.	
	T	4.00	T	4.00
	Z	3.00	Z	3.00
	Y	2.00	Y	1.00
Display.	X	1.00	X	2.00 Display.

Similiarly, pressing h [x≷y] again will restore the numbers in the X- and Y-registers to their original places. This function can be used to position numbers in the stack, whether operating manually or from a program, or simply to bring the contents of the Y-register into the X-register for display.

Notice that whenever you move numbers in the stack using one of the data manipulation keys, the actual stack registers maintain their positions. Only the *contents* of the registers are shifted. The contents of the X-register are always displayed.

Automatic Stack Review

If you wish to quickly review the contents of the stack at any time, use the g [STK] operation. When you press g [STK], the contents of the stack are shifted, one register at a time, into the X-register and displayed for about a half-second each. The order of display is T, Z, Y, and finally the X-register contents again. Press g [STK] now and see the contents of the entire stack displayed. (If the stack contents in your calculator remain intact from the previous example, your displays should match the ones shown below):

Press	Display
g [STK]	4.00
	3.00
	1.00
	2.00

g [STK] operates exactly as four presses of h [R↓]. You can see that after displaying the contents of the entire stack, the original contents of the X-register are returned there and displayed.

While a g [STK] operation is being performed, the decimal point blinks twice during the display of the contents of each register. This is to identify this function as a program pause during a running program, so that you will not think the program has stopped.

When operating the HP-67 manually from the keyboard, you can slow down or speed up the review of the stack contents by pressing R/S or any other key on the keyboard while the calculator is executing a g STK stack review. As long as you hold the key depressed, the contents of the stack register currently being displayed will remain "frozen" in the display, permitting you to write down or examine the number. As soon as you release the key you are holding depressed, the contents of the next stack register to be displayed are shown.

> **Note:** If the g STK stack review is being executed as part of a running program, depressing a key to "freeze" a stack register display will cause the program to halt execution after the g STK has been executed.

See section 15 for a description of how this operation helps you interface programs that you create for your HP-67 Programmable Pocket Calculator with the Hewlett-Packard HP-97 Programmable Printing Calculator.

Clearing the Display

When you press CLx (*clear x*), the displayed X-register is cleared to zero. No other register is affected when you press CLx.

Press CLx now, and the stack contents are changed...

...from this...			...to this.		
T	*4.00*		T	*4.00*	
Z	*3.00*		Z	*3.00*	
Y	*1.00*		Y	*1.00*	
X	*2.00*	Display.	X	*0.00*	Display.

Although it may be comforting, *it is never necessary to clear the displayed X-register when starting a new calculation.* This will become obvious when you see how old results in the stack are automatically lifted by new entries.

The ENTER↑ Key

When you key a number into the calculator, its contents are written into the displayed X-register. For example, if you key in the number 314.32 now, you can see that the display contents are altered.

When you key in 314.32 with the stack contents intact from previous examples the contents of the stack registers are changed...

	...from this...			...to this.	
T	4.00		T	4.00	
Z	3.00		Z	3.00	
Y	1.00		Y	1.00	
X	0.00	Display.	X	314.32	Display.

In order to key in another number at this point, you must first terminate digit entry—i.e., you must indicate to the calculator that you have completed keying in the first number and that any new digits you key in are part of a new number.

Use the ENTER↑ key to separate the digits of the first number from the digits of the second.

When you press the ENTER↑ key, the contents of the stack registers are changed...

	...from this...			...to this.	
T	4.00		T	3.00	
Z	3.00		Z	1.00	
Y	1.00		Y	314.32	
X	314.32	Display.	X	314.32	Display.

As you can see, the number in the displayed X-register is copied into Y. The numbers in Y and Z have also been transferred to Z and T, respectively, and the number in T has been lost off the top of the stack.

Immediately after pressing ENTER↑, the X-register is prepared for a new number, and that new number writes over the number in X. For example, key in the number 543.28 and the contents of the stack registers change...

...from this...			...to this.		
T	3.00		T	3.00	
Z	1.00		Z	1.00	
Y	314.32		Y	314.32	
X	314.32	Display.	X	543.28	Display.

CLx replaces any number in the display with zero. Any new number then writes over the zero in X.

For example, if you had meant to key in 689.4 instead of 543.28, you would press CLx now to change the stack...

...from this...			...to this.		
T	3.00		T	3.00	
Z	1.00		Z	1.00	
Y	314.32		Y	314.32	
X	543.28	Display.	X	0.00	Display

and then key in 689.4 to change the stack...

...from this...			...to this.		
T	3.00		T	3.00	
Z	1.00		Z	1.00	
Y	314.32		Y	314.32	
X	0.00	Display.	X	689.4	Display.

Notice that numbers in the stack do not move when a new number is keyed in immediately after you press ENTER↑ or CLx. However, numbers in the stack *do* lift upward when a new number is keyed in immediately after you press most other functions, including h R↓ and h x⇄y. The g STK operation does not change the stack lift from the previous function, so you can always monitor stack operations with g STK. See appendix D, Stack Lift and LAST X, for a complete list of operations that cause the stack to then lift when a number is keyed in.

One-Number Functions and the Stack

One-number functions execute upon the number in the X-register only, and the contents of the Y-, Z-, and T-registers are unaffected when a one-number function key is pressed.

For example, with numbers positioned in the stack as in the earlier example, pressing f √x changes the stack contents...

	...from this...			...to this.	
T	3.00		T	3.00	
Z	1.00		Z	1.00	
Y	314.32		Y	314.32	
X	689.4	Display.	X	26.26	Display.

The one-number function executes upon only the number in the displayed X-register, and the answer writes over the number that was in the X-register. No other stack register is affected by a one-number function.

Two-Number Functions and the Stack

Hewlett-Packard calculators do arithmetic by positioning the numbers in the stack the same way you would on paper. For instance, if you wanted to add 34 and 21 you would write 34 on a piece of paper and then write 21 underneath it, like this:

$$\begin{array}{r} 34 \\ \underline{21} \end{array}$$

and then you would add, like this:

$$\begin{array}{r} 34 \\ +21 \\ \hline 55 \end{array}$$

Numbers are positioned the same way in the HP-67. Here's how it is done. (As you know, it is not necessary to remove earlier results from the stack before beginning a new calculation, but for clarity, the following example is shown with the stack cleared to all zeros initially. If you want the contents of your stack registers to match the ones here, first clear the stack by using the CLx and ENTER↑ keys to fill the stack with zeros.)

Press	Display	
CLx	0.00	
ENTER↑	0.00	
ENTER↑	0.00	
ENTER↑	0.00	Stack cleared to zeros initially.
34	34.	34 is keyed into X.
ENTER↑	34.00	34 is copied into Y.
21	21.	21 writes over the 34 in X.

Now 34 and 21 are sitting vertically in the stack as shown below, so we can add.

T	0.00	
Z	0.00	
Y	34.00	
X	21.	Display.

Press	Display	
+	55.00	The answer.

The simple old-fashioned math notation helps explain how to use your calculator. Both numbers are always positioned in the stack in the natural order first, then the operation is executed when the function key is pressed. *There are no exceptions to this rule.* Subtraction, multiplication, and division work the same way. In each case, the data must be in the proper position before the operation can be performed.

Chain Arithmetic

You've already learned how to key numbers into the calculator and perform calculations with them. In each case you first needed to position the numbers in the stack manually using the ENTER↑ key. However, the stack also performs many movements automatically. These automatic movements add to its computing efficiency and ease of use, and it is these movements that automatically store intermediate results. The stack automatically "lifts" every calculated number in the stack when a new number is keyed in because it knows that after it completes a calculation, any new digits you key in are a part of a new number. Also, the stack automatically "drops" when you perform a two-number operation.

To see how it works, let's solve

$$16 + 30 + 11 + 17 = ?$$

If you press CLx first, you will begin with zeros in all the stack registers, as in the example below, but of course, you can also do the calculation without first clearing the stack.

Remember, too, that you can always monitor the contents of the stack at any time by using the g STK operation.

Press	Stack Contents		
16	T 0.00 Z 0.00 Y 0.00 X 16.		16 is keyed into the displayed X-register.
ENTER↑	T 0.00 Z 0.00 Y 16.00 X 16.00		16 is copied into Y.
30	T 0.00 Z 0.00 Y 16.00 X 30.		30 writes over the 16 in X.

+	T	0.00	16 and 30 are added together. The answer, 46, is displayed.
	Z	0.00	
	Y	0.00	
	X	46.00	
11	T	0.00	11 is keyed into the displayed X-register. The 46 in the stack is automatically raised.
	Z	0.00	
	Y	46.00	
	X	11.	
+	T	0.00	46 and 11 are added together. The answer, 57, is displayed.
	Z	0.00	
	Y	0.00	
	X	57.00	
17	T	0.00	17 is keyed into the X-register. 57 is automatically entered into Y.
	Z	0.00	
	Y	57.00	
	X	17.	
+	T	0.00	57 and 17 are added together for the final answer.
	Z	0.00	
	Y	0.00	
	X	74.00	

After any calculation or number manipulation, the stack automatically lifts when a new number is keyed in. Because operations are performed when the operations are pressed, the length of such chain problems is unlimited unless a number in one of the stack registers exceeds the range of the calculator (up to $9.999999999 \times 10^{99}$).

In addition to the automatic stack lift after a calculation, the stack automatically drops during calculations involving both X- and Y-registers. It happened in the above example, but let's do the problems differently to see this feature more clearly. For clarity, first press CLx to clear the X-register. Now, again solve 16 + 30 + 11 + 17 = ?

Press	Stack Contents		
16	T	0.00	
	Z	0.00	16 is keyed into the
	Y	0.00	displayed X-register.
	X	16.	
ENTER↑	T	0.00	
	Z	0.00	
	Y	16.00	16 is copied into Y.
	X	16.00	
30	T	0.00	
	Z	0.00	30 is written over
	Y	16.00	the 16 in X.
	X	30.	
ENTER↑	T	0.00	
	Z	16.00	30 is entered into Y.
	Y	30.00	16 is lifted up to Z.
	X	30.00	
11	T	0.00	
	Z	16.00	11 is keyed into the
	Y	30.00	displayed register.
	X	11.	
ENTER↑	T	16.00	
	Z	30.00	11 is copied into Y. 16
	Y	11.00	and 30 are lifted up to T
	X	11.00	and Z respectively.

17

T	16.00
Z	30.00
Y	11.00
X	17.

17 is written over the 11 in X.

+

T	16.00
Z	16.00
Y	30.00
X	28.00

17 and 11 are added together and the rest of the stack drops. 16 drops to Z and is also duplicated in T. 30 and 28 are ready to be added.

+

T	16.00
Z	16.00
Y	16.00
X	58.00

30 and 28 are added together and the stack drops again. Now 16 and 58 are ready to be added.

+

T	16.00
Z	16.00
Y	16.00
X	74.00

16 and 58 are added together for the final answer and the stack continues to drop.

The same dropping action also occurs with −, × and ÷. The number in T is duplicated in T and drops to Z, the number in Z drops to Y, and the numbers in the Y and X combine to give the answer, which is visible in the X-register.

This automatic lift and drop of the stack give you tremendous computing power, since you can retain and position intermediate results in long calculations without the necessity of reentering the numbers.

Order of Execution

When you see a problem like this one:

$$5 \times \left[(3 \div 4) - (5 \div 2) + (4 \times 3)\right] \div (3 \times .213),$$

you must decide where to begin before you ever press a key.

Experienced HP calculator users have determined that by starting every problem at its innermost number or parentheses and working outward, just as you would with paper and pencil, you maximize the efficiency and power of your HP calculator. Of course, with the HP-67 you have tremendous versatility in the order of execution.

For example, you could work the problem above by beginning at the left side of the equation and simply working through it in left-to-right order. All problems cannot be solved using left-to-right order, however, and the best order for solving any problem is to begin with the innermost parentheses and work outward. So, to solve the problem above:

Press	Display	
3	3.	
ENTER↑	3.00	
4	4.	
÷	0.75	Intermediate answer for $(3 \div 4)$.
5	5.	
ENTER↑	5.00	
2	2.	
÷	2.50	Intermediate answer for $(5 \div 2)$.
−	−1.75	Intermediate answer for $(3 \div 4) - (5 \div 2)$.
4	4.	
ENTER↑	4.00	
3	3.	
×	12.00	Intermediate answer for (4×3).
+	10.25	Intermediate answer for $(3 \div 4) - (5 \div 2) + (4 \times 3)$.

3	3.	
ENTER↑	3.00	
.213	.213	
×	0.64	Intermediate answer for (3 × .213).
÷	16.04	
5	5.	The first number is keyed in.
×	80.20	The final answer.

LAST X

In addition to the four stack registers that automatically store intermediate results, the HP-67 also contains a separate automatic register, the LAST X register. This register preserves the value that was in the displayed X-register before the performance of a function. To place the contents of the LAST X register into the display again, press f LSTx.

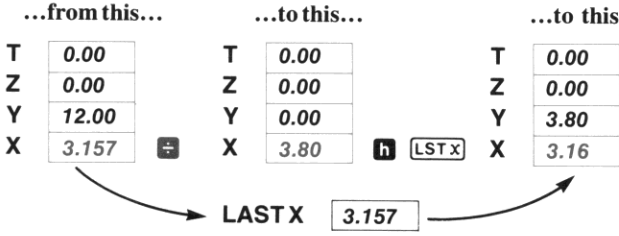
Recovering from Mistakes

LSTx makes it easy to recover from keystroke mistakes, such as pressing the wrong function key or keying in the wrong number.

Example: Divide 12 by 2.157 after you have mistakenly divided by 3.157.

Press	Display	
12	12.	
ENTER↑	12.00	
3.157 ÷	3.80	Oops! You made a mistake.
f LSTx	3.16	Retrieves that last entry (3.157).
×	12.00	You're back at the beginning.
2.157 ÷	5.56	The correct answer.

In the above example, when the first ÷ is pressed, followed by h LSTx, the contents of the stack and LAST X registers are changed...



This makes possible the correction illustrated in the example above.

Recovering a Number for Calculation

The LAST X register is useful in calculations where a number occurs more than once. By recovering a number using LSTx, you do not have to key that number into the calculator again.

Example: Calculate

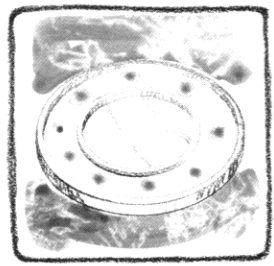
$$\frac{7.32 + 3.650112331}{3.650112331}$$

Press	Display	
7.32	7.32	
ENTER↑	7.32	
3.650112331	3.650112331	
+	10.97	Intermediate answer.
h LSTx	3.65	Recalls 3.650112331 to X-register.
÷	3.01	The answer.

Constant Arithmetic

You may have noticed that whenever the stack drops because of a two-number operation (not because of R↓), the number in the T-register is reproduced there. This stack operation can be used to insert a constant into a problem.

Example: A bacteriologist tests a certain strain whose population typically increases by 15% each day. If he starts a sample culture of 1000, what will be the bacteria population at the end of each day for six consecutive days?

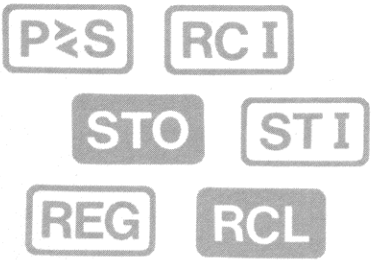


Method: Put the growth factor (1.15) in the Y-, Z-, and T-registers and put the original population (1000) in the X-register. Thereafter, you get the new population whenever you press [×].

Press	Display	
1.15	1.15	Growth factor.
[ENTER↑]	1.15	
[ENTER↑]	1.15	
[ENTER↑]	1.15	Growth factor now in T.
1000	1000.	Starting population.
[×]	1150.00	Population after 1st day.
[×]	1322.50	Population after 2nd day.
[×]	1520.88	Population after 3rd day.
[×]	1749.01	Population after 4th day.
[×]	2011.36	Population after 5th day.
[×]	2313.06	Population after 6th day.

When you press [×] the first time, you calculate 1.15 × 1000. The result (1150.00) is displayed in the X-register and a new copy of the growth factor drops into the Y-register. Since a new copy of the growth factor is duplicated from the T-register each time the stack drops, you never have to reenter it.

Notice that performing a two-number operation such as [×] causes the number in the T-register to be duplicated there each time the stack is dropped. However, the [R↓] key, since it rotates the contents of the stack registers, does not rewrite any number, but merely shifts the numbers that are already in the stack.


P≷S
RC I
STO
ST I
REG
RCL

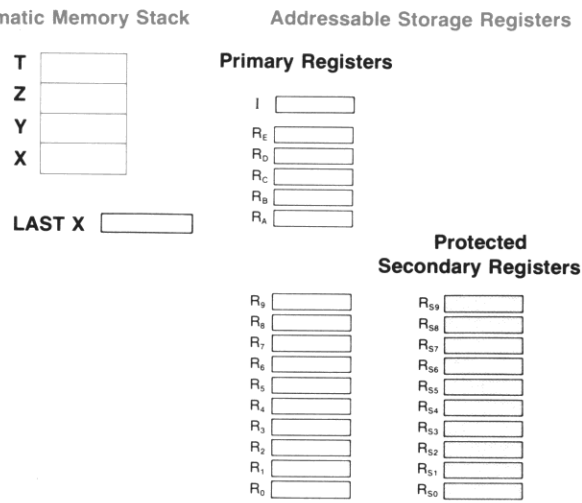
Section 4

Storing and Recalling Numbers

You have learned about the calculating power that exists in the four-register automatic memory stack and the LAST X register of your HP-67 calculator. In addition to the automatic storage of intermediate results that is provide by the stack, however, the HP-67 also contains 26 *addressable* data storage registers that are unaffected by operations within the stack. These registers allow you to manually store and recall constants or to set aside numbers for use in later calculations. Like all functions, you can use these storage registers either from the keyboard or as part of a program.

Storage Registers

The diagram below shows the addressable storage registers. You can see that these registers consist of two banks, the *primary registers* and the *secondary registers*. The subscripts A through E and 0 through 9 refer to the register addresses.



Storing Numbers

To store a displayed number in the primary storage registers R_A through R_E or R_0 through R_9:

1. Press STO (*store*).
2. Press the letter key (A through E), or the number key (0 through 9) of the desired primary register address.

For example, to store Avogadro's number (approximately 6.02×10^{23}) in register R_2:

Press	Display
6.02 EEX 23	6.02 23
STO 2	6.020000000 23

Avogadro's number is now stored in register R_2. You can see that when a number is stored, it is merely copied into the storage register, so 6.02×10^{23} also remains in the displayed X-register. To store the square of Avogadro's number in register R_B:

Press	Display
g x^2	3.624040000 47
STO B	3.624040000 47

The square of Avogadro's number has been copied into storage register R_B and also remains in the displayed X-register.

Recalling Numbers

Numbers are recalled from primary storage registers back into the displayed X-register in much the same way as they are stored. To recall a number from any of primary storage registers R_A through R_E or R_0 through R_9:

1. Press RCL (*recall*).
2. Press the letter key (A through E), or the number key (0 through 9) of the desired storage register address.

For example, to recall Avogadro's number from register R_2:

Press	Display
RCL 2	6.020000000 23

To recall the square of Avogadro's number from register R_B:

Press	Display
RCL B	3.624040000 47

When you recall a number, it is copied from the storage register into the display, and it also remains in the storage register. You can recall a number from a storage register any number of times without altering it—the number will remain in the storage register as a 10-digit number with a two-digit exponent of 10 until you overwrite it by storing another number there, or until you clear the storage registers. For example, even though you earlier recalled Avogadro's number from storage register R_2, you can recall it again:

Press	Display
RCL 2	6.020000000 23

The I-Register

The I-register has a number of special properties that make it useful in programming, but these will be discussed later. The simplest function of the I-register is its use as another of the primary storage registers in your HP-67. To store a number in the I-register, press h STI (*store I*). To then recall that number from the I-register into the display, press h RCI (*recall I*).

Example: Three tanks have capacities in U.S. units of 2.0, 14.4, and 55.0 gallons, respectively. If 1 U.S. gallon is equivalent to 3.785 liters, what is the capacity of each of the tanks?

Method: Place the conversion constant in one of the storage registers and bring it out as required.

Press	Display	
3.785 h STI	3.79	Constant placed in I-register.
2 ×	7.57	Capacity in liters of 1st tank.
14.4 h RCI ×	54.50	Capacity in liters of 2nd tank.
55 h RCI ×	208.18	Capacity in liters of 3rd tank.

Protected Secondary Storage Registers

In addition to the primary storage registers, your HP-67 also provides you with 10 secondary storage registers that are protected; that is, you cannot access the secondary storage registers directly with STO and RCL. These registers are used most often by the statistical function Σ+ (about which more later) and for programming purposes. However, they can be accessed manually from the keyboard by using the P≷S key.

For example, in order to store a number from the displayed X-register into secondary storage register R_{S5}, you first store the number in primary register R_5 and then press f P≷S (*primary exchange secondary*). When you press P≷S, the contents of the primary registers R_0 through R_9 are exchanged with the contents of secondary storage registers R_{S0} through R_{S9}. No other storage or stack registers are affected.

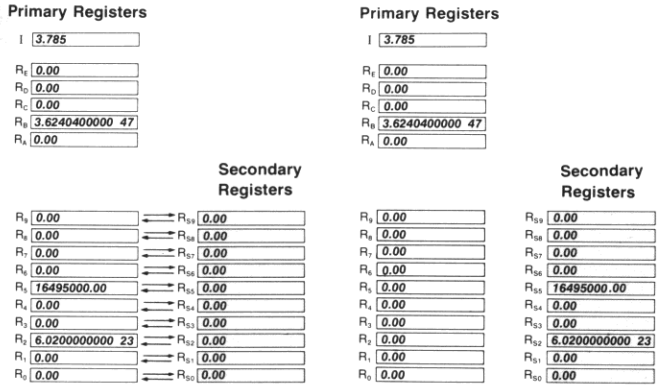
For example, to store 16,495,000 (the number of persons carried daily by the Japanese National Railway) in secondary storage register R_{S5}:

Press	Display	
16495000	16495000.	
STO 5	16495000.00	Number stored in register R_5.
f P≷S	16495000.00	All secondary registers exchanged with numbered primary registers, so number is now stored in secondary storage register R_{S5}.

With results from previous examples intact, when you pressed [P≷S] in the above example, the contents of all *numbered* storage registers were exchanged.

So the contents of the storage registers changed...

...from this... **...to this.**



When you press [P≷S], the contents of *each* number-addressed primary storage register are exchanged with its opposite-numbered secondary storage register. Thus, in order to bring out the numbers that are now in the secondary storage registers, you must use the [f] [P≷S] keys followed by the [RCL] key and the number key of the register address. For example, to recall the number of persons carried daily by the Japanese National Railway, you cannot merely press [RCL] 5 now, since the number in primary storage register R_5 is 0.00:

Press	**Display**
[RCL] 5	0.00

However, you can press f P≷S to bring the stored quantities back into the primary storage registers, then summon the desired quantities by pressing RCL followed by the number key of the desired address:

Press	Display	
f P≷S	0.00	
RCL 5	16495000.00	Number of persons carried daily by the Japanese National Railway.

When you press P≷S, only the *contents* of the primary and secondary registers are exchanged. The actual registers remain intact and are not exchanged.

You can place numbers in corresponding primary and secondary registers and recall them at will. For example, to place the number of persons carried in *five* days by the Japanese National Railway into secondary register R_{S5} while leaving the number of persons carried *daily* intact in primary register R_5:

Press	Display
5 ×	82475000.00
f P≷S	82475000.00
STO 5	82475000.00
f P≷S	82475000.00

You can now use RCL 5 to summon the number of persons carried daily, and f P≷S followed by RCL 5 to summon the number of persons carried in five days:

Press	Display
RCL 5	16495000.00
f P≷S	16495000.00
RCL 5	82475000.00

Automatic Register Review

To view the contents of any individual primary storage register, you can recall the contents of the register into the displayed X-register. However, you can also review the contents of *all* primary storage registers by using the REG (*register review*) function.

When you press h REG, the contents of each primary storage register are automatically shown by the display, beginning with register R_0 and continuing through register R_9, then R_A through R_E, and finally I. In addition, an address identifying the register being displayed appears on the right-hand side of the display preceding the storage register contents. The addresses are 0 through 9 to indicate storage registers R_0 through R_9, 20 through 24 to indicate registers R_A through R_E, and 25 to indicate the I-register.

(The reason for this addressing scheme will become clear later, when you learn about indirect addressing.)

For example, if you have worked through the examples as shown above, an automatic register review should give you displays like the ones shown below.

Press	Display	
h REG	0	Address for register R_0.
	0.00	Contents of R_0.
	1	
	0.00	
	2	
	0.00	
	3	
	0.00	
	4	
	0.00	
	5	Address for register R_5.
	82475000.00	Contents of R_5.
	6	
	0.00	
	7	
	0.00	

Display	
8	
0.00	
9	
0.00	
20	
0.00	
21	Address for R_B.
3.624040000 47	Contents of R_B.
22	
0.00	
23	
0.00	
24	
0.00	
25	Address for I-register.
3.79	Contents of I.
82475000.00	Original contents of X-register.

If you want only a partial listing of the primary storage registers, you stop the review of them at any time by pressing [R/S] or any other key from the keyboard. The key function is *not* executed.

To view the contents of the secondary storage registers, simply press f [P≷S] to bring those contents into the primary registers, then press h [REG] to view the desired primary registers again. For example:

Press	Display
f [P≷S]	82475000.00
h [REG]	0
	0.00
	1
	0.00
	2
	6.020000000 23
	3
	0.00

	4
0.00	
	5
16495000.00	
	6
0.00	
	7
0.00	
	8
0.00	
	9
0.00	
R/S	82475000.00

When you press any key, the automatic review stops and the original contents of the X-register are returned to the display.

Naturally, if you want the present contents of primary registers R_0 through R_9 returned to the protected secondary registers, you must press f P≷S again.

Clearing Storage Registers

Even though you have recalled the contents of a storage register into the displayed X-register, the number also remains in the storage register. You can clear primary storage registers in either of two ways:

- To replace a number in a single storage register, merely store another number there. To clear a storage register, replace the number in it with zero. For example, to clear storage register R_2, press 0 STO 2.
- To clear *all* primary storage registers back to zero at one time, press f CL REG. This clears all primary storage registers, while leaving the automatic memory stack and the secondary storage registers unchanged.

To clear the *secondary* storage registers, use the P≷S key to bring their contents into the primary registers, then clear those registers in either of the methods described above.

For example, to clear storage register R_B only, then to clear all primary registers, and finally all secondary registers:

Press	Display	
0 STO B	0.00	
RCL B	0.00	R_B contents have been cleared to zero.
f CL REG	0.00	All primary registers cleared to zero. Secondary registers remain intact.
h REG	0	
	0.00	
	1	
	0.00	
	etc.	
f P≷S	0.00	Contents of secondary registers exchanged with primary registers.
f CL REG	0.00	All storage registers have now been cleared to zero.
h REG	0	
	0.00	
	1	
	0.00	
	2	
	0.00	
	etc.	

Notice that the stack registers remain intact when you press f CL REG. To clear the displayed X-register, of course, you can press CL x. To clear the entire stack, press CL x ENTER↑ ENTER↑ ENTER↑. (Because of the automatic lift and drop of the stack, you should never have to clear it.) When the calculator is turned ON, it "wakes up" with the stack and *all* storage registers cleared to zero, so turning the calculator OFF, then ON clears the stack, the storage registers, and all program information. (This also should never be necessary.)

Storage Register Arithmetic

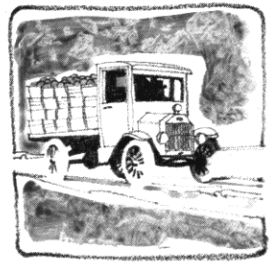
You can, of course, perform arithmetic (or any other function) in the normal manner by recalling and *using* the contents of any storage register just as if it were a number you keyed in. The HP-67 also permits you to perform storage register arithmetic in storage registers; that is, arithmetic *upon* the contents of the selected register.

Storage register arithmetic can be performed directly upon the contents of primary registers R_0 through R_9 only; it cannot be performed directly upon any other storage register. (However, storage register arithmetic *can* be performed indirectly upon the contents of *any* storage register, as you will see in section 12, Using the I-Register for Indirect Control.)

To perform storage register arithmetic directly, press STO followed by the arithmetic function key followed in turn by the number key (0 through 9) of the primary register address. For example:

Press	Result
STO + 1	Number in displayed X-register added to contents of primary storage register R_1, and sum placed into R_1; $(r_1 + x \rightarrow R_1)$.
STO − 2	Number in displayed X-register subtracted from contents of primary storage register R_2, and difference placed into R_2; $(r_2 - x \rightarrow R_2)$.
STO × 3	Number in displayed X-register multiplied by contents of primary storage register R_3, and the product placed into R_3; $[(r_3) \times \rightarrow R_3]$.
STO ÷ 4	Contents of storage register R_4 divided by number in displayed X-register, and quotient placed into register R_4; $(r_4 \div x \rightarrow R_4)$.

When storage register arithmetic operations are performed, the answer is written into the selected storage register, while the contents of the other storage registers and the displayed X-register and the rest of the stack remain unchanged.



Example: During harvest, farmer Flem Snopes trucks tomatoes to the cannery for three days. On Monday and Tuesday he hauls loads of 25 tons, 27 tons, 19 tons, and 23 tons, for which the cannery pays him $55 per ton. On Wednesday the price rises to $57.50 per ton, and Snopes ships loads of 26 tons and 28 tons. If the cannery deducts 2% of the price on Monday and Tuesday because of blight on the tomatoes, and 3% of the price on Wednesday, what is Snopes' total net income?

Press	Display	
25 ENTER↑ 27 + 19 + 23 +	94.00	Total of Monday's and Tuesday's tonnage.
55 ×	5170.00	Gross amount for Monday and Tuesday.
STO 5	5170.00	Gross placed in storage register R_5.
2 f %	103.40	Deductions for Monday and Tuesday.
STO − 5	103.40	Deductions subtracted from total in storage register R_5.
26 ENTER↑ 28 +	54.00	Wednesday's tonnage.
57.50 ×	3105.00	Gross amount for Wednesday.
STO + 5	3105.00	Wednesday's gross amount added to total in storage register R_5.
3 f %	93.15	Deduction for Wednesday.
STO − 5	93.15	Wednesday's deduction subtracted from total in storage register R_5.
RCL 5	8078.45	Snopes' total net income from his tomatoes.

(You could also work this problem using the stack alone, but doing it as shown here illustrates how storage register arithmetic can be used to maintain and update different running totals.)

Storage Register Overflow

If you attempt a storage register arithmetic operation that would cause the magnitude of a number in any of the storage registers to exceed $9.999999999 \times 10^{99}$, the operation is not performed and the HP-67 display immediately indicates Error .

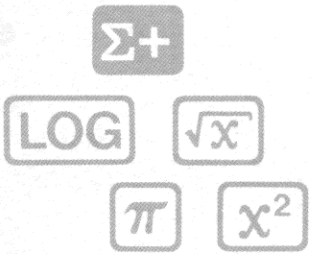
When you then press any key, the error condition is cleared and the last value in the X-register before the error is again displayed. The storage registers all contain the values they held before the error-causing operation was attempted.

For example, if you store 7.33×10^{52} in primary register R_1 and attempt to use storage register arithmetic to multiply that value by 10^{50}, the HP-67 display will show Error :

Press	Display
7.33	7.33
EEX 52	7.33 52
STO 1	7.330000000 52
EEX 50	1. 50
STO × 1	Error

To clear the error and display the contents of the X-register, press any key. The original contents of storage register R_1 are still present there.

Press	Display	
CLx	1.000000000 50	Contents of X-register.
RCL 1	7.330000000 52	Contents of storage register R_1.


Σ+
LOG
√x
π
x²

Section 5

Function Keys

The HP-67 has dozens of internal functions that allow you to compute answers to problems quickly and accurately. Each function operates the same way, regardless of whether you press the function key manually or the function is executed as part of a program.

To use any of the keys manually, first ensure that the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN is set to RUN.

Number Alteration Keys

Besides CHS, there are four keys provided for altering numbers in the HP-67. These keys are RND, ABS, INT, and FRAC, and you will find them most useful when performing operations as part of a program.

Rounding a Number

As you know, when you change display formats with one of the display control keys (FIX, SCI, ENG, or DSP), the number maintains its full value to 10 digits multiplied by a two-digit exponent of 10 no matter how many digits you see. When you press the f prefix key followed by the RND (*round*) key, however, the number that is in the display becomes the *actual* number in the calculator. For example, key in the number of cubic centimeters in one cubic inch, 16.387064 and round it to two decimal places:

Press	Display	
16.387064	16.387064	
DSP 2	16.39	Number rounded to two decimal places in display. Maintains entire value internally.
f RND	16.39	Number rounded to two decimal places internally.

DSP 6	16.390000	FIX 6 display shows that number has been rounded.
h LST x	16.387064	The original number.
DSP 2	16.39	Display mode reset to FIX 2.

A fixed point number that has underflowed to scientific notation display is rounded to 0.00 by the RND function.

Absolute Value

Some calculations require the absolute value, or magnitude, of a number. To obtain the absolute value of the number in the displayed X-register, press the h shift key followed by the ABS (*absolute value*) key. For example, to calculate the absolute value of −3:

Press	Display	
3 CHS	-3.	
h ABS	3.00	$\lvert -3 \rvert$

To see the absolute value of +3:

Press	Display	
h ABS	3.00	$\lvert +3 \rvert$

Integer Portion of a Number

To extract and display the integer portion of a number, press the f prefix key followed by the INT *(integer)* key. For example, to display only the integers of the number 123.456:

Press	Display	
123.456	123.456	
f INT	123.00	Only the integer portion of the number remains.

When f INT is pressed, the fractional portion of the number is lost. The entire number, of course, is preserved in the LAST X register.

Fractional Portion of a Number

To extract and display only the fractional portion of a number, press the g prefix key followed by the FRAC *(fraction)* key. For example, to see the fractional portion of the 123.456 used above:

Press	Display	
h LSTx	123.46	Summons the original number back to the X-register.
g FRAC	0.46	Only the fractional portion of the number is displayed, rounded here to FIX 2 display.

When g FRAC is pressed, the integer portion of the number is lost. The entire number, of course, is preserved in the LAST X register.

Reciprocals

To calculate the reciprocal of a number in the displayed X-register, key in the number, then press h 1/x. For example, to calculate the reciprocal of 25:

Press	Display
25 h 1/x	0.04

You can also calculate the reciprocal of a value in a previous calculation without reentering the number.

Example: In an electrical circuit, four resistors are connected in parallel. Their values are 220 ohms, 560 ohms, 1.2 kilohms, and 5 kilohms. What is the total resistance of the circuit?

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$

$$= \frac{1}{\frac{1}{220} + \frac{1}{560} + \frac{1}{1200} + \frac{1}{5000}}$$

Press	Display	
220 h 1/x	4.545454545-03	
560 h 1/x	1.785714286-03	
+	0.01	
1200 h 1/x	8.333333333-04	
+	0.01	
5000 h 1/x	2.000000000-04	
+	0.01	Sum of reciprocals.
h 1/x	135.79	The reciprocal of the sum of the reciprocals yields the answer in ohms.

Factorials

The N! *(factorial)* key permits you to handle permutations and combinations with ease. To calculate the factorial of a positive integer in the displayed X-register, press h N!.

Example: Calculate the number of ways that six people can line up for a photograph.

Method: $P_6^6 = 6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1$.

Press	Display	
6	6.	
h N!	720.00	The answer.

The calculator overflows for factorials of numbers greater than 69.

Square Roots

To calculate the square root of a number in the displayed X-register, press f $\sqrt{x}$. For example, to find the square root of 16:

Press	Display
16 f $\sqrt{x}$	4.00

To find the square root of the result:

Press	Display
f $\sqrt{x}$	2.00

Squaring

To square a number in the displayed X-register, press g x^2. For example, to find the square of 45:

Press	Display
45 g x^2	2025.00

To find the square of the result:

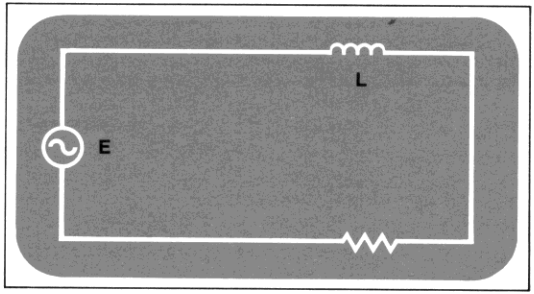
Press	Display
g x^2	4100625.00

Using Pi

The value π accurate to 10 places (3.141592654) is provided as a fixed constant in the HP-67. Merely press h π whenever you need it in a calculation. For example, to calculate 3π:

Press	Display
3 h π ×	9.42

Example: In the schematic diagram below, X_L is 12 kilohms, E is 120 volts, and f is 60 Hz. Find the inductance of the coil L in henries according to the formula: $L = \frac{X_L}{2\pi f}$.



$$L = \frac{X_L}{2\pi f} = \frac{12{,}000}{2 \times \pi \times 60}$$

Press	Display	
12 EEX 3 ENTER↑	12000.00	
2 ÷	6000.00	
h π ÷	1909.86	
60 ÷	31.83	Henries.

Percentages

The % key is a two-number function which allows you to compute percentages. To find the percentage of a number:

1. Key in the base number.
2. Press ENTER↑.
3. Key in the number representing percent rate.
4. Press f %.

The formula used is: $\frac{x \cdot y}{100} = \%$.

For example, to calculate a sales tax of 6.5% on a purchase of $1500:

Press	Display	
1500 ENTER↑	1500.00	Base number.
6.5	6.5	Percent rate.
f %	97.50	The answer.

6.5% of $1500 is $97.50.

In the above example, when f % is pressed, the calculated answer writes over the percentage rate in the X-register, and the base number is preserved in the Y-register.

When you pressed f % the stack contents were changed...

...from this...		...to this.	
T	0.00	T	0.00
Z	0.00	Z	0.00
Y	1500.00	Y	1500.00
X	6.5	X	97.50

Since the purchase price is now in the Y-register and the amount of tax is in the X-register, the total amount can be obtained by simply adding:

Press	Display	
+	1597.50	Total of price and sales tax combined.

Percent of Change

The %CH *(percent of change)* key is a two-number function that gives the percent increase or decrease from Y to X. To find the percent of change:

1. Key in the base number (usually, the number that happens first in time).
2. Press ENTER↑.
3. Key in the second number.
4. Press g %CH.

Example: Find the percent of increase of your rent 10 years ago ($70 per month) to today ($240 per month).

Press	Display	
70 ENTER↑	70.00	
240 g %CH	242.86	Percent increase.

The formula used is: $\frac{(x - y)\ 100}{y} = \%CH.$

Trigonometric Functions

Your HP-67 provides you with six trigonometric functions, which operate in decimal degrees, radians, or grads. You can easily convert angles from decimal degrees to radians or vice versa, and you can convert between decimal degrees, and *degrees, minutes, seconds*. You can also add angles specified in *degrees, minutes, seconds* directly, without converting them to decimal.

Degrees/Radians Conversions

The →R and D→ functions are used to convert angles between degrees and radians. To convert an angle specified in degrees to radians, key in the angle and press g →R. For example, to change 45° to radians:

Press	Display	
45	45.	
g →R	0.79	Radians.

To convert an angle specified in radians to decimal degrees, key in the angle and press f D→. For example, to convert 4 radians to decimal degrees:

Press	Display	
4	4.	
f D→	229.18	Decimal degrees.

Trigonometric Modes

For trigonometric functions, angles can be assumed by the calculator to be in decimal degrees, radians, or grads. When the HP-67 is first turned ON, it "wakes up" with angles assumed to be in decimal degrees. To select radians mode, press h [RAD] *(radians)* before using a trigonometric function. To select grads mode, press h [GRD] *(grads)*. To select decimal degrees again, press h [DEG] *(degrees)*.

Note: 360 degrees = 400 grads = 2π radians

Functions

The six trigonometric functions provided by the calculator are:

f [SIN] *(sine)*
g [SIN^{-1}] *(arc sine)*
f [COS] *(cosine)*
g [COS^{-1}] *(arc cosine)*
f [TAN] *(tangent)*
g [TAN^{-1}] *(arc tangent)*

Each trigonometric function assumes that angles are in decimal degrees, radians, or grads, depending upon the trigonometric mode selected.

All trigonometric functions are one-number functions, so to use them, you key in the number, then press the function key(s).

Example: Find the cosine of 35°.

Press	Display
35	35.
f [COS]	0.82

The HP-67 "woke up" in degrees mode when you first turned it ON.

Example 2: Find the arc sine in radians of .964.

Press	Display	
h [RAD]	0.82	Selects radians mode. (Results remain from previous example.)
.964	.964	
g [SIN^{-1}]	1.30	Radians.

Example 3: Find the tangent of 43.66 grads.

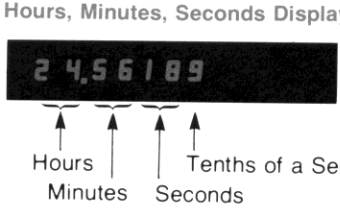
Press	Display	
h GRD	1.30	Selects grads mode. (Results remain from previous example.)
43.66	43.66	
f TAN	0.82	Grads.

Hours, Minutes, Seconds/Decimal Hours Conversions

Using the HP-67, you can change time specified in decimal hours to *hours, minutes, seconds* format by using the →H.MS *(to hours, minutes, seconds)* key; you can also change from *hours, minutes, seconds* to decimal hours by using the H→ *(to hours)* key.

When a time is displayed or printed in *hours, minutes, seconds* format, the digits specifying *hours* occur to the left of the decimal point, while the digits specifying *minutes, seconds,* and *fractions of seconds* occur to the right of the decimal point.

Hours, Minutes, Seconds Display



To convert from decimal hours to *hours, minutes, seconds,* simply key in the value for decimal hours and press g →H.MS. For example, to change 21.57 hours to *hours, minutes, seconds:*

Press	Display	
21.57	21.57	Key in the decimal time.
DSP 4	21.5700	Reset display format to FIX 4.
g →H.MS	21.3412	This is 21 hours, 34 minutes, 12 seconds.

Notice that the display is not automatically switched to show you more than the normal two digits after the decimal point (FIX 2), so to see the digits for *seconds,* you had to reset the display format to FIX 4.

To convert from *hours, minutes, seconds* to decimal hours, simply key in the value for *hours, minutes, seconds* in that format and press f [H→]. For example, to convert 132 hours, 43 minutes, and 29.33 seconds to its decimal degree equivalent:

Press	Display	
132.432933	132.432933	This is 132 hours, 43 minutes, 29.33 seconds.
f [H→]	132.7248	This is 132.7248 hours. (FIX 4 display remains specified from previous example.)

Using the [→H.MS] and [H→] operations, you can also convert angles specified in decimal degrees to *degrees, minutes, seconds,* and vice versa. The format for *degrees, minutes, seconds* is the same as for *hours, minutes, seconds.*

Example: Convert 42.57 decimal degrees to *degrees, minutes, seconds.*

Press	Display	
42.57	42.57	Key in the angle.
g [→H.MS]	42.3412	This means 42°34′12″. (Display assumes FIX 4 notation remains specified from previous example.)

Example: Convert 38°8′56.7″ to its decimal equivalent.

Press	Display	
38.08567	*38.08567*	Key in the angle.
f H⇔	*38.1491*	Answer in decimal degrees. (FIX 4 display specified from previous examples.)

Notice that you had to key in 8′ as 08.

Adding and Subtracting Time and Angles

To add or subtract decimal hours, merely key in the numbers for the decimal hours and press + or −. To add *hours, minutes, seconds,* use the H.MS+ *(add hours, minutes, seconds)* key.

Likewise, angles specified in *degrees, minutes, seconds* are added by pressing h H.MS+.

Example: Find the sum of 45 hours, 10 minutes, 50.76 seconds and 24 hours, 49 minutes, 10.95 seconds.

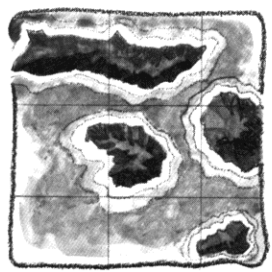
Press	Display	
45.105076	*45.105076*	
ENTER↑	*45.1051*	FIX 4 notation from previous example.
24.491095	*24.491095*	
h H.MS+	*70.0002*	
DSP 6	*70.000171*	

To subtract a time specified in *hours, minutes, seconds* from another (or to subtract an angle specified in *degrees, minutes, seconds*), simply use the CHS key to make the second time (or angle) negative, then add with the H.MS+ key.

Example: Subtract 142.78° from 312°32′17″, with the answer in *degrees, minutes, seconds* format.

Press	Display	
312.3217	*312.3217*	
ENTER↑	*312.321700*	FIX 6 from previous example.
142.78	*142.78*	Decimal degrees.
g [→H.MS]	*142.464800*	To *degrees, minutes, seconds*.
CHS	*-142.464800*	Angle made negative.
h [H.MS+]	*169.452900*	This is 169°45′29″.
DSP 2	*169.45*	Display mode reset to FIX 2.

In the HP-67, trigonometric functions assume angles in decimal degrees, decimal radians, or decimal grads, so if you want to compute any trigonometric functions of an angle given in *degrees, minutes, and seconds,* you must first convert the angle to decimal degrees.



Example: Lovesick sailor Oscar Odysseus dwells on the island of Tristan da Cunha (37°03′S, 12°18′W), and his sweetheart, Penelope, lives on the nearest island. Unfortunately for the course of true love, however, Tristan da Cunha is the most isolated inhabited spot in the world. If Penelope lives on the island of St. Helena (15°55′S, 5°43′W), use the following formula to calculate the great circle distance that Odysseus must sail in order to court her.

$$\text{Distance} = \cos^{-1}\left[\sin(\text{LAT}_s)\sin(\text{LAT}_d) + \cos(\text{LAT}_s)\cos(\text{LAT}_d)\cos(\text{LNG}_d - \text{LNG}_s)\right] \times 60.$$

Where LAT_s and LNG_s = latitude and longitude of the source (Tristan da Cunha).

LAT_d and LNG_d = latitude and longitude of the destination.

Solution: Convert all *degrees, minutes, seconds* entries into decimal degrees as you key them in. The equation for the great circle distance from Tristan da Cunha to the nearest inhabited land is:

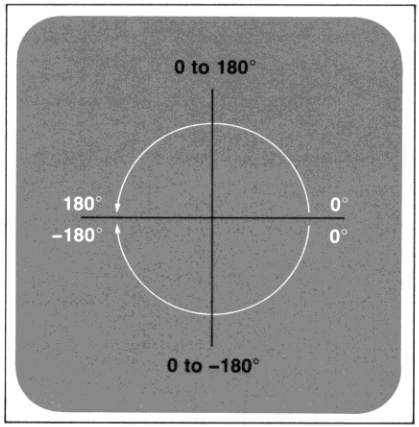
$$\text{Distance} = \cos^{-1}\left[\sin(37°03') \sin(15°55') + \cos(37°03') \cos(15°55') \cos(5°43' - 12°18')\right] \times 60$$

Press	Display	
h DEG	0.00	Selects degrees mode. (Display assumes no results remain from previous examples.)
5.43 f H◂	5.72	
12.18 f H◂ −	-6.58	
f COS	0.99	
15.55 f H◂ STO 1	15.92	
f COS	0.96	
×	0.96	
37.03 f H◂ STO 0	37.05	
f COS	0.80	
×	0.76	
RCL 0 f SIN	0.60	
RCL 1 f SIN	0.27	
×	0.17	
+	0.93	
g COS⁻¹	21.92	
60 ×	1315.41	Distance in nautical miles that Odysseus must sail to visit Penelope.

Polar/Rectangular Coordinate Conversion

Two functions are provided for polar/rectangular coordinate conversions. Angle θ is assumed in decimal degrees, radians, or grads, depending upon the trigonometric mode first selected by DEG, RAD, or GRD.

In the HP-67, angle θ is represented in the following manner:



To convert from rectangular x, y coordinates to polar r, θ coordinates (magnitude and angle, respectively):

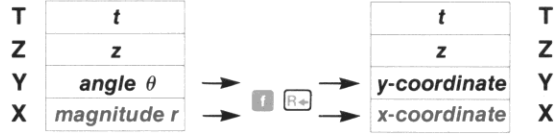
1. Key in the y-coordinate.
2. Press ENTER↑ to raise the y-coordinate value to the Y-register of the stack.
3. Key in the x-coordinate.
4. Press g →P *(to polar)*. Magnitude r then appears in the X-register and angle θ is placed in the Y-register. (To display the value for θ, you can press h x⇄y.)

The following diagram shows how the stack contents change when you press g →P.

To convert from polar r, θ coordinates to rectangular x, y coordinates:

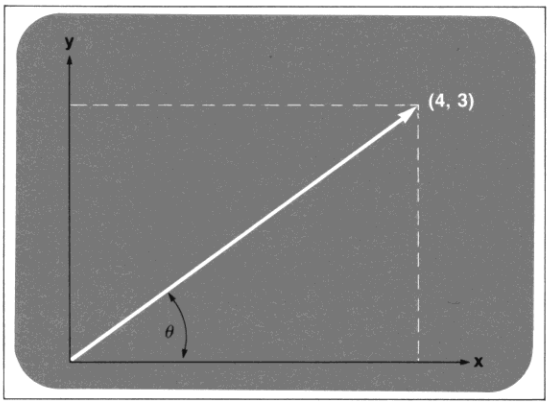
1. Key in the value for the angle θ.
2. Press ENTER↑ to raise the value for θ to the Y-register of the stack.
3. Key in the value for magnitude r.
4. Press f [R→] *(to rectangular)*. The x-coordinate then appears in the displayed X-register and the y-coordinate is placed in the Y-register. (To display the value for the y-coordinate, you can press h [x≷y].)

The following diagram shows how the stack contents change when you press f [→R].



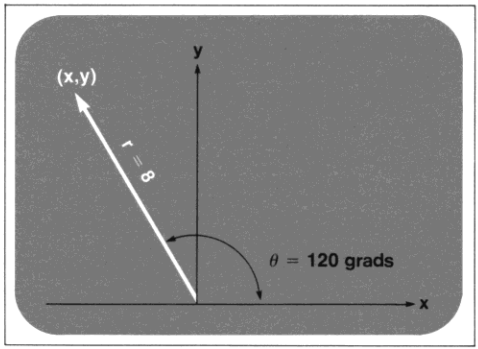
After you have pressed f [R→] or g [→P], you can use the [x≷y] key to bring the calculated angle θ or the calculated y-coordinate into the X-register for viewing or further calculation.

Example 1: Convert rectangular coordinates (4, 3) to polar form with the angle expressed in radians.

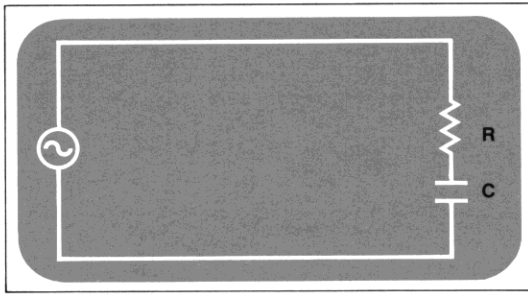


Press	Display	
h RAD	0.00	Radians mode selected. (Display assumes no results remain from previous examples.)
3 ENTER↑	3.00	y-coordinate entered into the Y-register.
4	4.	x-coordinate keyed into the X-register.
g →P	5.00	Magnitude r.
h x≷y	0.64	Angle θ in radians.

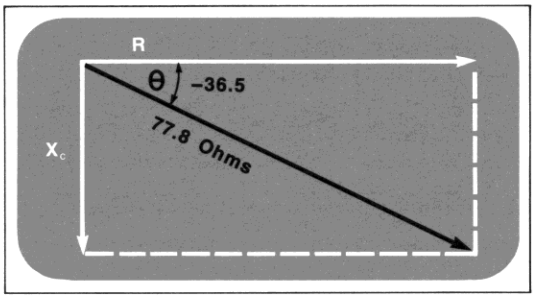
Example 2: Convert polar coordinates (8, 120 grads) to rectangular coordinates.



Press	Display	
h GRD	0.64	Grads mode selected. (Note that results can remain from previous examples.)
120 ENTER↑	120.00	Angle θ entered into the Y-register.
8	8.	Magnitude r placed in displayed X-register.
f R↓	−2.47	x-coordinate.
h x≷y	7.61	y-coordinate brought into displayed X-register.



Example 3: Engineer Tobias Slothrop has determined that in the RC circuit shown above, the total impedance is 77.8 ohms and voltage lags current by 36.5°. What are the values of resistance R and capacitive reactance X_c in the circuit?



Method: Draw a vector diagram using total impedance 77.8 ohms for polar magnitude r and $-36.5°$ for angle θ. When the values are converted to rectangular coordinates, the x-coordinate value yields resistance R in ohms, and the y-coordinate value yields reactance X_c in ohms.

Solution:

Press	Display	
h DEG	7.61	Degrees mode selected. (Note that results can remain from previous examples.)

36.5 CHS	-36.5	
ENTER↑	-36.50	
77.8	77.8	
f R↓	62.54	Resistance R in ohms.
h x≷y	-46.28	Reactance X_c, 46.28 ohms, available in displayed X-register.

Logarithmic and Exponential Functions

Logarithms

The HP-67 computes both natural and common logarithms as well as their inverse functions (antilogarithms):

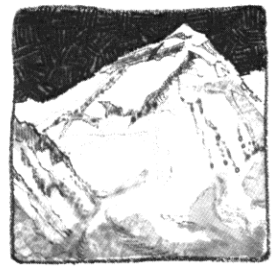
- f LN is $\log_e$ (natural log). It takes the log of the value in the X-register to base e (2.718...).
- g e^x is antilog$_e$ (natural antilog). It raises e (2.718...) to the power of the value in X-register. (To display the value of e, press 1 g e^x.)
- f LOG is $\log_{10}$ (common log). It computes the log of the value in the X register to base 10.
- g 10^x is antilog$_{10}$ (common antilog). It raises 10 to the power of the value in the X-register.

Example 1: The 1906 San Francisco earthquake, with a magnitude of 8.25 on the Richter Scale is estimated to be 105 times greater than the Nicaragua quake of 1972. What would be the magnitude of the latter on the Richter Scale? The equation is:

$$R_1 = R_2 - \log \frac{M_2}{M_1} = 8.25 - \left(\log \frac{105}{1} \right)$$

Solution:

Press	Display	
8.25 ENTER↑	8.25	
105 f LOG	2.02	
−	6.23	Rating on Richter scale.



Example 2: Having lost most of his equipment in a blinding snowstorm, ace explorer Jason Quarmorte is using an ordinary barometer as an altimeter. After measuring the sea level pressure (30 inches of mercury) he climbs until the barometer indicates 9.4 inches of mercury. Although the exact relationship of pressure and altitude is a function of many factors, Quarmorte knows that an *approximation* is given by the formula:

$$\text{Altitude (feet)} = 25{,}000\ ln\frac{30}{\text{Pressure}} = 25{,}000\ ln\ \frac{30}{9.4}$$

Where is Jason Quarmorte?

Solution:

Press	Display	
30 ENTER↑	30.00	
9.4 ÷	3.19	
f LN	1.16	
25000	25000.	
×	29012.19	Altitude in feet.

Quarmorte is probably near the summit of Mount Everest (29,028 feet).

Raising Numbers to Powers

The y^x key is used to raise numbers to powers. Using h y^x permits you to raise a positive real number to any real power—that is, the power may be positive or negative, and it may be an integer, a fraction, or a mixed number. h y^x also permits you to raise any negative real number to the power of any integer (within the calculating range of the HP-67, of course).

For example, to calculate 2^9 (that is, $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$):

Press	Display
2 ENTER↑ 9	9.
h y^x	512.00

To calculate $8^{-1.2567}$:

Press	Display
8 ENTER↑	8.00
1.2567 CHS	-1.2567
h y^x	0.07

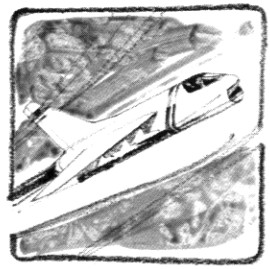
To calculate $(-2.5)^5$:

Press	Display
2.5 CHS ENTER↑	-2.50
5	5.
h y^x	-97.66

In conjunction with $1/x$, y^x provides a simple way to extract roots. For example, find the cube root of 5. (This is equivalent to $5^{1/3}$.)

Press	Display	
5 ENTER↑	5.00	
3 h $1/x$	0.33	Reciprocal of 3.
h y^x	1.71	Cube root of 5.

Example: In a rather overoptimistic effort to break the speed of sound, high-flying pilot Ike Daedalus cranks open the throttle on his surplus Hawker Siddeley Harrier aircraft. From his instruments he reads a pressure altitude (PALT) of 25,500 feet with a calibrated airspeed (CAS) of 350 knots. What is the flight mach number



$$M = \frac{\text{speed of aircraft}}{\text{speed of sound}}$$

if the following formula is applicable?

$$M = \sqrt{5\left[\left(\left\{\left[\left(1 + 0.2\left[\frac{350}{661.5}\right]^2\right)^{3.5} - 1\right]\left[1 - (6.875 \times 10^{-6})\,25{,}500\right]^{-5.2656}\right\} + 1\right)^{0.286} - 1\right]}$$

Method: The most efficient place to begin work on this problem is at the innermost set of brackets. So begin by solving for the quantity $\left[\frac{350}{661.5}\right]^2$ and proceed outward from there.

Press	Display	
350 ENTER↑	350.00	
661.5 ÷	0.53	
g x^2	0.28	Square of bracketed quantity.
.2 ×	0.06	
1 +	1.06	
3.5 h y^x	1.21	
1 −	0.21	Contents of left-hand set of brackets are in the stack.

1 ENTER↑	1.00	
6.875 EEX CHS 6	6.875 −06	
ENTER↑	6.875000000−06	
25500 ×	0.18	
−	0.82	
5.2656 CHS h y^x	2.76	Contents of right-hand set of brackets are in the stack.
×	0.58	
1 +	1.58	
.286 h y^x	1.14	
1 −	0.14	
5 ×	0.70	
f $\sqrt{x}$	0.84	Mach number of Daedalus' Harrier.

In working through complex equations like the one containing six levels of parentheses above, you really appreciate the value of the Hewlett-Packard logic system. Because you calculate one step at a time, you don't get "lost" within the problem. You see every intermediate result, and you emerge from the calculation confident of your final answer.

Statistical Functions

Accumulations

Pressing the Σ+ key automatically gives you several different sums and products of the values in the X- and Y-registers at once. In order to make these values accessible for sophisticated statistics problems, they are automatically placed by the calculator into secondary storage registers R_{S4} through R_{S9}. *The only time that information is automatically accumulated in the storage registers is when* Σ+ *(or* Σ−*) is used.* Before you begin any calculations using the Σ+ key, you should first clear the protected secondary storage registers by pressing f CL REG followed by f P≷S.

When you key a number into the display and press the Σ+ key, each of the following operations is performed:

1. The number that you keyed into the X-register is added to the contents of secondary storage register R_{S4}; ($\Sigma x \rightarrow R_{S4}$).
2. The square of the number that you keyed into the X-register is added to the contents of secondary storage register R_{S5}; ($\Sigma x^2 \rightarrow R_{S5}$).
3. The number in the Y-register of the stack is added to the contents of secondary storage register R_{S6}; ($\Sigma y \rightarrow R_{S6}$).
4. The square of the number in the Y-register of the stack is added to the contents of secondary storage register R_{S7}; ($\Sigma y^2 \rightarrow R_{S7}$).
5. The number that you keyed into the X-register is multiplied by the contents of the Y-register, and the product added to the contents of storage register R_{S8}; ($\Sigma xy \rightarrow R_{S8}$).
6. The number 1 is added to storage register R_{S9}, and the total number in R_{S9} then writes over the number in the displayed X-register of the stack. The stack does not lift; [n ⟵ X, R_{S9}].

The number that you keyed into the X-register is preserved in the LAST X register, while the number in the stack Y-register remains in the Y-register.

Thus, when you press Σ+, the stack contents are changed...

...from this...		...to this.	
T	*t*	T	*t*
Z	*z*	Z	*z*
Y	*y*	Y	*y*
X	*x*	X	*n*
	LAST X		*x* LAST X

... and the storage register contents are changed...

...from this...

Addressable Storage Registers

Primary Registers

I

R_E
R_D
R_C
R_B
R_A

Protected Secondary Registers

R_9	R_{S9}
R_8	R_{S8}
R_7	R_{S7}
R_6	R_{S6}
R_5	R_{S5}
R_4	R_{S4}
R_3	R_{S3}
R_2	R_{S2}
R_1	R_{S1}
R_0	R_{S0}

...to this.

Addressable Storage Registers

Primary Registers

I

R_E
R_D
R_C
R_B
R_A

Protected Secondary Registers

R_9	R_{S9} n
R_8	R_{S8} Σxy
R_7	R_{S7} Σy^2
R_6	R_{S6} Σy
R_5	R_{S5} Σx^2
R_4	R_{S4} Σx
R_3	R_{S3}
R_2	R_{S2}
R_1	R_{S1}
R_0	R_{S0}

Before you begin accumulating results in secondary storage registers R_{S4} through R_{S9} using the Σ+ key, you should first ensure that the contents of these registers have been cleared to zero by pressing f CL REG followed by f P≠S.

> **Note:** Unlike storage register arithmetic, the Σ+ function allows overflows (i.e., numbers whose magnitudes are greater than $9.999999999 \times 10^{99}$) in storage registers R_{S4} through R_{S9} without registering *Error* in the display.

After you have accumulated these products and sums using the Σ+ key, they remain in the secondary storage registers, where they are used to compute mean and standard deviation using the x̄ and s functions.

To use *only* the Σx and Σy that you have accumulated in the secondary storage registers, you can press RCL followed by $\Sigma+$. This brings Σx into the displayed X-register and Σy into the Y-register, overwriting the contents of those two stack registers. The stack does not lift. (This feature is particularly useful when performing vector arithmetic, like that illustrated on pages 118-120.)

To use *any* of the summations individually, simply exchange the contents of the secondary storage registers with the primary registers by pressing f P≷S; then recall the desired summation by pressing RCL followed by the number key of the register address.

Example: Find Σx, Σx^2, Σy, Σy^2, and Σxy for the paired values of x and y listed below.

y	7	5	9
x	5	3	8

Press	Display	
f CL REG f P≷S	0.00	Ensures that storage registers R_{S4} through R_{S9} contain all zeros initially. (Display assumes no results remain from previous example.)
7 ENTER↑	7.00	
5 Σ+	1.00	First pair is accumulated; n = 1.
5 ENTER↑	5.00	
3 Σ+	2.00	Second pair is accumulated; n = 2.
9 ENTER↑	9.00	
8 Σ+	3.00	Third pair is accumulated; n = 3.
f P≷S	3.00	Brings contents of secondary registers into primary registers.

RCL 4	16.00	Sum of x values from register R_4.
RCL 5	98.00	Sum of squares of x values from register R_5.
RCL 6	21.00	Sum of y values from register R_6.
RCL 7	155.00	Sum of squares of y values from register R_7.
RCL 8	122.00	Sum of products of x and y values from register R_8.
RCL 9	3.00	Number of entries (n = 3).

By using the P≥S function in conjunction with the Σ+ key, you can actually maintain *two* complete sets of products and sums in your HP-67.

Mean

The x̄ *(mean)* key is the key you use to calculate the mean (arithmetic average) of data accumulated in secondary registers R_{S4}, R_{S6}, and R_{S9}. When you press f x̄:

1. The mean ($\bar{x}$) of x is calculated using the data accumulated in register R_{S4} (Σx) and R_{S9} (n) according to the formula:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad \left(\text{That is, } \frac{R_{S4}}{R_{S9}} = \bar{x}\right)$$

   The resultant value for $\bar{x}$ is seen in the displayed X-register.

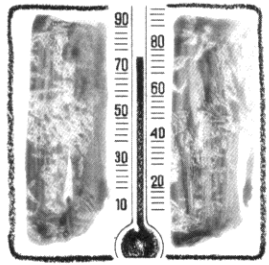
2. The mean ($\bar{y}$) of y is calculated using the data accumulated in register R_{S6} (Σy) and register R_{S9} (n) according to the formula:

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \quad \left(\text{That is, } \frac{R_{S6}}{R_{S9}} = \bar{y}\right)$$

   The resultant value for $\bar{y}$ is available in the Y-register of the stack.

Although you could place data in the accumulation registers manually using the [P≥S] and [STO] keys, the easiest way to accumulate the required data in the secondary storage registers is through the use of the [Σ+] key as described above.

Example: Below is a chart of daily high and low temperatures for a winter week in Fairbanks, Alaska. What are the *average* high and low temperatures for the week selected?

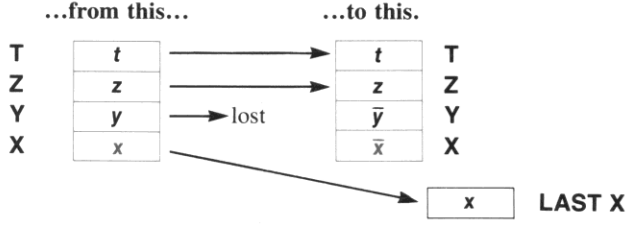


	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
High	6	11	14	12	5	-2	-9
Low	-22	-17	-15	-9	-24	-29	-35

Press	Display	
[f] [CL REG] [f] [P≥S]	0.00	Ensures that secondary registers contain all zeros initially. (Display assumes no results remain from previous calculations.)
6 [ENTER↑] 22		
[CHS] [Σ+]	1.00	Number of data pairs (n) is now 1.
11 [ENTER↑] 17		
[CHS] [Σ+]	2.00	Number of data pairs (n) is now 2.
14 [ENTER↑] 15		
[CHS] [Σ+]	3.00	
12 [ENTER↑] 9		
[CHS] [Σ+]	4.00	
5 [ENTER↑] 24		
[CHS] [Σ+]	5.00	

2 CHS ENTER↑		
29 CHS Σ+	6.00	
9 CHS ENTER↑		
35 CHS Σ+	7.00	Number of data pairs (n) is now 7.
f x̄	-21.57	Average low temperature.
h x≷y	5.29	Average high temperature.

The illustration below represents what happens in the stack when you press f x̄. Press f x̄ and the contents of the stack registers are changed...



Standard Deviation

The s *(standard deviation)* key is the key you use to calculate the standard deviation (a measure of dispersion around the mean) of data accumulated in secondary storage registers R_{S4} through R_{S9}.

When you press g s:

1. Sample x standard deviation (s_x) is calculated using the data accumulated in storage registers R_{S5} (Σx^2), R_{S4} (Σx), and R_{S9} (n) according to the formula:

$$s_x = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1}}$$

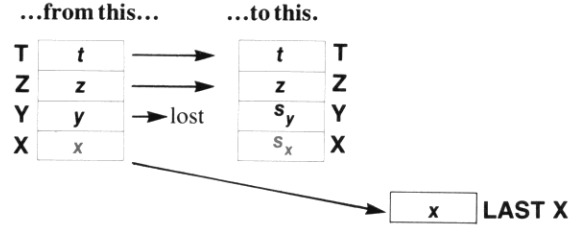
The resultant value for standard deviation of x (s_x) is seen in the displayed X-register.

2. Sample y standard deviation (s_y) is calculated using the data accumulated in storage registers R_{S7} (Σy^2), R_{S6} (Σy), and R_{S9} (n) according to the formula:

$$s_y = \sqrt{\frac{\Sigma y^2 - \frac{(\Sigma y)^2}{n}}{n - 1}}$$

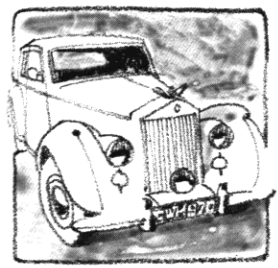
The resultant value for standard deviation of y (s_y) is available in the Y-register of the stack.

Thus, with data first accumulated in secondary storage registers R_{S4} through R_{S9}, when you press g [s], the contents of the stack registers are changed...



To use the value for standard deviation of y (s_y) simply use the [x⇄y] key to bring that value into the displayed X-register of the stack.

Example: In a recent survey to determine the age and net worth (in millions of dollars) of six of the 50 wealthiest persons in the United States, the following data were obtained (sampled). Calculate the average age and net worth of the sample, and calculate the standard deviations for these two sets of data.



Age	62	58	62	73	84	68
Net Worth	1200	1500	1450	1950	1000	1750

Press	Display	
f CL REG f P≷S	0.00	Ensures that secondary storage registers used for accumulations are cleared to zero initially. (Display assumes no results remain from previous examples.)
62 ENTER↑ 1200 Σ+	1.00	Number of data pairs (n) is 1.
58 ENTER↑ 1500 Σ+	2.00	
62 ENTER↑ 1450 Σ+	3.00	
73 ENTER↑ 1950 Σ+	4.00	
84 ENTER↑ 1000 Σ+	5.00	
68 ENTER↑ 1750 Σ+	6.00	Number of data pairs (n) is 6.
f x̄	1475.00	Average value of net worth.
h x≷y	67.83	Average age of the sample.
g s	347.49	Standard deviation (s_x) of net worth of sample.
h x≷y	9.52	Standard deviation (s_y) of age of sample.

If the six persons used in the sample were actually the *six wealthiest persons*, the data would have to be considered as a population rather than as a sample. The relationship between sample standard deviation (s) and the population standard deviation (σ) is illustrated by the following equation.

$$\sigma = s \sqrt{\frac{n-1}{n}}$$

Since n is automatically accumulated in secondary register R_{S9} when data is accumulated, it is a simple matter to convert the sample standard deviations which have already been calculated to population standard deviations.

If the accumulations are still intact from the previous example in secondary registers R_{S4} through R_{S9}, you can calculate the population standard deviations this way:

Press	Display	
g [S]	347.49	Calculate s_x and s_y.
f [P≷S] RCL 9	6.00	Recall n.
1 −	5.00	Calculate n − 1.
RCL 9 ÷	0.83	Divide n − 1 by n.
f [√x] ×	317.21	Population standard deviation σ_x.
h [x≷y]	9.52	Brings s_y to the X-register.
h [LSTx]	0.91	Recall conversion factor.
×	8.69	Population standard deviation σ_y.

Remember that the accumulations must always be stored in the *secondary* bank of storage registers. Thus, if you have accumulated data using Σ+ and then brought the summations out to the primary registers for viewing using [P≷S], you will have to replace them in the secondary registers by pressing [P≷S] again before pressing [x̄] or [S].

Deleting and Correcting Data

If you key in an incorrect value and have not pressed Σ+, press CLx and key in the correct value.

If one of the values is changed, or if you discover after you have pressed the Σ+ key that one of the values is in error, you can correct the summations by using the [Σ−] (*summation minus*) key as follows:

1. Key in *incorrect* data pair into the X- and Y-registers. (You can use [LSTx] to return a single incorrect data value to the displayed X-register.)

2. Press h Σ− to delete the incorrect data.
3. Key in the correct values for x and y. (If one value of an x, y data pair is incorrect, both values must be deleted and reentered.)
4. Press Σ+.

The correct values for mean and standard deviation are now obtainable by pressing f x̄ and g s.

For example, suppose the poorer 62-year old member of the *sample* as given above were to lose his position as one of the wealthiest persons because of a series of ill-advised investments in cocoa futures. To account for the change in data if he were replaced in the sample by a 21-year old rock musician who is worth 1300 million dollars:

Press	Display	
f P≥S	8.69	Accumulations replaced in secondary storage registers.
62 ENTER↑ 1200	1200.	Data to be replaced.
h Σ−	5.00	Number of entries (n) is now five.
21 ENTER↑ 1300	1300.	The new data.
Σ+	6.00	Number of entries (n) is six again.

The new data have been calculated into each of the summations present in the secondary storage registers. To see the new mean and standard deviation:

Press	Display	
f x̄	1491.67	The new average (mean) worth.
h x≥y	61.00	The new average (mean) age available in X-register for use.
g s	333.79	The new standard deviation for worth.

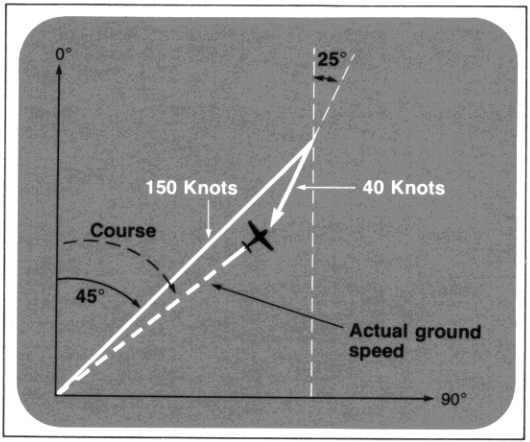
Press	Display	
h x⇄y	21.60	The new standard deviation for age is now available in X-register for use.

Vector Arithmetic

You can use your HP-67 to add or subtract vectors by combining the polar/rectangular conversion functions (the →P and R→ keys) with the summation functions (the Σ+ and Σ− keys).

Example: Grizzled bush pilot Apeneck Sweeney's converted Swordfish aircraft has a true air speed of 150 knots and an estimated heading of 45°. The Swordfish is also being buffeted by a headwind of 40 knots from a bearing of 25°. What is the actual ground speed and course of the Swordfish?

Method: The course and ground speed are equal to the difference of the vectors. (Notice that North becomes the x-axis so that the problem corresponds to navigational convention.)



Press	Display	
f CL REG f P≥S	0.00	Ensures that secondary registers used for accumulations are cleared to zero. (Display assumes no results remain from previous examples.)
45 ENTER↑	45.00	θ for 1st vector is entered to Y-register.
150	150.	r for 1st vector is keyed in.
f R→	106.07	Converted to rectangular coordinates.
Σ+	1.00	1st vector coordinates accumulated in storage registers R_{S4} and R_{S6}.
25 ENTER↑	25.00	θ for 2nd vector is entered to Y-register.
40	40.	r for 2nd vector is keyed in.
f R→	36.25	2nd vector is converted to rectangular coordinates.
h Σ-	0.00	2nd vector rectangular coordinates subtracted from those of 1st vector.

Press	Display	
RCL Σ+	69.81	Recalls both R_{S4} and R_{S6}.
g →P	113.24	Actual ground speed in knots of the Swordfish.
h x≷y	51.94	Course in degrees of the Swordfish.

Part Two
Programming the HP-67


-50.500
OFF
ON
W/PRGM
RUN
MOON ROCKET LANDER
SO-14 A
CNTRL
RESTART
GTO
DSP
SST
GSB
FIX
SCI
RND
LBL
STO
RCL
DSZ
ISZ
ENTER ↑
CHS
EEX
CLX
W/DATA
MERGE
P↔S
CL REG
CL PRGM
LN
LOG
PAUSE
R↔P
D↔R
H↔H.MS
INT
LST X
H.MS+
INT
FRAC
%
%CH
-x-
STK
SPACE
HEWLETT·PACKARD 67
UNITED STATES

Section 6

Simple Programming

If you read the introduction to this handbook, you have already seen that by using the programming capability of your HP-67, you can increase the flexibility of the calculator a hundredfold or more, and you save hours of time in long computations.

With your HP-67 Programmable Calculator, Hewlett-Packard has provided you with a Standard Pac, containing 15 programs already recorded on magnetic cards. You can begin using the programming power of the HP-67 by simply using any of the cards from the Standard Pac, or from one of the other Hewlett-Packard pacs in areas like finance, statistics, mathematics, engineering, or medicine. The growing list of application pacs is continually being updated and expanded by Hewlett-Packard, to provide you with a wide variety of software support.

However, we at Hewlett-Packard cannot possibly anticipate every problem for which you may want to use your HP-67. In order to get the *most* from your calculator, you'll want to learn how to *program* the HP-67 to solve your every problem. This part of the *HP-67 Owner's Handbook* teaches you step-by-step to create simple programs that will solve complex problems, then introduces you to the many editing features of the HP-67, and finally gives you a glimpse of just how sophisticated your programming can become with the HP-67 Programmable Calculator.

Programming your calculator is an extension of its use as a *manual* problem-solving machine, so if you haven't read Part One, Using Your HP-67 Calculator, you should go back and do so before you begin programming.

After most of the explanations and examples in this part, you will find problems to work using your HP-67. These problems are not essential to your basic understanding of the calculator, and they can be skipped if you like. But we urge that you work them. They are rarely difficult, and they have been designed to increase your proficiency, both in the actual use of the features of your calculator and in creating programs to

solve your *own* problems. If you have trouble with one of the problems, go back and review the explanations in the text, then tackle it again.

So that you can apply your own creative flair to the problems, no solutions are given for them. In programming, any solution that gives the correct outputs is the right one—there is no *one* correct program for any problem. In fact, when you have finished working through this part, and learned all the capabilities of the HP-67, you may be able to create programs that will solve many of the problems faster, or in fewer steps, than we have shown in our illustrations.

Now let's start programming!

What Is a Program?

A *program* is nothing more than a series of calculator keystrokes that you would press to solve a problem manually. The calculator remembers these keystrokes when you key them in, then executes them in order at the press of a single key. If you want to execute the program again and again, you have only to press the single key each time.

If you worked through Meet the HP-67 (pages 15-24), you learned how to create, load, run, and record a simple program to solve for the area of a sphere. Now look at a more complex program.

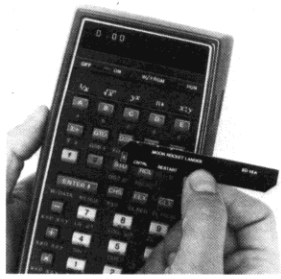
Loading a Prerecorded Program

First, set the calculator controls as follows:

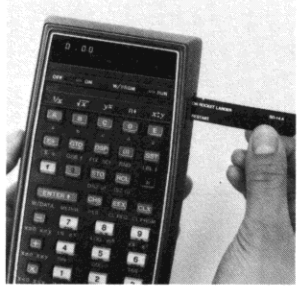
ON-OFF switch OFF ON to ON.

W/PRGM-RUN switch W/PRGM RUN to RUN.

Now select the Moon Rocket Lander card from the Standard Pac shipped with your HP-67. Insert side 1 of the card, face up, into the lower slot provided on the right side of the calculator, and press it into the slot until the reading mechanism picks it up and propels it out the left slot. Let go of the card as soon as you feel it begin to be propelled by the reading mechanism—don't try to restrain its progress. If the card does not read properly, the display will show Error; and you should then press any key on the keyboard to clear the error and again pass side 1 of the card through the card reader slot. Then insert the card in the upper slot so that the writing is visible in the window above the keys marked A B C D E.



1. Select the card.



2. Pass the card through the card reader slot.

3. Insert the card in the card window slot.

Some programs are recorded on *both* sides of a magnetic card, so the card must be run through the card reading mechanism twice—once on each side. If a second side of a magnetic card must be read, the calculator prompts you by displaying [Crd] after you have read the first side. However, the Moon Rocket Lander program is fairly short, so the complete program has been recorded twice, once on each side of this factory-prerecorded card. You can easily see when a card has been read completely because the calculator will then display the original contents of the X-register. The Moon Rocket Lander program has now been loaded into the calculator and you can try to "land" the calculator on the moon without "crashing."

The Game. The game simulates a rocket attempting to land on the moon, with you as the pilot. As the game begins, you are descending at a velocity of 50 ft/sec from a height of 500 feet. Velocity and altitude are shown in a combined display as -50.500, the altitude appearing to the right of the decimal point and the velocity to the left. The negative sign on the velocity indicates downward motion. As the game begins, you have 60 units of rocket fuel.

The object of the game is to control your descent by keying in fuel "burns" so that when you reach the surface of the moon (altitude 0), your velocity is also zero and you settle down gently into the powdery moon dust.

When you press [A], the game begins. The velocity and altitude are shown in the calculator display. Then the number of remaining fuel units are shown, and the display begins a countdown to burn time. The display counts "3," "2," "1," "0." When the countdown reaches zero, you have one second to key in a fuel burn. The best choices for fuel burns are digits of 1 through 9. A zero burn, which is very common, is accomplished by doing nothing.

After each burn, the calculator display will show first the new velocity and altitude, then the remaining fuel units, then will count down to

zero for you to key in another burn. This sequence is repeated until you successfully land (when the display will show you blinking zeros), or you smash into the lunar surface (when the display shows you the blinking crash velocity).

If you attempt to key in a fuel burn during any time other than the one-second "fire window," the rocket engine will shut off and you will have to restart it by pressing B. Restarting automatically uses up five units of fuel and gives no thrust.

So press A now and try to land on the moon with your HP-67.

Stopping a Running Program

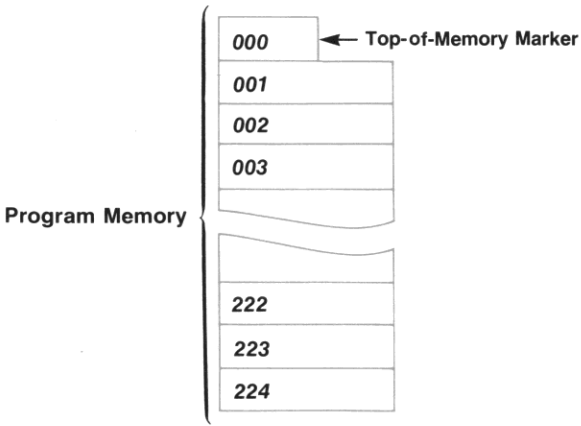
After you have successfully landed on the moon (or even if you have crashed), you can stop the running program by pressing R/S or any key on the keyboard. When you press any key on the keyboard while a program is running, the program immediately stops and displays the current contents of the X-register. The key function is not executed.

Looking at Program Memory

As you may remember from the program you created, loaded, executed, and recorded onto a magnetic card in Meet the HP-67 at the beginning of this handbook, a program is nothing more than a series of keystrokes you would press to solve a problem manually. Whether you load these keystrokes into the calculator from the keyboard, as you did then, or from a magnetic card, as when you loaded the Moon Rocket Lander program, the keystrokes are stored in a part of the calculator known as *program memory*. When you slide the W/PRGM-RUN switch to W/PRGM, you can examine the contents of program memory, one step at a time.

First, press GTO . 000 to return the calculator to the beginning of program memory. Then slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM. The display should show 000 .

Program memory consists of 224 "steps," which are numbered from 001 to 224, together with a top-of-memory marker, step 000. Program memory is separate from the stack and storage registers.



With the W/PRGM-RUN switch set to W/PRGM, the number that you see on the left side of the display indicates the *step number* of program memory to which the calculator is set. You should be set at step 000, indicated by a display of [000]. Now we'll use the SST *(single-step)* key to examine the next step of program memory. SST lets you step through program memory, one step at a time.

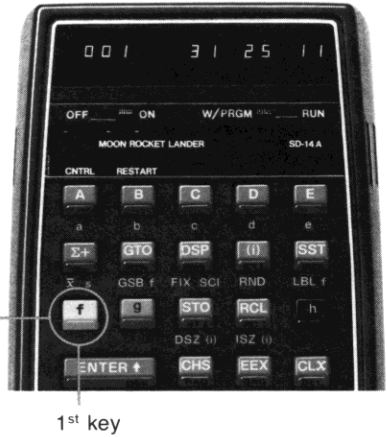
Press	Dispiay
SST	001 31 25 11

The calculator is now set to step 001 of program memory, as indicated by the number 001 that you see on the left side of the display. The other numbers in the display are two-digit *keycodes* for the keystrokes that have been loaded into that step of program memory.

Each step of program memory can "remember" a single operation, whether that operation consists of one, two, or three keystrokes. Thus, one step of program memory might contain a single-keystroke operation like CHS, while another step of program memory could contain a two-keystroke operation, like STO 6. Step 001 of program memory currently contains an operation that requires three keystrokes, f LBL A.

Keycodes

Each key on the calculator is identified by a two-digit keycode. When the W/PRGM-RUN switch is set to W/PRGM, the keycodes for the keystrokes loaded into the current step of program memory appear on the right side of the display. For example, the first keycode, 31, identifies the 3rd row of the keyboard, 1st key in that row. By counting down three rows and looking at the first key on the calculator keyboard, you can see that it is the f key.



The second keycode, 25, then refers to the 2nd row, 5th key in that row; and since the previous keycode was for the f prefix key, the function selected by the keycode for the 2nd row, 5th key in that row is LBL. The last keycode is 11; that is, the 1st row, 1st key in that row, the A key. So the complete operation loaded into step 001 is f LBL A.

Using this handy matrix system, you can easily identify any key by its keycode in the display. Remember, always count from the top down and from left to right. Each key, no matter how large, counts as one. For convenience, digit keys are identified by keycodes 00 through 09, although prefixed functions associated with digit keys are identified by the matrix address. A step of program memory cannot contain more than a decimal point or a single digit of a number. For example, if you press SST again, you can see that the number 5 is loaded into step 002 of program memory.

Press	Display
SST	002 05

Pressing SST twice more shows you that zeros have been loaded into steps 003 and 004:

Press	Display
SST	003 00
SST	004 00

Pressing SST again shows you that the operation loaded into step 005 is STO 6:

Press	Display
SST	005 33 06

Thus, in order to load this portion of the program into the calculator from the keyboard, you would have pressed the following keys:

f LBL A
500
STO 6

Remember that each step of program memory can hold a complete operation, no matter whether the operation consists of one (e.g., ÷), two (e.g., h π), or three (e.g., STO × 9) keystrokes. You can see that the 224 steps of program memory can actually hold many more than 224 keystrokes.

In addition to the 224 steps of program memory in which you can load keystrokes for programs, program memory also contains step 000. No functions can be loaded into step 000, and in fact, step 000 serves only as a kind of marker within memory, a convenient "starting point" when you begin loading a program.

Any function on the keyboard can be loaded into program memory except the five default functions, and certain editing functions like SST.

Default Functions

The default functions, [1/x] [√x] [y^x] [R↓] [x:y], that are found above the [A] through [E] keys on the keyboard have been placed in the calculator to enhance its usability in manual calculations. As soon as you load even a single operation into program memory, whether from the keyboard or from a magnetic card, the default functions are lost, and the top row keys, [A] through [E], are used in programming. Since the five default functions are also duplicated on the keyboard as prefixed functions, you can still utilize those operations in a program.

> **Note:** In actuality, if you press one of the top row keys in W/PRGM mode when no operations have been loaded into program memory, the prefixed function associated with that default function is loaded. After that, however, since an operation *has* been loaded into program memory, the default functions are lost. In this handbook, we have always used prefixed functions when programming, and we urge that you do the same, reserving the default functions for manual operation.

Default functions are restored when the calculator is turned OFF then ON, or when program memory is cleared using [f] [CLPRGM].

Problems

1. What would be the keycodes for the following operations: [CHS], [h] [GRD], [h] [H.MS+], [STO] [+] 1?

2. What operations are identified by the following keycodes: 41, 31 63, 35 62, 33 51 00?

3. How many steps of program memory would be required to load the following sections of programs?

   a. 2 [ENTER↑] 3 [+]

   b. 10 [STO] 6 [RCL] 6 [×]

   c. 100 [STO] 2 50 [STO] [×] 2 [RCL] 2 [f] [√x] [×]

4. What keystroke(s) would you load into a program to perform an *x exchange y?* (That is, to exchange the contents of the X-register with those of the Y-register.)

Clearing a Program

When you ran the magnetic card containing the Moon Rocket Lander program through the card reader with the W/PRGM-RUN switch set to RUN, the program was copied from the card into program memory in the calculator. Before you can key in a program, you will first want to clear, or erase, the Moon Rocket Lander program from the calculator's program memory. You can clear a program in any of three ways.

To clear a program from the calculator, you can either:

1. Press f CLPRGM with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM. This replaces whatever instructions are in program memory with R/S instructions. In W/PRGM mode, f CLPRGM also specifies FIX 2 display mode, DEG trigonometric mode, clears all flags, and restores the default functions to the top row keys. (A R/S instruction encountered in a program stops the execution of that program. A flag is a status indicator within a program. More about these later.) The stack and storage register contents remain intact when f CLPRGM is pressed.

2. Pass another magnetic card containing a program through the card reader with the W/PRGM-RUN switch W/PRGM RUN set the RUN. This replaces whatever instructions are contained in the calculator's program memory with the instructions for the new program. (Reading a blank card does not alter the contents of program memory, and the calculator displays *Error* to indicate that the card has not been read.)

3. Turn the HP-67 OFF, then ON. This replaces whatever instructions are in program memory with R/S instructions.

Now you are going to load your own program into the calculator from the keyboard, so to first clear the HP-67 of the previous program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press f CLPRGM to clear program memory. (This also sets the calculator to step 000 of program memory.)

Creating Your Own Program

In Meet the HP-67, at the beginning of this handbook, you created, loaded, ran, and recorded a program that solved for the surface area of a sphere, given the diameter of that sphere. Now let's create, load, and run another program to show you how to use some of the other features of the HP-67.

If you wanted to use the HP-67 to manually calculate the area of a circle using the formula $A = \pi r^2$ you could first key in the radius r, then square it by pressing g [x²]. Next you would summon the quantity pi into the display by pressing h [π]. Finally you would multiply the squared radius and the quantity pi together by pressing [×].

Remember that a *program* to solve a problem is nothing more than the keystrokes you would press to solve the problem manually. Thus, in order to create a program for the HP-67 that will solve for the area of *any* circle, you use the same keys you pressed to solve the problem manually.

The keys that you used to solve for area of a circle according to the formula $A = r^2\pi$ are:

g [x²]
h [π]
[×]

You will load these keystrokes into program memory. In addition, your program will contain two other operations, [LBL] [A] and [RTN].

The Beginning of a Program

To define the beginning of a program you should use an f [LBL] *(label)* instruction followed by one of the letter keys ([A], [B], [C], [D] or [E]) or g [LBL f] followed by [a] through [e]. The use of labels permits you to have several different programs or parts of programs loaded into the calculator at any time, and to run them in the order you choose.

The digit keys ([0] through [9]), when prefaced by f [LBL], can also be used to define the beginning of a program. However, since you must use f [GSB] [n] from the keyboard if you want to select and execute that program, [LBL] [0] through [LBL] [9] are usually reserved for defining *routines*—that is, parts of larger programs.

Ending a Program

To define the end of a program, you should use an h RTN *(return)* instruction. When the calculator is executing a program and encounters a RTN instruction in program memory, it stops (unless executed as part of a subroutine—more about subroutines later). For example, if the calculator were executing a program that had begun with LBL C, when it encountered h RTN, it would stop. Another instruction that will cause a running program to stop is R/S. When a running program executes a R/S instruction in program memory, it stops just as it does when it executes RTN. Good programming practice, however, dictates that you normally use h RTN rather than R/S to define the end of your program.

The Complete Program

The complete program to solve for the area of any circle given its radius is now:

f LBL A	Assigns name to and defines beginning of program.
g x^2	Squares the radius.
h π	Summons pi into the display.
×	Multiplies r^2 by π and displays the answer.
h RTN	Defines the end of and stops the program.

Loading a Program

You load a program into the calculator in either of two ways:

1. By passing a magnetic card containing program instructions through the card reader with the W/PRGM-RUN switch W/PRGM RUN set to RUN.
2. By setting the W/PRGM-RUN switch W/PRGM RUN to W/PRGM *(program)* and pressing the keys from the keyboard in the natural order you would press them to solve a problem manually.

Since we do not have a magnetic card that contains the program we have written to solve for the area of a circle, we will use this second method to load our program.

To load a program from the keyboard, simply slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM *(program)*. When the W/PRGM-RUN switch is in the W/PRGM position, the functions and operations that are normally executed when you press the keys are not executed. Instead, they are *stored* in program memory for later execution. *All operations on the keyboard except five can be loaded into program memory for later execution.* The five operations that cannot be loaded in as part of a program are:

f CLPRGM, h BST, SST, h DEL, GTO • n n n

These five operations are used to help you load, edit, and modify your programs in the calculator.

> **Note:** Naturally, the five default keys cannot be loaded into program memory, either. However, these keys are duplicated by prefixed keys that can be loaded. Thus, although you cannot load y^x, you can load the h y^x operation, etc.

All other functions when pressed with the W/PRGM-RUN switch W/PRGM RUN in W/PRGM mode are loaded into the calculator as program instructions to be executed later.

So if you have not already done so:

1. Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.
2. Press f CLPRGM to clear program memory of any previous programs and to reset the calculator to the top of program memory.

You can tell that the calculator is at the top of program memory because the digits 000 appear at the left of the display. The digits appearing at the left of the display with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM indicate the *program memory step number* being shown at any time.

The keys that you must press to key in the program for the area of a circle are:

f LBL A
g x^2
h π
×
h RTN

Press the first key, f, of the program.

Press	Display
f	000

You can see that the display of program memory has not changed. Now press the second and third keys of the program.

Press	Display
LBL	000
A	001 31 25 11

When the step number (001) of program memory appears on the left of the display, it indicates that a complete operation has been loaded into that step. As you can see from the keycodes present on the right side of the display, the complete operation is f (keycode 31), LBL (keycode 25), A (keycode 11). Nothing is loaded into program memory until a complete operation (whether 1, 2, or 3 keystrokes) has been specified.

Now load the remainder of the program by pressing the keys. Observe the program memory step numbers and keycodes.

Press	Display	
g x^2	002	32 54
h π	003	35 73
×	004	71
h RTN	005	35 22

The program for solving the area of a circle given its radius is now loaded into program memory of the HP-67. Notice that nothing could be loaded into the top-of-memory marker, step 000.

Running a Program

To run a program, you have only to slide the W/PRGM-RUN switch to RUN, key in any "unknown" data that is required, and press the letter key (A through E, f a through f e) that labels your program.

For example, to use the program now in the calculator to solve for circles with radii of 3 inches, 6 meters, and 9 miles:

First, slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
3 A	28.27	Square inches.
6 A	113.10	Square meters
9 A	254.47	Square miles.

Now let's see how the HP-67 executed this program.

Searching for a Label

When you switched the W/PRGM-RUN switch W/PRGM RUN to RUN, the calculator was set at step 005 of program memory, the last step you had filled with an instruction when you were loading the program. When you pressed the A key, the calculator began *searching* sequentially downward through program memory, beginning with that step 005, for a LBL A instruction. When the calculator searches, it does not execute instructions.

The calculator reached the last step of program memory, step 224, without encountering an f LBL A instruction. It then passed step 000 again and continued searching sequentially through program memory for a LBL A instruction. Only when the calculator found an f LBL A instruction in step 001 did it begin executing instructions.

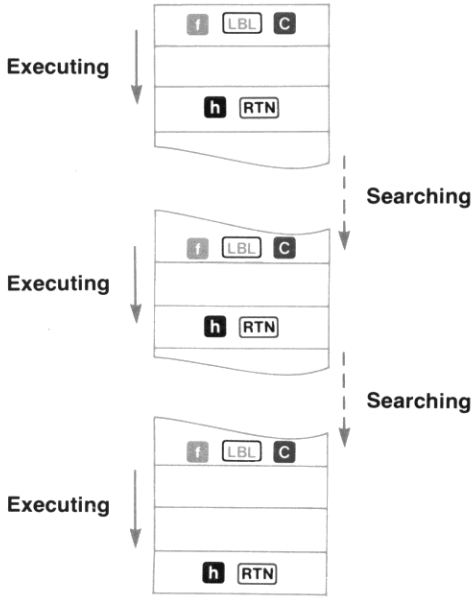
Executing Instructions

When the calculator found the f LBL A instruction in step 001, it ceased *searching* and began *executing* instructions. The calculator executes instructions in exactly the order you keyed them in, performing the g x^2 operation in step 002 first, then h π as in step 003, etc., until it executes an h RTN instruction or a R/S *(run/stop)* instruction. Since an h RTN instruction is executed in step 005, the calculator stops there and displays the contents of the X-register. (To see the next step number of program memory after the one at which the calculator has stopped, you can briefly switch the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.)

If you key in a new value for the radius of a circle in RUN mode and press A, the HP-67 repeats this procedure. It searches sequentially downward through program memory until it encounters a LBL A instruction, then sequentially executes the instructions contained in the next steps of program memory until it executes an h RTN or a R/S instruction.

You can see that it is possible to have many different programs or parts of a program loaded in the HP-67 at any time. You can run any one of these programs by pressing the letter key (A through E, f a through f e) that corresponds with its label.

It is also possible to have several different programs or routines defined by the same label. For example, suppose you had three programs in your HP-67 that were defined by f LBL C. When you pressed C, the calculator would search sequentially through program memory from wherever it was located until it encountered the first f LBL C instruction. The HP-67 would then execute instructions until it executed a RTN or a R/S instruction and stopped. When you pressed C again, the calculator would resume searching sequentially from the RTN or R/S through program memory until it encountered the second f LBL C instruction, whereupon it would execute that f LBL C and all subsequent instructions until it executed an h RTN or a R/S instruction and stopped. When you pressed C a third time, the HP-67 would search downward to the third f LBL C instruction and execute that program.



If you try to press a letter key (A through E , f a through f e) that is not contained as a label instruction in program memory, the HP-67 will execute no instruction and will display Error . For example, if your HP-67 contains only the program for area of a circle that you keyed in earlier, you can see this by simply pressing another letter key.

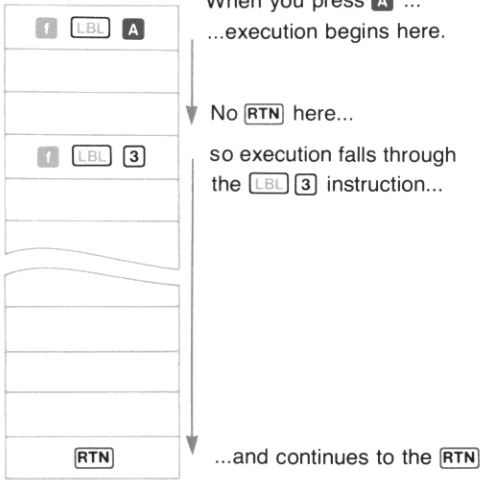
First, ensure that the W/PRGM-RUN switch W/PRGM RUN is set to RUN.

Press	Display
D	Error

To clear the error from the display, you can press CLx , or any key on the keyboard, or you can slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM. The calculator remains set at the current step of program memory.

Labels and Step 000

The labels (A through E, f a through f e, 0 through 9) in your programs act as addresses—they tell the calculator where to begin or resume execution. When a label is encountered as part of a program, execution merely "falls through" the label and continues onward. For example, in the program segment shown below, when you pressed A, execution would begin at LBL A and continue downward through program memory, on through the LBL 3 instruction, and continue until the RTN was encountered and execution was stopped.



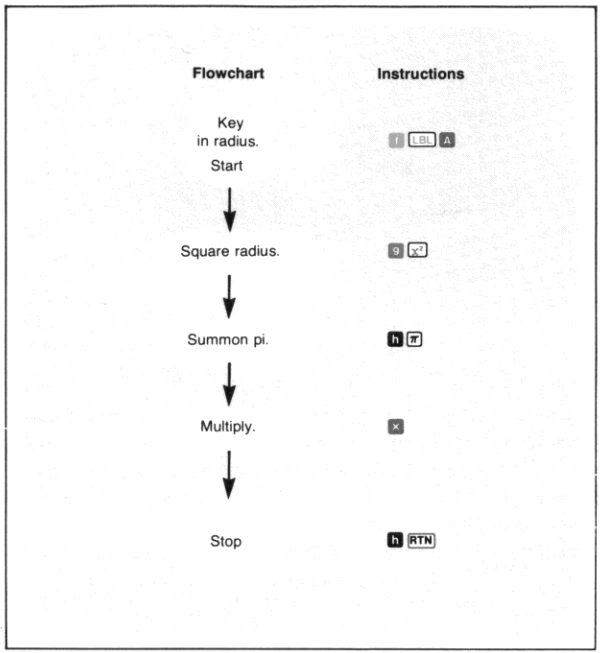
Execution falls through step 000, too. You can load instructions into steps 001 through 224 of program memory, but you cannot load an instruction into step 000. In fact, step 000 merely acts as a kind of label in program memory, a beginning point for the loading of a program. When step 000 is encountered by a running program, execution continues without a halt from step 224 to step 001, just as if step 000 were not there.

Flowcharts

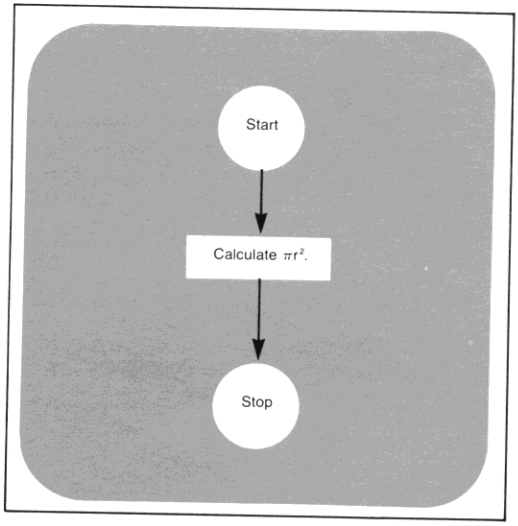
At this point, we digress for a moment from our discussion of the calculator itself to familiarize ourselves with a fundamental and extremely useful tool in programming—the flowchart.

A flowchart is an *outline* of the way a program solves a problem. With 224 possible instructions, it is quite easy to get "lost" while creating a long program, especially if you try to simply load the complete program from beginning to end with no breaks. A flowchart is a shorthand that can help you design your program by breaking it down into smaller groups of instructions. It is also very useful as documentation—a road map that summarizes the operation of a program.

A flowchart can be as simple or as detailed as you like. Here is a flowchart that shows the operations you executed to calculate the area of a circle according to the formula $A = \pi r^2$. Compare the flowchart to the actual instructions for the program:



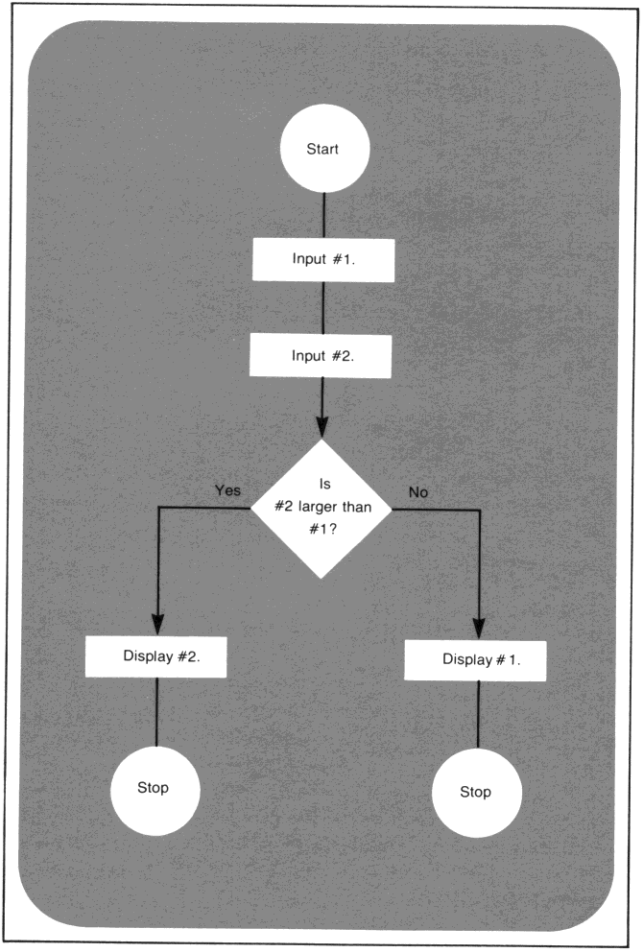
You can see the similarities. At times, a flowchart may duplicate the set of instructions exactly, as shown above. At other times, it may be more useful to have an entire group of instructions represented by a single block in the flowchart. For example, here is another flowchart for the program to calculate the area of a circle:



Here an entire group of instructions was replaced by one block in the flowchart. This is a common practice, and one which makes a flowchart extremely useful in visualizing a complete program.

You can see how a flowchart is drawn linearly, from the top of the page to the bottom. This represents the general flow of the program, from beginning to end. Although flowcharting symbols sometimes vary, throughout this handbook and in the Standard Pac, we have held to the convention of circles for the beginning and end of a program or routine, and rectangles to represent groups of functions that take an input, process it, and yield a single output. We have used a diamond to represent a *decision,* where a single input can yield either of two outputs.

For example, if you had two numbers and wished to write a program that would display only the larger, you might design your program by first drawing a flowchart that looked like this:



After drawing the flowchart, you would go back and substitute groups of instructions for each element of the flowchart. When the program was loaded into the calculator and run, if #2 was larger than #1, the answer to the question "Is #2 larger than #1?" would be YES, and the program would take the left-hand path, display #2, and stop. If the answer to the question was NO, the program would execute the right-hand path, and #1 would be displayed. (You will see later the many decision-making instructions available on your HP-67.)

As you work through this handbook, you will become more familiar with flowcharts. Use the flowcharts that illustrate the examples and problems to help you understand the many features of the calculator, and draw your own flowcharts to help you create, edit, eliminate errors in, and document your programs.

Problems

1. You have seen how to write, load, and run a program to calculate the area of a circle from its radius. Now write and load a program that will calculate the radius r of a circle given its area A using the formula $r = \sqrt{A/\pi}$. Be sure to slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM and press f CLPRGM first to clear program memory. Define the program with f LBL B and h RTN. After you have loaded the program, run it to calculate the radii of circles with areas of 28.27 square inches, 113.10 square meters, and 254.47 square miles.)

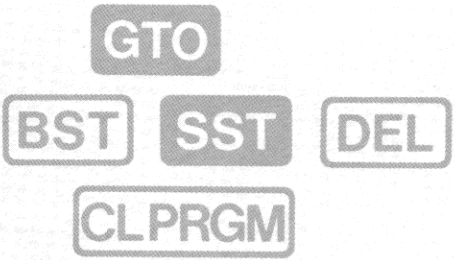
   (Answers: 3.00 inches, 6.00 meters, 9.00 miles.

2. Write and load a program that will convert temperature in Celsius degrees to Fahrenheit, according to the formula $F = 1.8\ C + 32$. Define the program with f LBL C and h RTN and run it to convert Celsius temperatures of −40°, 0°, and +72°.

   (Answers: −40.00 ° F, 32.00 ° F, 161.60 ° F.)

3. Immediately after running the program in Problem 2, create a program that will convert temperature in degrees Fahrenheit back to Celsius according to the formula $C = (F-32)5/9$, defining it using g LBL f C and h RTN, and load it into program memory immediately after the program you loaded in Problem 2. Run this new program to convert the temperatures in °F you obtained back to °C.

If you wrote and loaded the programs as called for in Problems 2 and 3, you should now be able to convert any temperature in Celsius to Fahrenheit by pressing C, and any temperature in Fahrenheit to Celsius by pressing f C. You can see how you can have many different programs loaded into the HP-67 and select any one of them for running at any time.


GTO
BST
SST
DEL
CLPRGM

Section 7

Program Editing

Often you may want to alter or add to a program that is loaded in the calculator. On your HP-67 keyboard, you will find several editing functions that permit you to easily change any steps of a loaded program *without* reloading the entire program.

As you may recall, except for the default function keys, all functions and operations on the HP-67 keyboard can be recorded as instructions in program memory except five others. These five functions are *program editing and manipulation functions,* and they can aid you in altering and correcting your programs. (The default functions above the top-row keys are duplicated elsewhere on the calculator by keys that can be recorded.)

Nonrecordable Operations

f CLPRGM is one keyboard operation that cannot be recorded in program memory. When you press f CLPRGM with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM, program memory is cleared to R/S instructions and the calculator is reset to the top of memory (step 000) so that the first instruction will be stored in step 001 of program memory. f CLPRGM also sets the trigonometric mode to DEG, the display mode to FIX 2, clears flags F0, F1, F2, and F3 (more about flags in section 13), and restores the default functions to the keys (A through E) on the top row of the keyboard. With the W/PRGM-RUN switch set to RUN, CLPRGM merely cancels an f prefix key that you have pressed.

SST *(single step)* is another nonrecordable operation. When you press SST with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM, the calculator moves to and displays the next step of program memory. When you press SST down with the W/PRGM-RUN switch W/PRGM RUN set to RUN, the calculator displays the next step of program memory—when you release the SST key, the calculator executes the instruction loaded in that step. SST permits you to single step through a program, executing the program one step at a time or merely viewing each step without execution, as you choose.

h BST *(back step)* is a nonrecordable operation that displays the *previous* step of program memory. When you press h BST with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM, the calculator moves to and displays the previous step of program memory. When you press and release h and then press down BST with the W/PRGM-RUN switch W/PRGM RUN set to RUN, the calculator moves to and displays the contents of the previous step of program memory. When you then release BST, the original contents of the X-register are displayed. No instructions are executed.

GTO *(go to)* • n n n is another keyboard operation that cannot be loaded as an instruction. (GTO A or GTO followed by any other label, however, *can* be loaded as a program instruction. More about the use of this instruction later.) Whether the Program Mode switch is set to RUN or W/PRGM, when you press GTO • followed by a three-digit step number, the calculator transfers execution so that the next operation or instruction will begin at that step number. No instructions are executed. If the calculator is in RUN mode, you can verify that the calculator is set to the specified step by briefly sliding the Program Mode switch W/PRGM RUN to W/PRGM. The GTO • n n n operation is especially useful in W/PRGM mode because it permits you to jump to any location in program memory for editing of or additions or corrections to your programs.

The DEL *(delete)* key is a nonrecordable operation that you can use to delete instructions from program memory. When the Program Mode switch W/PRGM RUN is set to W/PRGM and you press h DEL, the instruction at the current step of program memory is erased, and all subsequent instructions in program memory move upward one step. The section of program memory shown below illustrates what would happen when you press h DEL with the calculator set to step 004.

With the calculator set to step 004 when you press h DEL, program memory is changed...

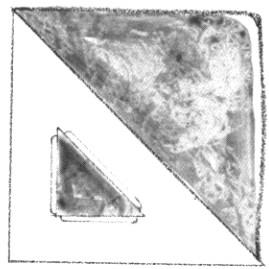
...from this...		...to this.	
001	f LBL A	001	f LBL A
002	g x^2	002	g x^2
003	h π	003	h π
004	×	004	h RTN
005	h RTN	005	R/S
006	R/S		

Now let's load a program from the keyboard and use these editing tools to check and modify it.

Pythagorean Theorem Program

The following program computes the hypotenuse of any right triangle, given the other two sides. The formula used is $c = \sqrt{a^2 + b^2}$.

Below are instructions for the program (basically, the same keys you would press to solve for c manually), assuming that values for sides a and b have been input to the X- and Y-registers of the stack.



To load the program:

First slide the Program Mode switch W/PRGM RUN to W/PRGM. Then press f CLPRGM to clear program memory of any previous programs and reset the calculator to step 000 of program memory.

Finally, load the program by pressing the keys shown below.

Press	Display
f LBL E	001 31 25 15
g x^2	002 32 54
h $x \rightleftarrows y$	003 35 52
g x^2	004 32 54
+	005 61
f $\sqrt{x}$	006 31 54
h RTN	007 35 22

With the program loaded into the HP-67, you can run the program. For example, calculate the hypotenuse of a right triangle with side *a* of 22 meters and side *b* of 9 meters.

Before you can run the program, you must *initialize* it.

Initializing a Program

Initialization of a program means nothing more than setting up the program (providing inputs, setting display mode, etc.) prior to the actual running of it. Some programs contain initialization routines that set up the data to run the program. In other programs, you may have to initialize manually from the keyboard before running. In the case of the program for calculating the hypotenuse of a triangle, to initialize the program you must place the values for sides *a* and *b* in stack registers X and Y. (Notice that the *order* does not matter in this case.) Thus, to initialize this program:

First, slide the Program Mode switch W/PRGM RUN to RUN.

Press	Display
22 ENTER↑	22.00
9	9.

The program for hypotenuse of a right triangle using the Pythagorean Theorem is now initialized for sides of 22 and 9 meters.

Running the Program

To run the program you have only to press the user-definable key that selects this program.

Press	Display	
E	23.77	Length of side *c* in meters.

To compute the hypotenuse of a right triangle with a side *a* of 73 miles and a side *b* of 99 miles:

Press	Display	
73 ENTER↑	73.00	
99	99.	Program initialized for new set of data before running.
E	123.00	Length of side *c* in miles.

Now let's see how we can use the nonrecordable editing features of the HP-67 to examine and alter this program.

Resetting to Step 000

As you know, when you press f CL PRGM with the Program Mode switch set to W/PRGM, the calculator is reset to step 000 and all instructions in program memory of the HP-67 are erased and replaced with R/S instructions. However, you can reset the HP-67 to step 000 of program memory while *preserving* existing programs in program memory by pressing GTO . 000 in W/PRGM or RUN mode, or h RTN in RUN mode.

To set the calculator to step 000 with the Pythagorean theorem program loaded into program memory:

Press	Display	
GTO . 000	123.00	Length of side *c* remains in display from previous running of program.

You could also have pressed h RTN in RUN mode to set the calculator to step 000.

Slide the Program Mode switch W/PRGM RUN to W/PRGM to verify that the calculator is now set at step 000 of program memory.

	Display
	000

Single-Step Execution of a Program

With the Program Mode switch set to RUN, you can execute a recorded program one step at a time by pressing the SST *(single-step)* key.

To single-step through the Pythagorean Theorem program using a triangle with side a of 73 miles and side b of 99 miles:

First slide the Program Mode switch W/PRGM RUN to RUN.

Press	Display	
73 ENTER↑	73.00	
99	99.	Program initialized for this set of data before running.

Now, press SST and hold it down to see the keycode for the next instruction. When you release the SST key, that next instruction is executed.

Press	Display	
SST	001 31 25 15	Keycode for f LBL E seen when you hold SST down.
	99.00	f LBL E executed when you release SST.

The first instruction of the program is executed when you press and release SST. (Notice that you didn't have to press E—when you are executing a program one step at a time, pressing the SST key begins the program from the current step of program memory without the need to press the user-definable E key.)

Continue executing the program by pressing SST again. When you hold SST down, you see the keycode for the next instruction. When you release SST, that instruction is executed.

Press	Display	
SST	002 32 54	Keycode for x^2.
	9801.00	Executed.

When you press SST a third time in RUN mode, step 003 of program memory is displayed. When you release the SST key, the instruction in that step, h $x \rightleftarrows y$, is executed, and the calculator halts.

Press	Display	
SST	003 35 52	Keycode for $x \rightleftarrows y$.
	73.00	Executed.

Continue executing the program by means of the SST key. When you have executed the h RTN instruction in step 007, you have completed executing the program and the answer is displayed, just as if the calculator had executed the program automatically, instead of via the SST key.

Press	Display
SST	004 32 54
	5329.00
SST	005 61
	15130.00

Press	Display
SST	006 31 54
	123.00
SST	007 35 22
	123.00

You have seen how the SST key can be used in RUN mode to single-step through a program. Using the SST key in this manner can help you create and correct programs. Now let's see how you can use SST, BST, and GTO • n n n in W/PRGM mode to help you modify a program.

Modifying a Program

Since you have completed execution of the above program, the HP-67 is set at step 008. You can verify that the calculator is set at this step by sliding the Program Mode switch W/PRGM RUN to W/PRGM and observing the step number and keycode in the display.

Now let's modify this Pythagorean Theorem program so that the stack contents will automatically be reviewed at certain points in the program. We will do this by inserting the instruction g STK at three points in the program.

Press	Display
f LBL E	001 31 25 15
g x^2	002 32 54
h $x \rightleftarrows y$	003 35 52
g x^2	004 32 54
+	005 61
f $\sqrt{x}$	006 31 54
h RTN	007 35 22

We will insert a g STK instruction after each of these instructions.

To begin modification of the loaded program, again reset the calculator to step 000 of program memory without erasing the program:

Ensure that the Program Mode switch W/PRGM ▮▯ RUN is set to RUN.

Press	Display	
h RTN	123.00	Calculator reset to step 000 of program memory.

Single-Step Viewing without Execution

You can use the SST key in W/PRGM mode to single-step to the desired step of program memory *without* executing the program. When you slide the Program Mode switch to W/PRGM, you should see that the calculator is reset to step 000 of program memory. When you press SST once, the calculator moves to step 001 and displays the contents of that step of program memory. No instructions are executed.

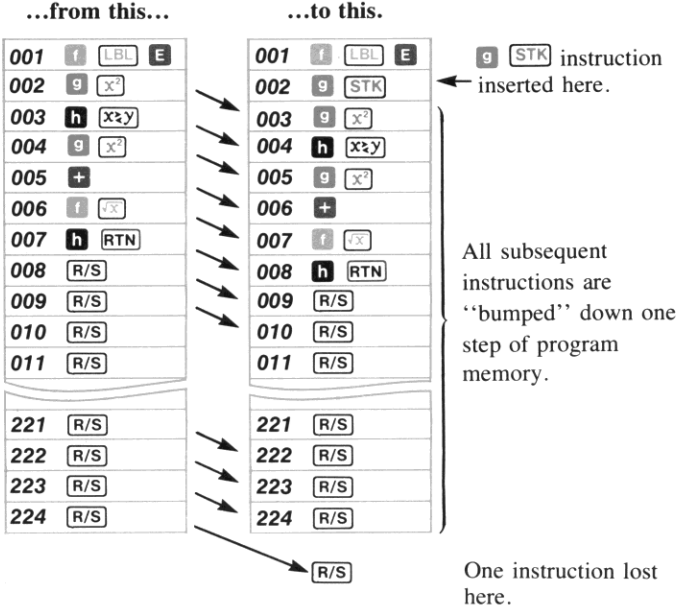
Slide the W/PRGM-RUN switch W/PRGM ▯▮ RUN to W/PRGM.

Press	Display	
	000	Step 000 of program memory displayed.
SST	001 31 25 15	Calculator moves to step 001 without executing instructions.

You can see that the calculator is now set at step 001 of program memory. If you press a recordable operation now, it will be loaded in the *next* step, step 002, of program memory, and all subsequent instructions will be "bumped" down one step in program memory. Thus, to load the g STK instruction so that the calculator will review the values in the stack at this point during execution:

Press	Display
g STK	002 32 84

Now let's see what happened in program memory when you loaded that instruction. With the calculator set at step 001, when you pressed g STK program memory was altered...



You can see that when you insert an instruction in a program, all instructions after the one inserted are moved down one step of program memory, and the instruction formerly loaded in step 224 is lost and cannot be recovered. In this case, the last instruction was a R/S instruction and was not used in the program. Note, however, that if you inserted an instruction into program memory when step 224 contained an instruction used in a program, the instruction would be lost from step 224. You should always view the contents of the last few steps of program memory before adding instructions to a program to ensure that no vital instructions will be lost from there.

Going to a Step Number

It is easy to see that if you wanted to single-step from step 000 to some remote step number in program memory, it would take a great deal of time and a number of presses of the SST key. So the HP-67 gives you another nonrecordable operation, GTO . n n n, that permits you to go to *any* step number of program memory.

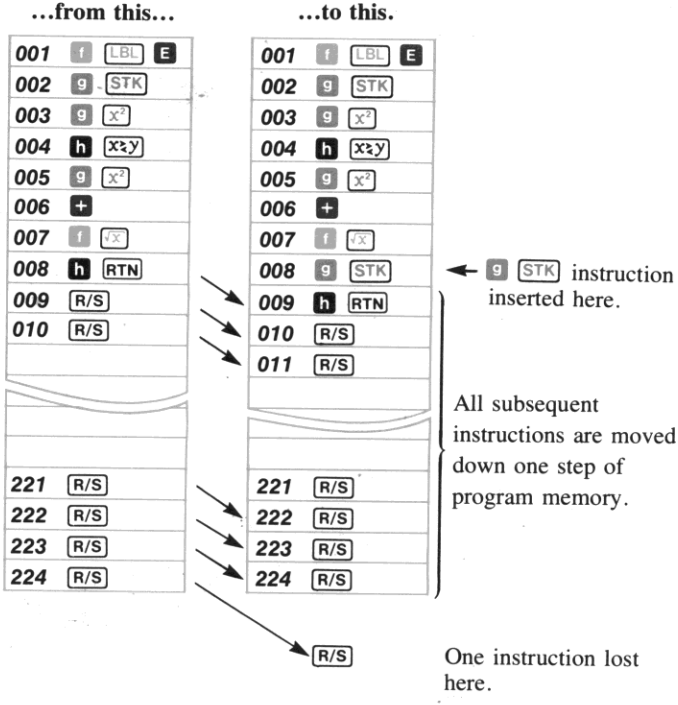
Whether the Program Mode switch is set to W/PRGM or to RUN, when you press GTO . n n n, the calculator immediately jumps to the program memory step number specified by the three-digit number n n n. No instructions are executed. In RUN mode, you can momentarily slide the Program Mode switch to W/PRGM to view this program information, while if the calculator is already in W/PRGM mode, the step number and keycode for the instruction contained in that step are displayed. Program searching or execution then will begin with that step of program memory. Loading will begin with the next step of program memory.

For example, to add a g STK instruction to review the stack contents after the hypotenuse has been calculated by the instruction in step 007, you can first press GTO *(go to)* followed by a decimal point and the appropriate three-digit step number of program memory. Then press g STK to place that instruction in the *following* step of program memory. Remember that when you add an instruction in this manner, each subsequent instruction is moved down one step in program memory, and the last instruction is lost from step 224. To add a g STK instruction after the f $\sqrt{x}$ instruction, keycode 31 54, that is now loaded into step 007:

Press	Display
GTO . 007	007 31 54
g STK	008 32 84

As you load the g STK instruction into step 008, the instruction that was *formerly* in step 008 is moved to step 009, and the instructions in subsequent steps are similarly moved down one step. The R/S instruction in step 224 is lost from program memory.

When you added the g STK instruction after step 007, program memory was altered...



Stepping Backwards through a Program

The BST (*back step*) key allows you to back step through a loaded program for editing whether the calculator is in RUN or W/PRGM mode. When you press h BST, the calculator backs up one step in program memory. If the calculator is in RUN mode, the previous step is displayed as long as you hold down the BST key. When you release it, the original contents of the X-register are again displayed. In W/PRGM mode, of course, you can see the step number and keycode of the instruction in the display at all times. No instructions are executed, whether you are in RUN or W/PRGM mode.

You now have one more g STK instruction to add to the Pythagorean Theorem program. The g STK instruction should be added after the h x≷y instruction, keycode 35 52, that is now loaded in step 004 of program memory. If you have just completed loading a g STK instruction in step 008 as described above, the calculator is set at step 008 of program memory. You can use BST to back the calculator up to step 004, then insert the g STK instruction in step 005. To begin:

Ensure that the Program Mode switch W/PRGM RUN is set to W/PRGM.

Press	Display	
	008 32 84	Calculator initially set to step 008.
h BST	007 31 54	Pressing BST once moves the calculator back one step in program memory.

When you press h BST, the calculator backs up one step in program memory. No instructions are executed when you use the BST key. Continue using the BST key to move backward through program memory until the calculator displays step 004.

Press	Display
h BST	006 61
h BST	005 32 54
h BST	004 35 52

Since you wish to insert the g STK instruction *after* the h x≷y instruction now loaded in step 004, you move the calculator to step 004 first. As always, when you key in an instruction, it is loaded into the next step *after* the step being displayed. Thus, if you press g STK now, that instruction will be loaded into step 005 of program memory, and all subsequent instructions will be moved down, or "bumped," one step.

Press	Display
g STK	005 32 84

You have now finished modifying the Pythagorean Theorem program so that you can review the stack at several points during the running of it. The altered program is shown below:

001	f LBL E
002	g STK
003	g x^2
004	h $x \rightleftarrows y$
005	g STK
006	g x^2
007	+
008	f $\sqrt{x}$
009	g STK
010	h RTN
011	R/S

If you wish, you can use the SST key in W/PRGM mode to verify that the program in your HP-67 matches the one shown above.

Running the Modified Program

To run the Pythagorean Theorem program, you have only to key in the values for sides a and b and press E. The HP-67 will now review the stack contents, then square side b, exchange the contents of the X- and Y-registers, and review the stack contents again. Finally, the value for the hypotenuse will be calculated, the stack contents will be reviewed a third time, and the calculated value for the hypotenuse will appear in the X-register when the program stops running.

For example, to compute the hypotenuse of a right triangle with sides a and b of 22 meters and 9 meters:

Slide the W/PRGM switch W/PRGM ▮▮▮ RUN to RUN.

Press	Display
22 ENTER↑	22.00

9	9.	Program initialized.
E	23.77	After reviewing the stack contents three times during the running program, the answer in meters is displayed.

Now run the program for a right triangle with sides a and b of 73 miles and 99 miles.

(Answer: 123 miles.)

Deleting an Instruction

Often in the modification of a program you may wish to delete an instruction from program memory. To delete the instruction to which the calculator is set, merely press the nonrecordable operation h DEL (*delete*) with the HP-67 Program Mode switch W/PRGM RUN set to W/PRGM. (When the Program Mode switch is set to RUN, pressing DEL does nothing except cancel a pressed prefix key h.) When you delete an instruction from program memory using the DEL key, all subsequent instructions in program memory are moved *up* one step, and a R/S instruction is loaded into step 224. The calculator moves to the step *before* the deleted step and displays it.

For example, if you wanted to modify the Pythagorean Theorem program that is now loaded into the calculator so that the stack was only reviewed once, at the end of the program, you would have to delete the g STK instructions, keycodes 32 84, that are presently loaded in steps 002 and 005 of program memory. To delete these instructions, you must first set the calculator at these steps using SST, h BST or GTO . n n n, then press h DEL. To delete the g STK instruction now loaded in step 002:

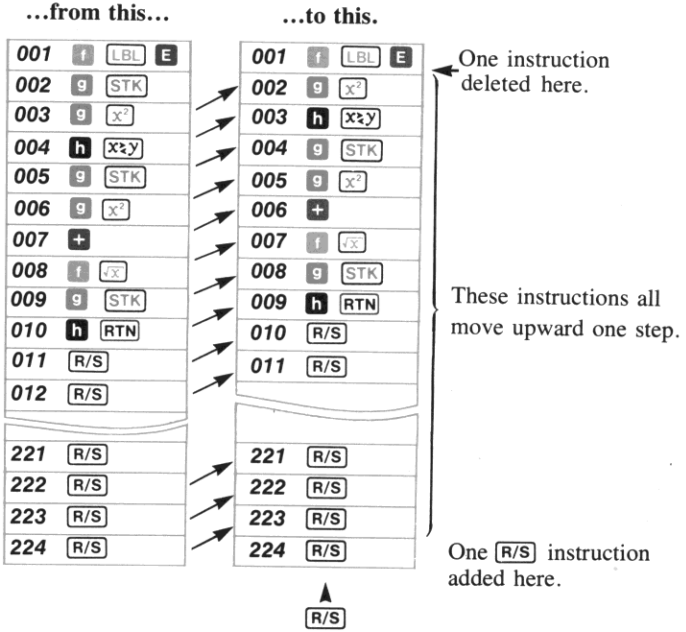
First, slide the Program Mode switch W/PRGM RUN to W/PRGM.

Press	Display	
GTO .002	002 32 84	Step 002 is displayed.
h DEL	001 31 25 15	The instruction in step 002 is deleted and the calculator moves to step 001.

You can use the SST key to verify that the g STK instruction, keycodes 32 84, has been deleted, and subsequent instructions have been moved up one step.

Press	Display	
SST	002 32 54	The instruction formerly in step 003 was moved up to step 002, and all subsequent instructions were moved up one step, when you pressed h DEL.

When you set the calculator to step 002 of program memory and pressed h DEL, program memory was altered...



To delete the g STK instruction now loaded in step 004 you can use the SST key to single-step down to that step number and then delete the instruction with the h DEL operation.

Press	Display	
SST	003 35 52	
SST	004 32 84	
h DEL	003 35 52	The g STK instruction, keycodes 32 84, is deleted from step 004 and the calculator displays step 003. Subsequent instructions move up one step of program memory.

If you have modified the program as described above, the HP-67 should now review the contents of the stack only once, just before the program stops. The calculated value of the hypotenuse is then displayed.

Slide the Program Mode switch W/PRGM RUN to RUN, and run the program for right triangles with:

Sides *a* and *b* of 17 and 34 meters. (After reviewing the stack, calculator displays answer for side *c*, 38.01 meters.)

Sides *a* and *b* of 5500 rods and 7395 rods. (After reviewing the stack, calculator displays answer for side *c*, 9216.07 rods.)

To replace any instruction with another, simply set the calculator to the desired step of program memory, press h DEL to delete the first instruction, then press the keystrokes for the new instruction.

The editing features of the HP-67 have been designed to provide you with quick and easy access to any part of your program, whether for editing, debugging, or documentation. If a program stops running because of an error or because of an overflow, you can simply slide the W/PRGM-RUN switch to W/PRGM to see the step number and keycode of the operation that caused the error or overflow. If you suspect a portion of your program is faulty, you can use the GTO . n n n operation from the keyboard to go to the suspect section, then use the SST operation in RUN mode to monitor every change in calculator status as you execute the program one step at a time.

Problems

1. You may have noticed that there is a single keyboard operation, g [→P], that calculates the hypotenuse, side c, of a right triangle with sides a and b input to the X- and Y-registers. Replace the [x^2], [$x \rightleftarrows y$], [x^2], [+], and [$\sqrt{x}$] instructions in the Pythagorean Theorem program with the single g [→P] instruction as follows:

   a. Use the GTO [.] [n] [n] [n] and SST keys to verify that the Pythagorean Theorem program in your HP-67 contains the instructions shown below.

001	f [LBL] [E]	
002	g [x^2]	Replace all of these instructions with a g [→P] instruction.
003	h [$x \rightleftarrows y$]	
004	g [x^2]	
005	+	
006	f [$\sqrt{x}$]	
007	g [STK]	
008	h [RTN]	

   b. Use the GTO [.] [n] [n] [n] keyboard operation to go to step 006, the last instruction to be deleted in the program.

   c. Use the h [DEL] keyboard operation in W/PRGM mode to delete the instructions in steps 006, 005, 004, 003, and 002.

   Note: When modifying a program, you should always *delete* instructions before you *add* others, to ensure that no vital instructions are "bumped" from the bottom of program memory and lost.

   d. Load the g [→P] instruction into step 002.

   e. Verify that the modified program looks like the one below.

001	f [LBL] [E]
002	g [→P]
003	g [STK]
004	h [RTN]

   f. Switch to RUN mode and run the program for a right triangle with sides a and b of 73 feet and 112 feet.

   (Answer: 133.69 feet)

2. The following program is used by the manager of a savings and loan company to compute the future amounts of savings accounts according to the formula $FV = PV\ (1 + i)^n$, where FV is future value or amount, PV is present value, i is the periodic interest rate expressed as a decimal, and n is the number of periods. With PV entered into the Y-register, n keyed into the X-register, and an annual standard interest rate of 7.5%, the program is:

001	f LBL A
002	1
003	ENTER↑
004	.
005	0
006	7
007	5
008	+
009	h $x\rightleftarrows y$
010	h y^x
011	×
012	h RTN

a. Load the program into the calculator.

b. Run the program to find the future amount of $1,000 invested for 5 years.

(Answer: $1,435.63)

Of $2,300 invested for 4 years.

(Answer: $3,071.58)

c. Alter the program to account for a change of the annual interest rate from 7.5% to 8%.

d. Run the program for the new interest rate to find the future value of $500 invested for 4 years; of $2,000 invested for 10 years.

(Answer: $680.24; $4,317.85)

3. The following program calculates the time it takes for an object to fall to the earth when dropped from a given height. (Friction from the air is not taken into account.) When the program is initialized by keying the height h in meters into the displayed X-register and [A] is pressed, the time t in seconds the object takes to fall to earth is computed according to the formula:

$$t = \sqrt{\frac{2h}{9.8 \text{ meters/second}^2}}$$

a. Clear all previously recorded programs from the calculator and load the program below.

001	f LBL A
002	ENTER↑
003	2
004	×
005	9
006	.
007	8
008	÷
009	f √x
010	h RTN

b. Run the program to compute the time taken by a stone to fall from the top of the Eiffel Tower, 300.51 meters high; from a blimp stationed 1000 meters in the air.

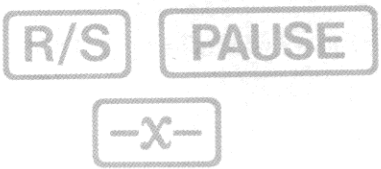
(Answers: 7.83 seconds; 14.29 seconds)

c. Alter the program to compute the time of descent when the height in *feet* is known, according to the formula:

$$t = \sqrt{\frac{2h}{32.1740 \text{ feet/second}^2}}$$

d. Run the altered program to compute the time taken by a stone to fall from the top of the Grand Coulee Dam, 550 feet high; from the 1350-foot height of the World Trade Center buildings in New York City.

(Answers: 5.85 seconds; 9.16 seconds)


R/S
PAUSE
−x−

Section 8

Interrupting Your Program

Using R/S (SPACE)

As you know, the R/S *(run/stop)* function can be used either as an instruction in a program or pressed from the keyboard.

When pressed from the keyboard:

1. If a program is running, R/S stops the program.
2. If a program is stopped or not running, and the calculator is in RUN mode, R/S starts the program running beginning with the current location in program memory.

When executed as an instruction during a running program, R/S stops program execution after its step of program memory. If R/S is then pressed from the keyboard, execution begins with the current step of program memory. (When R/S is pressed, the step number and keycode of that current step are displayed—when released, execution begins with that step.)

You can use these features of the R/S instruction to stop a running program at points where you want to key in data. After the data has been keyed in, restart the program using the R/S key from the keyboard.

Example: The following program lets you key in a percentage discount and calculates the cumulative cost of various quantities of differently priced items from which the discount has been subtracted. R/S instructions are inserted in the program to allow you to key in data at various points.

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display
f CLPRGM	000

Press	Display	
g LBL f a	001 32 25 11	Initialization routine, storing discount percentage in R_0.
f CL REG	002 31 43	
STO 0	003 33 00	
f LBL A	004 31 25 11	
ENTER↑	005 41	
R/S	006 84	Stop to key in price.
×	007 71	
RCL 0	008 34 00	
f %	009 31 82	
−	010 51	
STO + 1	011 33 61 01	Add to running total in R_1.
RCL 1	012 34 01	Recall running total for display.
h RTN	013 35 22	

In order to calculate the cumulative total for each percentage of discount, first initialize the program by keying in the percentage value and pressing f a. Then key in the first quantity and press A. When the program stops, key in the price for the first quantity, then press R/S to resume execution. The calculator will display the running total. For a second quantity and price, key in the second quantity and press A again; when the program stops at the R/S instruction, key in the price of the second item and press R/S from the keyboard again. The calculator will display the running total once more.

For each new percentage of discount, you must re-initialize the program by keying in the percentage value and pressing f a.

Now run the program to calculate the cumulative total of the following purchases at a discount of 15%:

Quantity	Price of Each
5	$ 7.35
7	$12.99
14	$14.95

Then run the program to calculate the cumulative total of the following purchases at a discount of 25%:

Quantity	Price of Each
7	$4.99
12	$1.88
37	$8.50

To run the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
15	15.	Key in percentage of discount.
f a	15.00	Initialize program.
5 A	5.00	The first quantity.
7.35 R/S	31.24	Running total.
7 A	7.00	The second quantity.
12.99 R/S	108.53	Running total.
14 A	14.00	The third quantity.
14.95 R/S	286.43	Cumulative cost for items at 15% discount.
25	25.	Percentage of discount.
f a	25.00	Re-initialize program.
7 A	7.00	The first quantity.
4.99 R/S	26.20	Running total.
12 A	12.00	
1.88 R/S	43.12	Running total.
37 A	37.00	
8.50 R/S	278.99	Cumulative cost for items at 25% discount.

If you have a number of halts for data entries in a program, it may be helpful to "identify" each step by recording a familiar number into the program immediately before each [R/S] instruction. When the calculator then stops execution because of the [R/S] instruction, you can look at the displayed X-register to see the "identification number" for the required data input at that point. For example, if your program contained eight stops for data inputs, it might be helpful to have the numbers 1 through 8 appear so that you would know which input was required each time. (Don't forget that the "identification number" will be pushed up into the Y-register of the stack when you key in a new number.)

Pausing in a Program

Pausing to View Output

As you know, a [R/S] instruction in a program halts execution of the program until [R/S] is again pressed from the keyboard. There are often times when you may want a running program to pause long enough for you to write down or view an answer, and then resume execution again automatically. On your HP-67, there are two functions that are used to cause a running program to momentarily pause, [-x-] and [PAUSE].

f [-x-], when encountered as an instruction by a running program, halts the program and displays the contents of the X-register for about 5 seconds, plenty of time to write down the answer, in most cases. So that you will know that the program has not stopped completely, the decimal point blinks eight times during the pause. When the pause is completed, the program resumes execution automatically with the next instruction in program memory. If you press any key during an [-x-] pause, program execution stops altogether.

h [PAUSE] *(pause),* when encountered as an instruction by a running program, halts the program and displays the contents of the X-register for about 1 second. This type of pause is usually employed where you want to monitor the operation of a program, but where the recording of answers is not important. When the pause is completed, the program resumes execution with the next instruction in program memory. Unlike an [-x-] pause, you can key in numbers or execute functions from the keyboard during a [PAUSE].

The following example illustrates the operation of both types of pauses to view output.

Example: Arthur Dimsdale is solely responsible for the night shift at Tintoretto Tins, a canning company. For each of several sizes of cylindrically-shaped cans, Dimsdale knows only the radius r and the height h of each size of can, and the number of cans of each size. He needs to first calculate the area of the base and display it long enough to set a dial on his production line (a 1-second display will do). Then he needs to know the volume of the can long enough to write it down (this should take him about 5 seconds), and finally he needs to know the total volume of all cans of that size.

Solution: The program below first calculates the area A of the base by the formula $A = \pi r^2$, and uses a [PAUSE] to display the area for about 1 second. Then the program calculates the volume V of a single can according to the formula $V = A \times h$, and uses an [-X-] pause to display the volume long enough for Dimsdale to write it down. Finally, the program multiplies the number of cans *(n)* times the volume of each can to compute the total volume of all cans of that size. The program assumes that the number of cans *(n)* has been entered to the Z-register of the stack, that the height h of the can has been entered to the Y-register, and that the radius r has been placed in the displayed X-register.

To load the program into the calculator:

Slide the Program Mode switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	
g x^2	002 32 54	Calculates $A = \pi r^2$.
h π	003 35 73	
×	004 71	
h PAUSE	005 35 72	Displays A for about 1 second.
×	006 71	Calculates $V = A \times h$.
f -X-	007 31 84	Displays V of one can for about 5 seconds.
×	008 71	Calculates total volume.
h RTN	009 35 22	Stops and displays total volume.

To find Dimsdale's outputs if he had 20,000 cans with heights of 25 centimeters and radii of 10 centimeters:

Slide the Program Mode switch W/PRGM RUN to RUN.

Press	Display	
20000 ENTER↑	20000.00	Number n of cans.
25 ENTER↑	25.00	Height h of single can.
10	10.	Radius r of single can.
A	314.16	Area of base of can.
	7853.98	Volume of can in cubic centimeters.
	157079632.7	Total volume of cans in cubic centimeters.

To find Dimsdale's outputs if he had 7500 cans that were 8 centimeters high with base radii of 4.5 centimeters:

Press	Display	
7500 ENTER↑	7500.00	
8 ENTER↑	8.00	
4.5	4.5	
A	63.62	Base area of can in square centimeters.
	508.94	Single can volume in cubic centimeters.
	3817035.07	Total volume of cans in cubic centimeters.

Pausing for Input

When the calculator executes a [PAUSE] instruction, program control actually returns to the keyboard for the period of time (about one second) of the pause. You can use a [PAUSE] to key data into or perform functions from the keyboard, instead of using the [R/S] instruction to stop the running program completely. (Control does *not* return to the keyboard during an [-x-] pause, however.)

When you press any key during the one-second "window" while the calculator is executing a [PAUSE] instruction, that key actually operates, and you have an additional one second of time to view the result or to press another key. If you press yet another key during the subsequent one second, the calculator will perform that operation and pause for another second.

If you press a function key during a pause, the function key operates upon the number contained in the X-register at the time. The result of the function is then seen in the display for about one second. Any function key that is programmable can also be operated from the keyboard during a [PAUSE].

If you press a digit key, or a series of digit keys, during a pause, the number appears in the display for the length of a pause (about one second) after you key in the number. (If a number has been input from the program immediately before the pause, that number is first terminated by the [PAUSE] instruction.) The number that you key in is terminated at the end of the pause. Any subsequent digits in a program will then be part of a new number.

When a [PAUSE] instruction has completed execution, the program continues to be executed sequentially. If you have performed a function, or keyed in a number, program execution begins with the next instruction using the number that is in the displayed X-register at the end of the pause. (You can also read a magnetic card during a [PAUSE]. More about this in section 14, Card Reader Operations.)

Number termination occurs at the end of each [PAUSE], so you should not attempt to key in a number during more than one subsequent pause. Since you have about one second after your last keystroke to continue keying in digits or functions, you don't need more than one [PAUSE] instruction to key in even a very long number.

Example: The following program calculates the average of any three numbers, which are keyed in during three pauses in program execution. To key in the program:

Slide the Program Mode switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	
f CL REG	002 31 43	
f P≠S	003 31 42	
CLx	004 44	
h PAUSE	005 35 72	Pause to input first number.
Σ+	006 21	
CLx	007 44	
h PAUSE	008 35 72	Pause to input second number.
Σ+	009 21	
CLx	010 44	
h PAUSE	011 35 72	Pause to input last number.
Σ+	012 21	
f x̄	013 31 21	Calculate average.
h RTN	014 35 22	

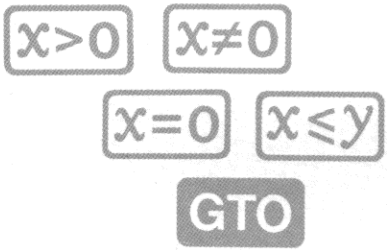
Now run the program to find the average of 1, 2, and 3; of 157, 839, and 735. Merely start the program running by pressing A, then key in the desired three numbers during the successive pauses.

Slide the Program Mode switch W/PRGM RUN to RUN.

Press	Display	
A	0.00	
1	0.00	
2	0.00	
3	2.00	Average of 1, 2, and 3.

A	0.00	
157	0.00	
839	0.00	
735	577.00	Average of 157, 839, and 735.

You can see that it is easy to key in a number of any length during the execution of a PAUSE pause instruction.


x>0
x≠0
x=0
x≤y
GTO

Section 9

Branching

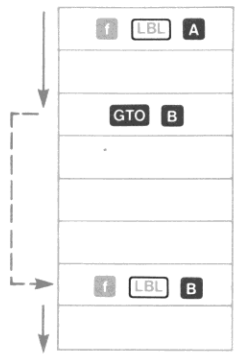
Unconditional Branching and Looping

You have seen how the nonloadable operation GTO . n n n can be used from the keyboard to transfer execution to any step number of program memory. You can also use the *go to* instruction as part of a program, but in order for GTO to be *recorded* as an instruction, it must be followed by a label designator (A through E, f a through f e, or 0 through 9). (It can also be followed by (i)—more about using (i) later.)

When the calculator is executing a program and encounters a GTO B instruction, for example, it immediately halts execution and begins searching sequentially downward through program memory for that label. When the first f LBL B instruction is then encountered, execution begins again.

By using a GTO instruction followed by a label designator in a program, you can transfer execution to any part of the program that you choose.

Execution branches to next f LBL B .



A GTO instruction used this way is known as an *unconditional branch*. It always *branches* execution from the GTO instruction to the specified label. (Later, you will see how a conditional instruction can be used in conjunction with a GTO instruction to create a *conditional* branch—a branch that depends on the outcome of a test.)

A common use of a branch is to create a "loop" in a program. For example, the following program calculates and displays the square roots of consecutive whole numbers beginning with the number 1. The HP-67 continues to compute the square root of the next consecutive whole number until you press R/S to stop program execution (or until the calculator overflows).

To key in the program:

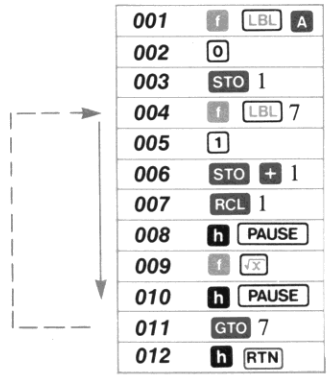
First, slide the Program Mode switch W/PRGM RUN to W/PRGM. Press f CLPRGM to clear program memory and reset the calculator to step 000.

Press	Display	
f LBL A	001 31 25 11	
0	002 00	
STO 1	003 33 01	
f LBL 7	004 31 25 07	
1	005 01	
STO + 1	006 33 61 01	Adds 1 to current number in R_1.
RCL 1	007 34 01	Recalls current number from R_1.
h PAUSE	008 35 72	Displays current number.
f √x	009 31 54	
h PAUSE	010 35 72	Displays square root of current number.
GTO 7	011 22 07	Transfers execution to f LBL 7 again.
h RTN	012 35 22	

To run the program, slide the Program Mode switch W/PRGM ▮▮▮ RUN to RUN and press A. The program will begin displaying a table of integers and their square roots and will continue until you press R/S from the keyboard or until the calculator overflows.

How it works: When you press A, the calculator searches through program memory until it encounters the f LBL A instruction that begins the program. It executes that instruction and each subsequent instruction in order until it reaches step 011, the GTO 7 instruction.

The GTO 7 instruction causes the calculator to *search* once again, this time for a LBL 7 instruction in the program. When it encounters the LBL 7 instruction loaded in step 004, execution begins again from that LBL 7. (Notice that the address after a GTO instruction in a program is a *label,* not a step number.)



Since execution is transferred to the LBL 7 instruction in step 004 each time the calculator executes the GTO 7 instruction in step 011, the calculator will remain in this "loop," continually adding one to the number in storage register R_1 and displaying the new number and its square root.

Looping techniques like the one illustrated here are common and extraordinarily useful in programming. By using loops, you take advantage of one of the most powerful features of the HP-67—the ability to update data and perform calculations automatically, quickly, and, if you so desire, endlessly.

You can use unconditional branches to create a loop, as shown above, or in any part of a program where you wish to transfer execution to another label. When the calculator executes a GTO instruction, it searches sequentially downward through program memory and begins execution again at the first specified label it encounters.

Problems

1. The following program calculates and pauses to display the square of the number 1 each time it is run. Key the program in with the W/PRGM-RUN switch W/PRGM RUN set to W/PRGM, then switch to RUN and run the program a few times to see how it works. Finally, modify the program by inserting an f LBL D instruction after the STO 1 instruction in step 003, and a GTO D instruction after the second h PAUSE instruction. This should create a loop that will continually display a new number and display its square, then increment the number by 1, display the new number and compute and display *its* square, etc. To load the original program, before modification, slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM. Then:

Press	Display
f CLPRGM	000
f LBL B	001 31 25 12
0	002 00
STO 1	003 33 01
1	004 01
STO + 1	005 33 61 01
RCL 1	006 34 01
h PAUSE	007 35 72
g x^2	008 32 54
h PAUSE	009 35 72
h RTN	010 35 22

Run the program to generate a table of squares.

2. Use the flowchart on the following page to create a program that computes and pauses to display the future value (FV) of a compound interest savings account in increments of one year according to the formula:

$$FV = PV(1 + i)^n$$

where FV = future value of the savings account.
PV = present value (or principal) of the account.
i = interest rate (expressed as a decimal fraction; e.g., 6% is expressed as 0.06).
n = number of compounding periods (usually, years).

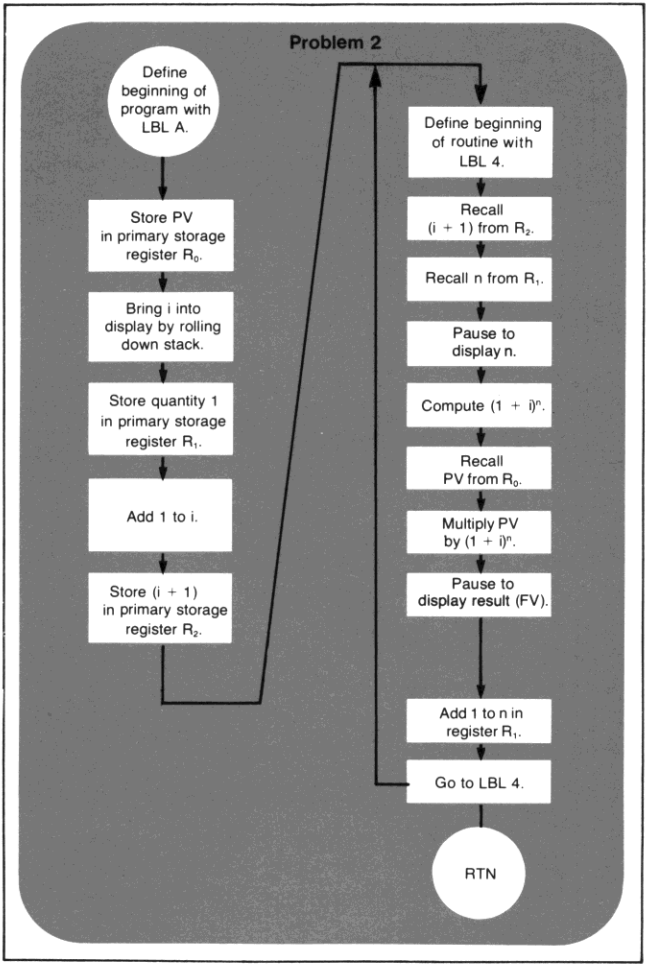
Assume that program execution will begin with *i* entered into the Y-register of the stack and with *PV* keyed into the displayed X-register.

After you have written and loaded the program, run it for an initial interest rate *i* of 6% (keyed in as .06) and an initial deposit (or present value, *PV*) of $1000.

(Answer: 1st year, $1060; 2nd year, $1123.60; 3rd year, $1191.02; etc.)

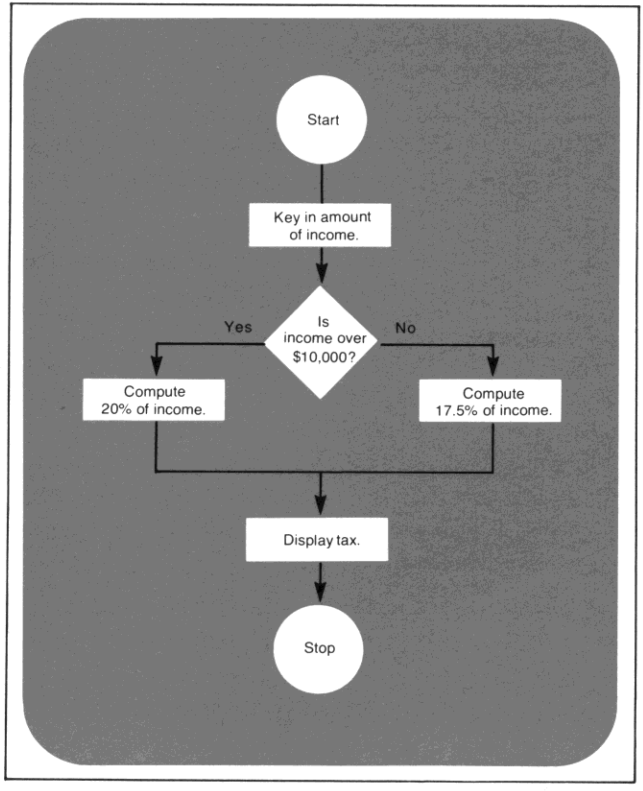
The program will continue running until you press [R/S] (or any key), or until the HP-67 overflows. You can see how your savings would grow from year to year. Try the program for different interest rates *i* and values of *PV*.

3. Write a program using [GTO] that will use the factorial function ([N!]) to calculate and pause to display the factorials of successive integers beginning with the number 1. (Hint: Place 1 in a storage register, recall it, then use storage register arithmetic to increment the number in the storage register, etc.)


Problem 2
Define beginning of program with LBL A.
Store PV in primary storage register R_0.
Bring i into display by rolling down stack.
Store quantity 1 in primary storage register R_1.
Add 1 to i.
Store (i + 1) in primary storage register R_2.
Define beginning of routine with LBL 4.
Recall (i + 1) from R_2.
Recall n from R_1.
Pause to display n.
Compute $(1 + i)^n$.
Recall PV from R_0.
Multiply PV by $(1 + i)^n$.
Pause to display result (FV).
Add 1 to n in register R_1.
Go to LBL 4.
RTN

Conditionals and Conditional Branches

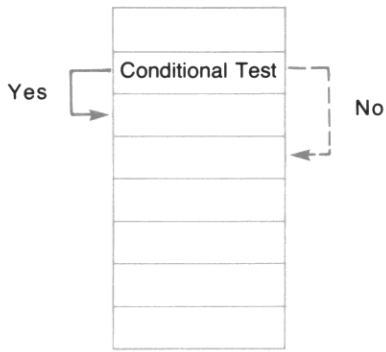
Often there are times when you want a program to make a decision. For example, suppose an accountant wishes to write a program that will calculate and display the amount of tax to be paid by a number of persons. For those with incomes of $10,000 per year or under, the amount of tax is 17.5%. For those with incomes of over $10,000, the tax is 20%. A flowchart for the program might look like this:



The *conditional* operations on your HP-67 keyboard are useful as program instructions to allow your calculator to make decisions like the one shown above. The eight conditionals that are available on your HP-67 are:

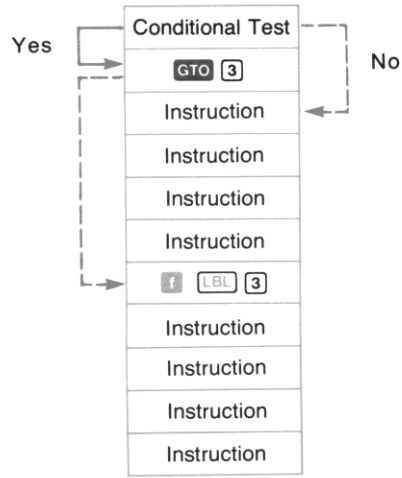
- g [x=y] tests to see if the value in the X-register is equal to the value in the Y-register.
- g [x≠y] tests to see if the value in the X-register is unequal to the value in the Y-register.
- g [x≤y] tests to see if the value in the X-register is less than or equal to the value in the Y-register.
- g [x>y] tests to see if the value in the X-register is greater than the value in the Y-register.
- f [x=0] tests to see if the value in the X-register is equal to zero.
- f [x≠0] tests to see if the value in the X-register is unequal to zero.
- f [x<0] tests to see if the value in the X-register is less than zero.
- f [x>0] tests to see if the value in the X-register is greater than zero.

Each conditional essentially asks a question when it is encountered as an instruction in a program. If the answer is YES, program execution continues sequentially downward with the next instruction in program memory. If the answer is NO, the calculator branches *around* the next instruction. For example:



You can see that after it has made the conditional test, the calculator will *do* the next instruction if the test is *true*. This is the "DO if TRUE" rule.

The step immediately following the conditional test can contain any instruction. The most commonly used instruction, of course, will be a GTO instruction. This will branch program execution to another section of program memory if the conditional test is true.



Now let's look at that accountant's problem again. For persons with incomes of more than $10,000 he wants to compute a tax of 20%. For persons with incomes of $10,000 or less, the tax is 17.5%. The following program will test the amount in the X-register and compute and display the correct percentage of tax.

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	
EEX	002 43	Amount of $10,000 placed in Y-register.
4	003 04	
h x≷y	004 35 52	
g x>y	005 32 81	If amount of income is greater than $10,000, go to portion of program defined by label B.
GTO B	006 22 12	
1	007 01	Tax percentage for this portion of program is 17.5.
7	008 07	
.	009 83	
5	010 05	
GTO C	011 22 13	
f LBL B	012 31 25 12	Tax percentage for this portion of program is 20.
2	013 02	
0	014 00	
f LBL C	015 31 25 13	
f %	016 31 82	
h RTN	017 35 22	

To run the program to compute taxes on incomes of $15,000 and $7,500:

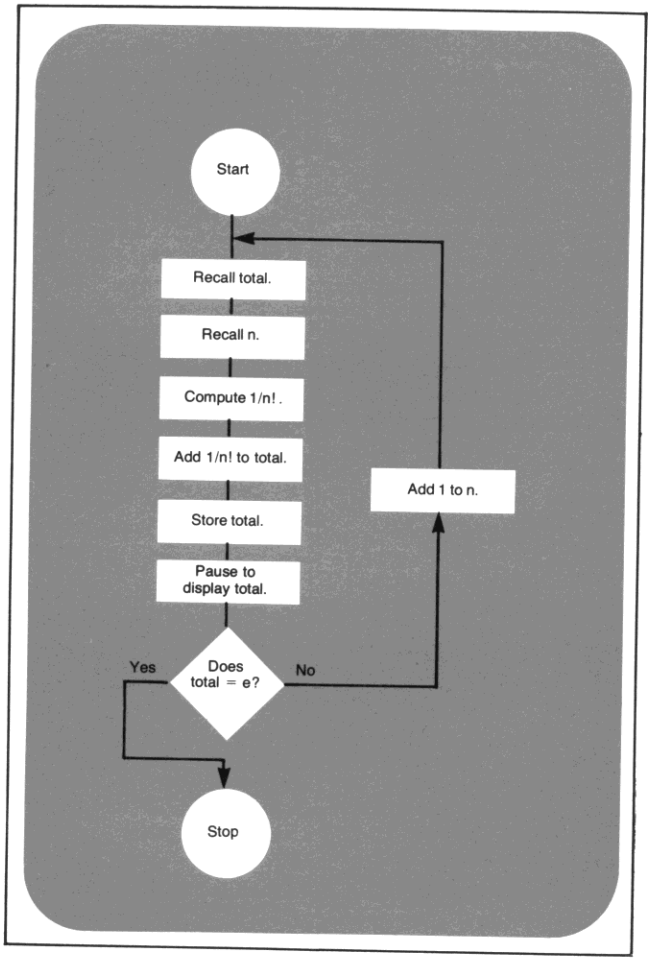
Slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

Press	Display	
15000 A	3000.00	Dollars of tax.
7500 A	1312.50	Dollars of tax.

Another place where you often want a program to make a decision is within a loop. The loops that you have seen have to this point been *infinite* loops—that is, once the calculator begins executing a loop, it remains locked in that loop, executing the same set of instructions over and over again, forever (or, more practically, until the calculator overflows or you halt the running program by pressing R/S or any other key).

You can use the decision-making power of the conditional instructions to shift program execution out of a loop. A conditional instruction can shift execution out of a loop after a specified number of iterations or when a certain value has been reached within the loop.

Example: As you know, your HP-67 contains a value for e, the base of natural logarithms. (You can display the calculator's value for e by pressing 1 g e^x.) The following program uses the series $e = 1/0! + 1/1! + 1/2! + \ldots + 1/n!$ to *approximate* the value for e. After each iteration through the loop, the latest approximation is displayed and compared to the *calculator's* value for e. When the two values are equal, the execution is transferred out of the loop to stop the program.


Start
Recall total.
Recall n.
Compute 1/n!.
Add 1/n! to total.
Store total.
Pause to display total.
Does total = e?
Yes
No
Add 1 to n.
Stop

To load the program into the calculator:

Slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to W/PRGM.

Press	Display
f CLPRGM	000
f LBL A	001 31 25 11
RCL 1	002 34 01
RCL 0	003 34 00
h N!	004 35 81
h 1/x	005 35 62
+	006 61
DSP 9	007 23 09
STO 1	008 33 01
h PAUSE	009 35 72
1	010 01
g e^x	011 32 52
g x=y	012 32 51
GTO 7	013 22 07
1	014 01
STO + 0	015 33 61 00
GTO A	016 22 11
f LBL 7	017 31 25 07
h RTN	018 35 22

To initialize the program ensure that the primary storage registers are cleared to zero. Then press A to run the program:

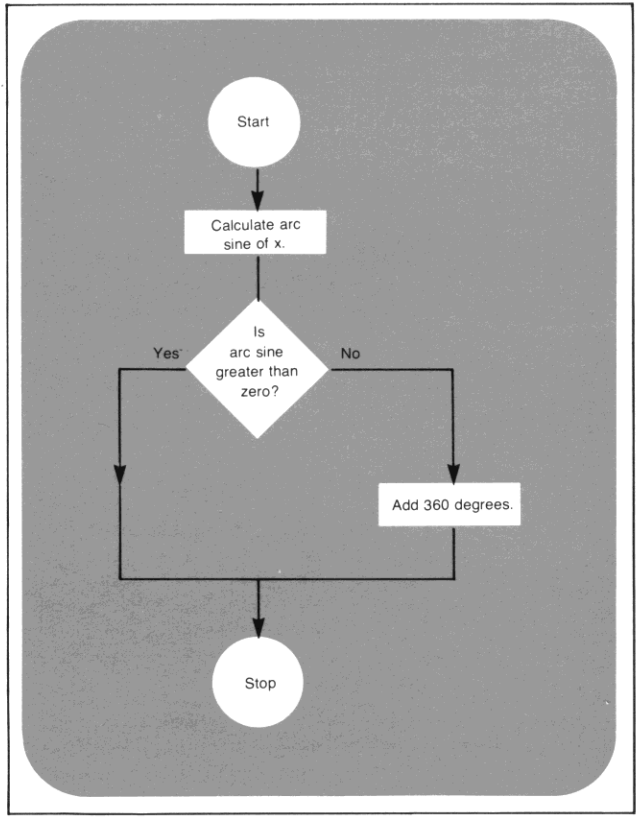
First, slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

Press	Display	
f CL REG	0.00	Ensures that primary storage registers are cleared to zero initially.
A	2.718281828	

You can see that execution continues within the loop until approximation for e equals the calculator's value for e. When the instruction x=y in step 012 is finally true, execution is transferred out of the loop by the subsequent GTO 7 instruction and halted by the RTN instruction.

Problems

1. Write a program that will calculate the arc sine (that is, $\sin^{-1}$) of a value that has been keyed into the displayed X-register. Test the resulting angle with a conditional, and if it is negative or zero, add 360 degrees to it to make the angle positive. Use the flowchart below to help you write the program.



2. The program below contains a loop that displays consecutive integers and their common logarithms. You can specify the *lowest* integer by storing a number in primary storage register R_0, but the program will continue until you press [R/S] or any other key from the keyboard, or until the calculator's capacity for display is exceeded.

001	f LBL A
002	DSP 9
003	RCL 0
004	f INT
005	h PAUSE
006	f LOG
007	h PAUSE
008	1
009	STO + 0
010	GTO A
011	h RTN

Using the additional instructions RCL 8, [x>y], GTO B and LBL B, you should be able to modify this program to halt execution when a certain number is reached. As you add these instructions, assume that the value for the upper limit has been manually stored in primary storage register R_8.

When the program is running and the value in register R_0 becomes greater than the limit you store in register R_8, program execution should be transferred out of the loop to the [RTN] instruction to halt the running program.

Modify the program, key it into the calculator, and initialize the calculator by storing a lower limit of 1 in register R_0 and an upper limit of 5 in register R_8. Then run the program. Your displays should look like the ones on the next page. Try other upper and lower limits. (The lower limit must always be greater than zero, and the upper limit should be greater than the lower limit.)

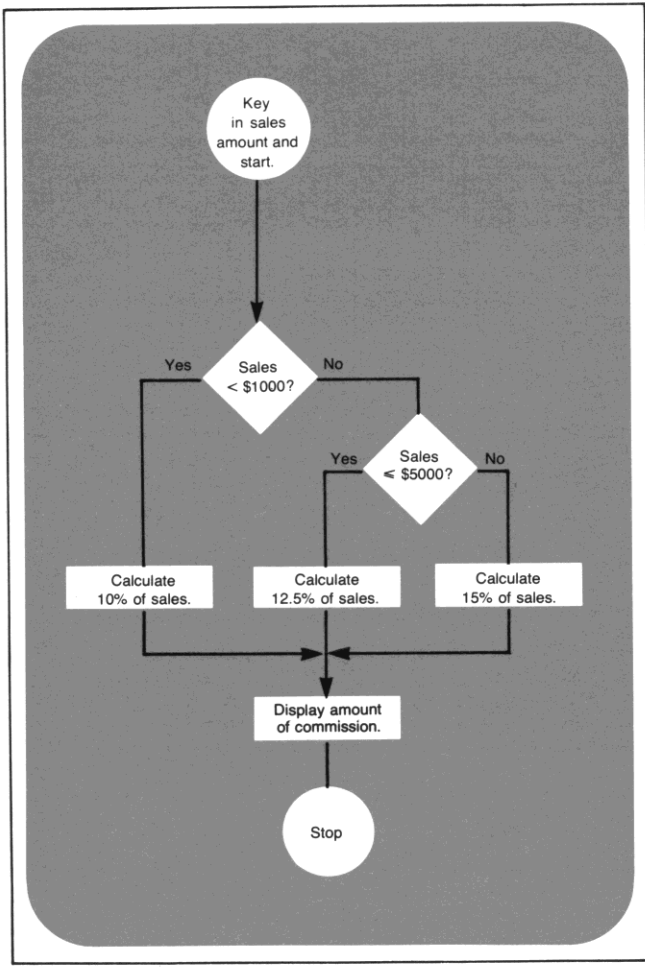
Display

1.000000000
0.000000000
2.000000000
0.301029996
3.000000000
0.477121255
4.000000000
0.602059991
5.000000000
0.698970004

3. Use the flowchart on the opposite page to help you write a program that will allow a salesman to compute his commissions at the rates of 10% for sales of up to $1000, 12.5% for sales of $1000 to $5000, and 15% for sales of over $5000. The program should display the amount of commission when it stops.

Load the program and run it for sales amounts of $500, $1000, $1500, $5000, and $6000.

(Answers: $50.00, $125.00, $187.50, $625.00, $900.00)


Key in sales amount and start.
Sales < $1000?
Yes
No
Sales ≤ $5000?
Yes
No
Calculate 10% of sales.
Calculate 12.5% of sales.
Calculate 15% of sales.
Display amount of commission.
Stop

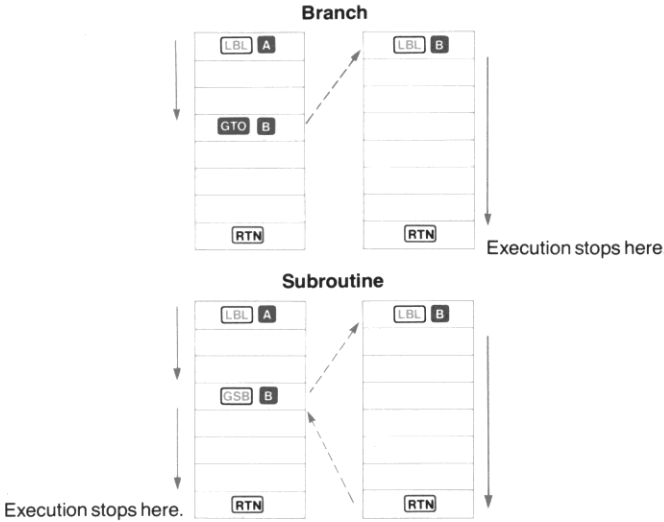

GSB
GSB f
LBL
D
RTN

Section 10

Subroutines

Often, a program contains a certain series of instructions that are executed several times throughout the program. When the same set of instructions occurs more than once in a program, it can be executed as a subroutine. A subroutine is selected by the GSB *(go to subroutine)* operation, followed by a label address (A through E, 0 through 9); or by GSB f followed by a through e. You can also select a subroutine with GSB (i)—more about (i) later.

A GSB or GSB f instruction transfers execution to the routine specified by the label address, just like a GTO instruction. However, after a GSB or GSB f instruction has been executed, when the running program then executes a RTN *(return)*, execution is transferred back to the next instruction after the GSB. Execution then continues sequentially downward through program memory. The illustration below should make the distinction between GTO and GSB more clear.



In the top illustration of a branch, if you pressed A from the keyboard, the program would execute instructions sequentially downward through program memory. If it encountered a GTO B instruction, it would then search for the next LBL B and continue execution from there, until it encountered a RTN. When it executed the RTN instruction, execution would stop.

However, if the running program encounters a GSB B *(go to subroutine B)* instruction, as shown in the lower illustration, it searches downward for the next LBL B and resumes execution. When it encounters a RTN *(return)*, program execution is once again transferred, this time back to the point of origin of the subroutine, and execution *resumes* with the next instruction after the GSB B.

As you can see, the only difference between a subroutine and a normal branch is the transfer of execution *after* the RTN. After a GTO, the next RTN halts a running program; after a GSB or GSB f, the next RTN returns execution back to the main program, where it continues until another RTN (or a R/S) is encountered. The same routine may be executed by GTO and GSB any number of times in a program.

Example: A quadratic equation is of the form $ax^2 + bx + c = 0$. Its two roots may be found by the formulas $r_1 = \dfrac{-b + \sqrt{b^2 - 4ac}}{2a}$ and $r_2 = \dfrac{-b - \sqrt{b^2 - 4ac}}{2a}$. Notice the similarity between the solutions for r_1 and r_2. The program below permits you to key the values for a, b, and c beneath user-definable keys A, B, and C; the resultant roots r_1 and r_2 are available by pressing D and E. Were you to record this program on a magnetic card, the card might look like this:

Here is a complete program for calculating the two roots of a quadratic equation:

Input *a*

001	f LBL A
002	STO 1
003	h RTN

Input *b*

004	f LBL B
005	STO 2
006	h RTN

Input *c*

007	f LBL C
008	STO 3
009	h RTN

Calculate r_1

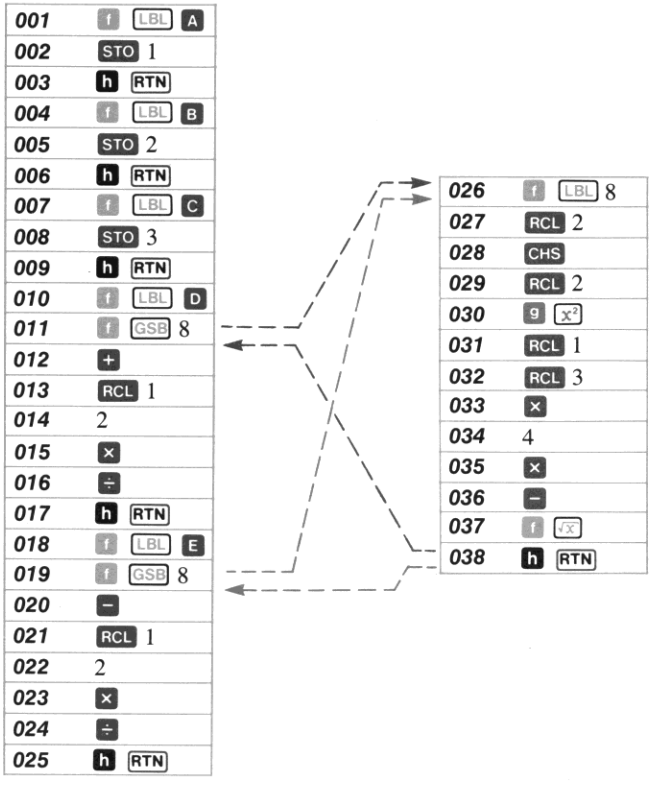
010	f LBL D
011	RCL 2
012	CHS
013	RCL 2
014	g x^2
015	RCL 1
016	RCL 3
017	×
018	4
019	×
020	−
021	f $\sqrt{x}$
022	+
023	RCL 1
024	2
025	×
026	÷
027	h RTN

These sections of program memory are identical.

Calculate r_2

028	f LBL E
029	RCL 2
030	CHS
031	RCL 2
032	g x^2
033	RCL 1
034	RCL 3
035	×
036	4
037	×
038	−
039	f $\sqrt{x}$
040	−
041	RCL 1
042	2
043	×
044	÷
045	h RTN

Since the routine for calculating r_1 contains a large section of program memory that is identical to a large section in the routine for calculating r_2, you can simply create a *subroutine* that will execute this section of instructions. The subroutine is then called up and executed in both the solution for r_1 and the solution for r_2:



With the modified program, when you press D, execution begins with the LBL D instruction in step 010. When the GSB 8 instruction in step 011 is encountered, execution transfers to LBL 8 in step 026 and computes the quantities $-b$ and $\sqrt{b^2 - 4ac}$, placing them in the X- and Y-registers of the stack, ready for addition or subtraction. When the RTN instruction in step 038 is encountered, execution transfers back to the main routine and continues with the + instruction in step 012. Thus the root r_1 is computed and displayed, and the routine stops with the RTN in step 017.

When you press E, execution begins with LBL E, transfers out to execute the LBL 8 subroutine, and returns. This time $\sqrt{b^2 - 4ac}$ is *subtracted* from $-b$, and root r_2 is computed. By using a subroutine, seven steps of program memory are saved!

To key in the program and the subroutine:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	Stores a in R_1.
STO 1	002 33 01	
h RTN	003 35 22	
f LBL B	004 31 25 12	Stores b in R_2.
STO 2	005 33 02	
h RTN	006 35 22	
f LBL C	007 31 25 13	Stores c in R_3.
STO 3	008 33 03	
h RTN	009 35 22	
f LBL D	010 31 25 14	Calculates $\frac{-b + \sqrt{b^2 - 4ac}}{2a} = r_1$.
f GSB 8	011 31 22 08	
+	012 61	
RCL 1	013 34 01	
2	014 02	
×	015 71	
÷	016 81	
h RTN	017 35 22	

Press	Display	
f LBL E	018 31 25 15	Calculates $\frac{-b - \sqrt{b^2 - 4ac}}{2a} = r_2$.
f GSB 8	019 31 22 08	
−	020 51	
RCL 1	021 34 01	
2	022 02	
×	023 71	
÷	024 81	
h RTN	025 35 22	
f LBL 8	026 31 25 08	Subroutine places $-b$ in Y-register and $\sqrt{b^2 - 4ac}$ in X-register, ready for addition or subtraction.
RCL 2	027 34 02	
CHS	028 42	
RCL 2	029 34 02	
g x^2	030 32 54	
RCL 1	031 34 01	
RCL 3	032 34 03	
×	033 71	
4	034 04	
×	035 71	
−	036 51	
f $\sqrt{x}$	037 31 54	
h RTN	038 35 22	

To initialize the program, you key in a and press A, key in b and press B, and key in c and press C. Then, to find root r_1, press D. To find root r_2, press E.

Run the program now to find the roots of the equation $x^2 + x - 6 = 0$; of $3x^2 + 2x - 1 = 0$.

To run the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
1 A	1.00	
1 B	1.00	
6 CHS C	-6.00	
D	2.00	Calculates the first root, r_1.
E	-3.00	Calculates the second root, r_2.
3 A	3.00	
2 B	2.00	
1 CHS C	-1.00	
D	0.33	Calculates r_1.
E	-1.00	Calculates r_2.

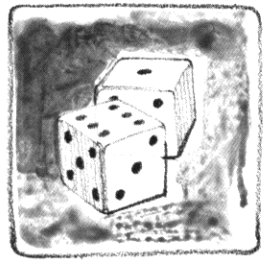
If the quantity $b^2 - 4ac$ is a negative number, the calculator will display Error and the running program will stop. For a more efficient and accurate method of finding the roots of a quadratic equation, see the Polynominal Evaluation program in your *HP-67 Standard Pac*.

Note: When loading instructions into the calculator in W/PRGM mode, you can load an f GSB A through E or a g GSB f a through e instruction by simply pressing the appropriate user-definable key(s). For example, to load the instruction f GSB A, you can simply press A; the keycode for f GSB A, 31 22 11, will appear in the display. For clarity and ease of reference, however, the complete keystroke sequence is always shown in this handbook.

Routine-Subroutine Usage

Subroutines give you extreme versatility in programming. A subroutine can contain a loop, or it can be executed as part of a loop. Another common and space-saving trick is to use the same routine both as a subroutine and as part of the main program.

Example: The program below simulates the throwing of a pair of dice, pausing to display first the value of one die (an integer from 1 to 6) and then pausing to display the value of the second die (another integer from 1 to 6). Finally the values of the two dice are added together to give the total value.



The "heart" of the program is a random number generator (actually a pseudo random number generator) that is executed first as a subroutine and then as part of the main program. When you key in a first number, called a "seed", and press A, the digit for the first die is generated and displayed using the f e routine as a subroutine. Then the digit for the second die is generated using the same routine as part of the main program.

To key in the program:

Slide the Program Mode switch W/PRGM RUN to W/PRGM.

Press	Display	
f CL PRGM	000	
f LBL A	001 31 25 11	
f CL REG	002 31 43	
STO 0	003 33 00	
g GSB f e	004 32 22 15	e executed first as subroutine.

g LBL f e	005 32 25 15	
RCL 0	006 34 00	
9	007 09	
9	008 09	
7	009 07	
×	010 71	
g FRAC	011 32 83	
STO 0	012 33 00	
6	013 06	
×	014 71	e then executed as a
1	015 01	routine.
+	016 61	
f INT	017 31 83	
DSP 0	018 23 00	
h PAUSE	019 35 72	
STO + 1	020 33 61 01	
RCL 1	021 34 01	
h RTN	022 35 22	

Now slide the W/PRGM-RUN switch to RUN and "roll" the dice with your HP-67. To roll the dice, key in a decimal "seed" (that is, $0 < n < 1$). Then press A. The calculator will display first the number rolled by the first die, then the number rolled by the second, and finally, when the program stops, you can see the total number rolled by the dice. To make another roll, key in a new seed and press A again.

You can play a game with your friends using the "dice." If your first "roll" is 7 or 11, you win. If it is another number, that number becomes your "point." You then keep "rolling" (keying in seeds and pressing A) until the dice again total your point (you win) or you roll a 7 or an 11 (you lose). To run the program:

Slide the Program Mode switch W/PRGM RUN to RUN.

Press	Display	
.2315478 A	10.	Your point is 10.
.3335897 A	5.	You missed your point.
.9987562 A	9.	Missed it again.
.9987563 A	10.	Congratulations! You win.

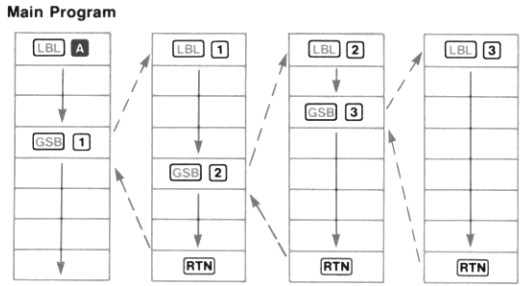
Now try it again.

Press	Display	
.21387963 A	4.	Your point is 4.
.6658975 A	7.	Whoops! You lose.

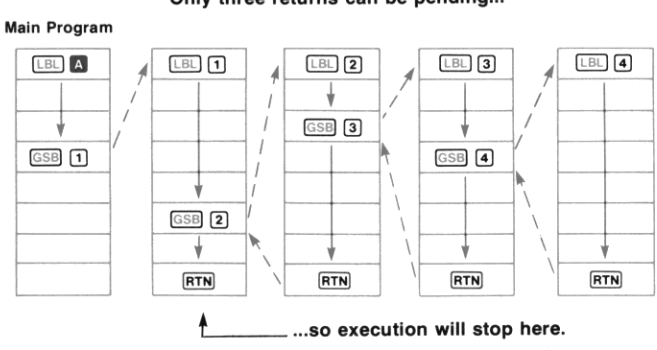
Subroutine Limits

A subroutine can call up another subroutine, and that subroutine can call up yet another. Subroutine branching is limited only by the number of *returns* that can be held pending by the HP-67. Three subroutine returns can be held pending at any one time in the HP-67. The diagram below should make this more clear.

Three returns can be pending.



The calculator can return back to the main program from subroutines that are three deep, as shown. However, if you attempt to call up subroutines that are four deep, the calculator will execute only three returns:



Naturally, the calculator can execute the RTN instruction as a stop any number of times. Also, if you press A through E, f a through f e, f GSB A through f GSB E, f GSB 0 through f GSB 9, or g GSB f a through g GSB f e from the *keyboard,* all *pending* RTN instructions are forgotten by the calculator.

If you are executing a program one step at a time with the SST key and encounter a GSB or GSB f instruction, the calculator will execute the entire subroutine before continuing to the next step. However, only one RTN instruction may be executed as the result of a GSB or GSB f instruction during single-step execution, so if a program contains a subroutine within a subroutine, execution will not return to the main program during SST execution.

Problems

1. Look closely at the program for finding roots r_1 and r_2 of a quadratic equation (page 200). Can you see other instructions that could be replaced by a subroutine? (Hint: look at steps 013 through 016 and steps 021 through 024.) Modify the program by using another subroutine and run it to find the roots of $x^2 + x - 6 = 0$; of $3x^2 + 2x - 1 = 0$.

   (Answers: 2, −3; 0.33, −1)

   How many more steps of program memory did you save?

2. The surface area of a sphere can be calculated according to the equation $A = 4\pi r^2$, where r is the radius. The formula for finding the volume of a sphere is $V = \frac{4\pi r^3}{3}$. This may also be expressed as $V = \frac{r \times A}{3}$.

   Create and load a program to calculate the area A of a sphere given its radius r. Define the program with [LBL] [A] and [RTN] and include an initialization routine to store the value of the radius. Then create and load a second program to calculate the volume V of a sphere, using the equation $V = \frac{r \times A}{3}$. Define this second program with [LBL] [B] and [RTN], and include the instruction [f] [GSB] [1] to use a portion of program [A] as a subroutine calculating area.

   Run the two programs to find the area and volume of the planet earth, a sphere with a radius of about 3963 miles. Of the earth's moon, a sphere with a radius of about 1080 miles.

   Answers: Earth area = 197359487.5 square miles
   Earth volume = 2.6071188×10^{11} cubic miles
   Moon area = 14657414.69 square miles
   Moon volume = 5276669290 cubic miles

3. Create, load, and run a program that will display all permutations of any three integers that you have stored in registers R_1, R_2, and R_3. For example, all permutations of the integers 1, 2, and 3 might be displayed as:

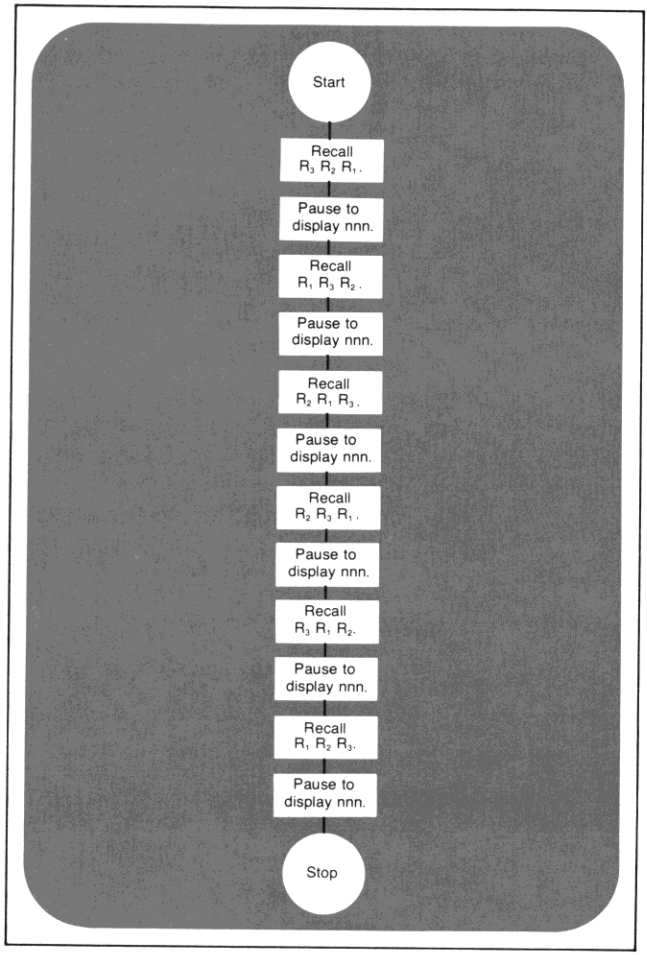
123
132
213
231
312
321

The following subroutine will cause the digits you recall from R_1, R_2, and R_3 to be displayed as a permutation in the order you have recalled them. Use the subroutine and the flowchart on the following page to help you create and load the program.

f LBL 1
1
0
0
×
h x≷y
1
0
×
h R↓
+
+
h PAUSE
h RTN

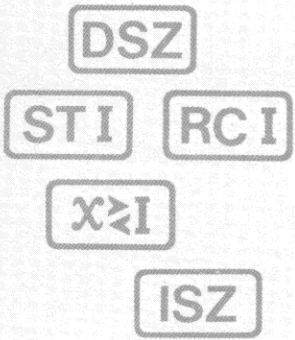
This subroutine pauses to display numbers recalled into the Z-, Y-, and X-registers of the stack as *nnn*.

The program should recall the contents of storage registers R_1, R_2, and R_3 into the Z-, Y-, and X-registers of the stack and then use the "display *nnn*" subroutine to show them in the order that they are recalled.


Start
Recall
R3 R2 R1.
Pause to
display nnn.
Recall
R1 R3 R2.
Pause to
display nnn.
Recall
R2 R1 R3.
Pause to
display nnn.
Recall
R2 R3 R1.
Pause to
display nnn.
Recall
R3 R1 R2.
Pause to
display nnn.
Recall
R1 R2 R3.
Pause to
display nnn.
Stop

When you have created and loaded the program, store the digits 5, 7, and 9 into storage registers R_1, R_2, and R_3, respectively. Then run the program to show all the permutations of these three numbers.

Answer: 579
795
957
597
759
975


DSZ
ST I
RC I
X≷I
ISZ

Section 11

Controlling the I-Register

The I-register is one of the most powerful programming tools available to you on your HP-67. In a preceding section, Storing and Recalling Numbers, you learned about the use of the I-register as a simple storage register, similar to registers R_0 through R_9, R_A through R_E, and R_{S0} through R_{S9}. And of course, you can always use the I-register this way, as another storage register, whether you are using it as an instruction in a program or operating manually from the keyboard.

Using the instructions [STO] [I], [(i)], and [x≷I] in conjunction with other instructions, you can specify the storage register addresses of [STO] and [RCL], the label addresses of [GTO], [GSB], and [GSB f], or the number of digits displayed by the [DSP] instruction. By storing a negative number in the I-register, you can even transfer execution to any step number of program memory. The [ISZ] and [DSZ] instructions permit you to increment (add 1 to) or decrement (subtract 1 from) the current value in I, while [ISZ (i)] and [DSZ (i)] allow you to increment or decrement *any* storage register. These are features that you will find extremely useful in controlling loops.

Storing a Number in I

To store a number in the I-register, you can use the [h] [STO] [I] operation. For example, to store the number 7 in the I-register:

Ensure that the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN is set to RUN.

Press	Display
7 [h] [STO] [I]	7.00

To recall a number from the I-register into the displayed X-register, you use h [RCI]:

Press	Display	
[CLx]	0.00	
h [RCI]	7.00	The number stored in I is recalled.

Exchanging x and I

In a manner similar to the [x⇄y] and [P⇄S] operations, the h [x⇄I] operation exchanges the contents of the displayed X-register with those of the I-register. For example, key the number 2 into the displayed X-register and exchange the contents of the X-register with those of the I-register now:

Press	Display	
2	2.	
h [x⇄I]	7.00	Contents of X-register and I-register exchanged.

When you pressed [x⇄I], the contents of the stack and the I-register were changed...

... from this ...			... to this.		
T	0.00		T	0.00	
Z	0.00		Z	0.00	
Y	7.00		Y	7.00	
X	2.00	Display	X	7.00	Display
	7.00	I		2.00	I

To restore the X-register and I-register contents to their original positions:

Press	Display
h [x⇄I]	2.00

Incrementing and Decrementing the I-Register

You have seen how a number can be stored in the I-register and then changed, either by storing another number there, or by using the h [x≷I] operation.

You will find either of these methods useful, whether you are utilizing them as instructions in a program or using them manually from the keyboard.

Another way of altering the contents of the I-register, and one that is most useful during a program, is by means of the f [ISZ] *(increment I, skip if zero)* and f [DSZ] *(decrement I, skip if zero)* instructions. These instructions either add the number 1 to (increment) or subtract the number 1 from (decrement) the I-register each time they are executed. In a running program, if the number in the I-register has become zero, program execution *skips* the next step after the [ISZ] or [DSZ] instruction and continues execution (just like a false conditional instruction).

The f [ISZ] and f [DSZ] instructions always increment or decrement first; *then* the test for zero is made. For test purposes, numbers between but not including −1 and +1 are the same as zero.

Example: Here is a program that illustrates how f [ISZ] works. It contains a loop that pauses to display the current value in the I-register, then uses the f [ISZ] instruction to increment that value. The program will continue to run, continually adding one to and displaying the contents of the I-register, until you press [R/S] (or any key) from the keyboard.

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f [CL PRGM]	000	
f [LBL] A	001 31 25 11	
h [RCI]	002 35 34	Recalls I-register contents.
h [PAUSE]	003 35 72	Pauses to display contents.

Press	Display	
f ISZ	004 31 34	Adds 1 to I-register.
GTO A	005 22 11	If contents of I-register are not zero, execution transfers back to LBL A.
1	006 01	If contents of I-register are zero, 1 is placed in I-register.
h STI	007 35 33	
GTO A	008 22 11	
h RTN	009 35 22	

Now run the program beginning with a value of 0 in the I-register. Stop the program after five iterations or so by pressing R/S.

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
0 h STI	0.00	Zero stored in I-register.
A	0.00	
	1.00	
	2.00	
	3.00	
	4.00	
R/S	5.00	

Although the ISZ and DSZ instructions increment and decrement the I-register by 1, the value of the I-register need not be a whole number.

For example:

Press	Display
5.28 CHS h STI	-5.28
A	-5.28
	-4.28
	-3.28
	-2.28
	-1.28
R/S	1.00

In practice, you will find that you will usually use [ISZ] and [DSZ] with numbers that are integers, since these instructions are most useful as counters—that is, to control the number of iterations of a loop—and to select storage registers, subroutines, or display settings. (More about using the I-register as a selection register later.)

The [DSZ] *(decrement I, skip if zero)* instruction operates in the same manner as the increment instruction, except that it subtracts, rather than adds, one each time it is used. When a running program executes an [f] [DSZ] instruction, for example, it subtracts 1 from the contents of the I-register, then tests to see if the I-register is 0. (A number between +1 and −1 tests as zero.) If the number in the I-register is greater than zero, execution continues with the next step of program memory. If the number in the I-register *is* zero, the calculator skips one step of program memory before resuming execution.

Example: The island of Manhattan was sold in the year 1624 for $24.00. The program on the next page shows how the amount would have grown each year if the original amount had been placed in a bank account drawing 5% interest compounded annually. The number of years for which you want to see the amount is stored in the I-register, then the [DSZ] instruction is used to keep track of the number of iterations through the loop.

Were you to prepare a magnetic card to store this program, it might look like this:

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	Initialization routine.
h STI	002 35 33	
1	003 01	
6	004 06	
2	005 02	
4	006 04	
STO 1	007 33 01	
2	008 02	
4	009 04	
STO 2	010 33 02	
h RTN	011 35 22	
f LBL B	012 31 25 12	Counting loop, controlled by I-register and DSZ.
RCL 2	013 34 02	
5	014 05	
f %	015 31 82	
STO + 2	016 33 61 02	
1	017 01	
STO + 1	018 33 61 01	
f DSZ	019 31 33	
GTO B	020 22 12	
RCL 1	021 34 01	◄When value in I becomes zero, execution skips to here, and year and amount are displayed.
DSP 0	022 23 00	
h PAUSE	023 35 72	
RCL 2	024 34 02	
DSP 2	025 23 02	
h PAUSE	026 35 72	
h RTN	027 35 22	

To run the program, key in the number of years for which you want to see the amount. Press [A] to store the number of years in the I-register and otherwise initialize the program. Then press [B] to run the program.

For example, to run the program to find the amount of the account after 5 years; after 15 years:

Slide the W/PRGM-RUN switch W/PRGM ▬▬ RUN to RUN.

Press	Display	
5 [A]	24.00	Program initialized.
[B]	1629.	
	30.63	After five years, in 1629, the account would have been worth $30.63.
15 [A]	24.00	Program initialized.
[B]	1639.	
	49.89	After 15 years, in 1639, the account would have been worth $49.89.

How it works: When you key in the number of years and initialize the program by pressing [A], the number of years is stored in the I-register by the [STI] instruction. The year (1624) is stored in primary storage register R_1, and the amount ($24.00) is stored in primary storage register R_2.

When you then press [B], calculation begins. Each time through the loop, 5% of the amount is computed and added to the amount in R_2, and one (1) year is added to the year in R_1. The [DSZ] instruction subtracts one from the I-register; if the value in I is not then zero, execution is transferred back to [LBL] [B] and the loop is executed again.

The loop continues to be executed until the value in the I-register becomes zero. Then execution skips to the [RCL] 1 instruction in program memory step 021. Execution continues sequentially downward from step 021, recalling the current year from R_1 and formatting and displaying it, then recalling the current amount from R_2 and formatting and displaying that following the year.

To see what the amount in the account would be in 1976, you can key in the number of years from 1624 to 1976 (the number is 352) and initialize and run the program. (This will take 4-5 minutes to run, plenty of time to go get a cup of coffee.)

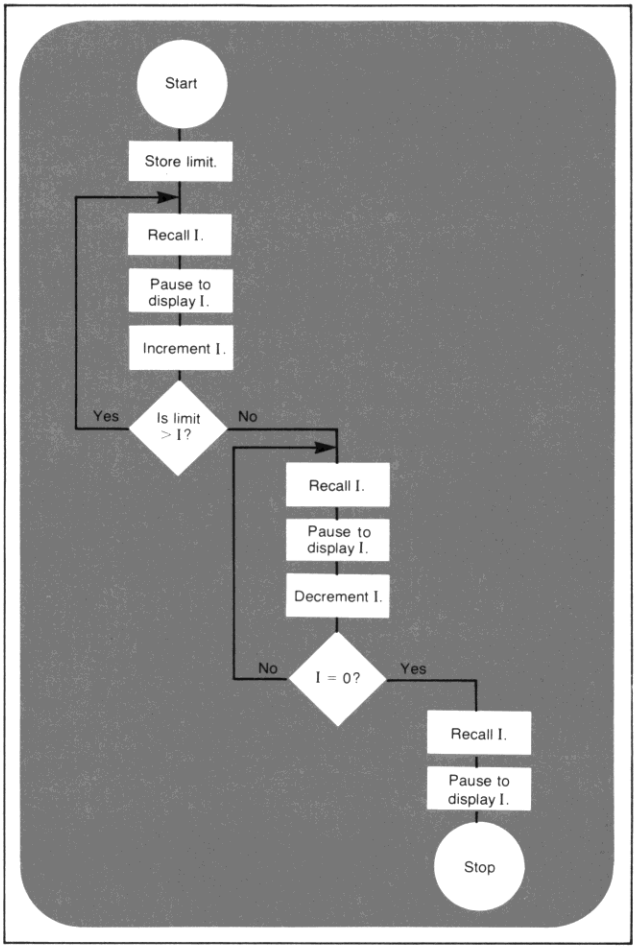
Problems

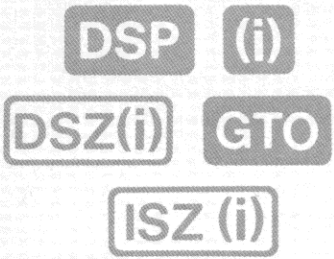
1. When you press [A], the program below stores in primary register R_9 a number that you have keyed in, then decrements the value in R_9 using storage register arithmetic. Each time through the loop, the program pauses to show the current value in R_9. When the value in R_9 reaches zero, the program stops. Write, load, and run a program that uses the I-register and [f] [DSZ] instead of R_9 and [f] [X≠0] to give the same results.

[f] [LBL] [A]
[STO] 9
[f] [LBL] 1
[h] [PAUSE]
1
[STO] [−] 9
[RCL] 9
[f] [X≠0]
[GTO] 1
[h] [RTN]

2. Write and load a program using [ISZ] to illustrate how an initial deposit of $1000 would grow year-by-year at a yearly compound interest rate of 5.5%. The program should display the current year (and subsequent years), followed by the value of the account for each year. The program should contain an infinite loop that you can stop by pressing [R/S] from the keyboard whenever you wish. Run the program to display the years and amounts for at least 5 years.

3. Write, load, and run a program that will count from zero *up* to a limit using the [ISZ] instruction, and then count back down to zero using the [DSZ] instruction. The program can contain two loops, and it can contain a conditional instruction besides the [ISZ] and [DSZ] instructions. Use the flowchart on page 221 to help you.


Start
Store limit.
Recall I.
Pause to display I.
Increment I.
Is limit > I?
Yes
No
Recall I.
Pause to display I.
Decrement I.
I = 0?
No
Yes
Recall I.
Pause to display I.
Stop


DSP
(i)
DSZ(i)
GTO
ISZ (i)

Section 12

Using the I-Register for Indirect Control

You have seen how the value in the I-register can be altered using the [STO], [x≷I], [ISZ] and [DSZ] operations. But the value contained in the I-register can also be used to *control* other operations. The [(i)] *(indirect)* function combined with certain other functions allows you to control those functions using the current number in the I-register. [(i)] uses the number stored in the I-register as an *address*.

The indirect operations that can be controlled by the I-register are:

[DSP] [(i)], when the number in the I-register is 0 through 9, changes display formatting so that the number in the display contains the number of decimal places specified by the current number in the I-register.

[STO] [(i)], when the number in the I-register is 0 through 25, stores the value that is in the display in the primary or secondary storage register addressed by the current number in the I-register.

[RCL] [(i)], when the number in the I-register is 0 through 25, recalls the contents of the primary or secondary storage register addressed by the current number in the I-register.

[STO] [+] [(i)], [STO] [−] [(i)], [STO] [×] [(i)], and [STO] [÷] [(i)], when the number in the I-register is 0 through 25, perform storage register arithmetic upon the contents of the primary or secondary storage register addressed by the current number in the I-register.

[g] [ISZ (i)], when the number in the I-register is 0 through 25, increments (adds 1 to) the contents of the primary or secondary storage register addressed by the current number in the I-register. In a running program, one step is skipped if the contents of the addressed register are then zero.

g DSZ(i), when the number in the I-register is 0 through 25, decrements (subtracts 1 from) the contents of the primary or secondary storage register addressed by the current number in the I-register. In a running program, one step is skipped if the contents of the addressed register are then zero.

GTO (i), when the number in the I-register is 0 or a positive 1 through 19, transfers execution of a running program sequentially downward through program memory to the next label specified by the current number in the I-register.

GTO (i), when the number in the I-register is a negative number between −1 and −999, transfers execution of a running program *back* in program memory the number of steps specified by the current negative number in the I-register.

f GSB (i), when the number in the I-register is 0 through 19, transfers execution of a running program to the subroutine specified by the current number in the I-register. Like a normal subroutine, when a RTN is then encountered, execution transfers forward and continues with the step following the GSB (i) instruction.

f GSB (i), when the number in the I-register is a negative number between −1 and −999, transfers execution of a running program *back* in program memory the number of steps specified by the current negative number in the I-register. Execution from that point is like a normal subroutine, so if a RTN instruction is then encountered, execution is transferred once again, this time to the next instruction after the GSB (i).

If the number in the I-register is outside the specified limits when the calculator attempts to execute one of these operations, the display will show *Error* . When using (i), DSZ(i), or ISZ (i), the calculator uses for an address only the integer portion of the number currently stored in the I-register. Thus, 25.99998785 stored in the I-register retains its full value there, but when used as address (i), it is read as 25 by the calculator.

> In all cases using the (i) *(indirect)* function, the HP-67 looks at only the integer portion of the current number stored in the I-register.

You can already see that using the I-register and (i), ISZ (i), and DSZ (i) in conjunction with these other functions gives you a tremendous amount of computing power and exceptional programming control. Now let's have a closer look at these operations.

Indirect Display Control

You can use the current number in the I-register in conjunction with the DSP key to control the number of decimal places to which a number is displayed. When DSP (i) is performed, the display is seen rounded to the number of decimal places specified by the current value contained in the I-register. (The display is *seen* rounded, but of course, the calculator maintains its full accuracy, 10 digits multiplied by 10 raised to a two-digit exponent, internally.) The number in the I-register can be any value, positive or negative, from 0 through 9. The DSP (i) operation is most useful as part of a program, but it can also be executed manually from the keyboard.

For example:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
5 h STI	5.00	
CL x	0.00	Normal FIX 2 display.
DSP (i)	0.00000	FIX 5 display specified because of the number 5 that is stored in the I-register.
9 h STI	9.00000	
DSP (i)	9.000000000	FIX 9 display selected by the number in the I-register.

Thus, by controlling the number in the I-register, you can control many different display options with very few instructions in a program.

Example: The following program pauses and displays an example of each display format that is available on your HP-67. It utilizes a subroutine loop containing the DSZ and DSP (i) instructions to automatically change the number of decimal places printed.

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	Initializes program.
CLx	002 44	
g SCI	003 32 23	Illustrates scientific notation.
f GSB B	004 31 22 12	
h ENG	005 35 23	Illustrates engineering notation.
f GSB B	006 31 22 12	
f FIX	007 31 23	Specifies fixed point notation.
f LBL B	008 31 25 12	
9	009 09	Initializes I-register to 9.
h STI	010 35 33	
f LBL 0	011 31 25 00	Sets displayed decimal places to current value in I-register.
h RCI	012 35 34	
DSP (i)	013 23 24	
h PAUSE	014 35 72	
f DSZ	015 31 33	
GTO 0	016 22 00	
h RCI	017 35 34	
DSP (i)	018 23 24	
h PAUSE	019 35 72	
h RTN	020 35 22	

To run the program and see the types of display formatting available on your HP-67:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
A	9.000000000 00	Scientific notation.
	8.00000000 00	
	7.0000000 00	
	6.000000 00	
	5.00000 00	
	4.0000 00	
	3.000 00	
	2.00 00	
	1.0 00	
	0. 00	
	9.000000000 00	Engineering notation.
	8.00000000 00	
	7.0000000 00	
	6.000000 00	
	5.00000 00	
	4.0000 00	
	3.000 00	
	2.00 00	
	1.0 00	
	0. 00	
	9.000000000	Fixed point notation.
	8.00000000	
	7.0000000	
	6.000000	
	5.00000	
	4.0000	
	3.000	
	2.00	
	1.0	
	0.	
	0.	

If a number containing a fraction is stored in the I-register, DSP (i) reads only the integer portion of the number. Thus, the I-register can contain a number as large as 9.999999999, and the DSP (i) operation will still execute. For example:

Press	Display	
9.999999999	9.999999999	
h STI	10.	Display is rounded, but number maintains its original value inside the calculator.
f GSB 0	9.999999999	Since the HP-67 is now in FIX mode, executing the subroutine loop yields the illustration of fixed point notation.
	9.00000000	
	8.0000000	
	7.000000	
	6.00000	
	5.0000	
	4.000	
	3.00	
	2.0	
	1.	
	1.	

The HP-67 displays Error if the number in the I-register is greater than 9.999999999 when a DSP (i) instruction is executed. For example:

Press	Display
10 h STI	10.
f GSB 0	Error

As with all error conditions, pressing any key clears the error and returns to the display the last value present there before the error.

Press	Display
R/S	10.

By using DSP (i), you have tremendous versatility in the types of output formats your HP-67 produces. With DSP (i) instructions, for example, the width of a displayed number (that is, the number of characters displayed) can be made dependent on data.

Indirect Store and Recall

You can use the number in the I-register to address the 26 storage registers that are in your HP-67. When you press STO (i), the value that is in the display is stored in the storage register addressed by the number in the I-register. RCL (i) addresses the storage registers in a like manner, as do the storage register arithmetic operations STO + (i), STO − (i), STO × (i), and STO ÷ (i). (If you have forgotten the normal operation of the storage registers, or of storage register arithmetic, go back and review section 4, Storing and Recalling Numbers, in this handbook.)

When using STO (i), RCL (i), or any of the storage register arithmetic operations utilizing the (i) function, the I-register can contain numbers positive or negative from 0 through 25. The numbers 0 through 9 address primary storage registers R_0 through R_9, while numbers from 10 through 19 will address secondary storage registers R_{S0} through R_{S9}. (You do not have to use the P⇄S function with (i).) Numbers 20 through 24 address storage registers R_A through R_E, and with the number 25 in the I-register, (i) addresses the I-register itself!

The diagram on the following page should illustrate these addresses more clearly.

Primary Registers

		(i) Address
I		25
R_E		24
R_D		23
R_C		22
R_B		21
R_A		20

Secondary Registers

		(i) Address
R_{S9}		19
R_{S8}		18
R_{S7}		17
R_{S6}		16
R_{S5}		15
R_{S4}		14
R_{S3}		13
R_{S2}		12
R_{S1}		11
R_{S0}		10

	(i) Address
R_9	9
R_8	8
R_7	7
R_6	6
R_5	5
R_4	4
R_3	3
R_2	2
R_1	1
R_0	0

By using the calculator manually, you can easily see how STO (i) and RCL (i) are used in conjunction with the I-register to address the different storage registers:

Ensure that the W/PRGM-RUN switch W/PRGM RUN is set to RUN.

Press	Display	
CLx DSP 2	0.00	
f CL REG	0.00	Clears all storage registers, including the I-register, to zero.
f P≷S	0.00	
f CL REG	0.00	
5 h STI	5.00	Stores the number 5 in the I-register.
1.23 STO (i)	1.23	Stores the number 1.23 in the storage register addressed by the number in I—that is, storage register R_5.
24 h STI	24.00	This number stored in the the I-register.
85083 STO (i)	85083.00	This number stored in the storage register (R_E) addressed by the current number (24) in I.
12 h STI	12.00	Stores the number 12 in the I-register.
77 EEX 43	77. 43	
STO (i)	7.700000000 44	Stores the number 7.7×10^{44} in the storage register addressed by the number in I—that is, in secondary storage register R_{S2}.

Notice that the number was stored *directly* in secondary storage register R_{S2}. You do not have to use the P≷S function to access the secondary storage registers when using the (i) function.

To recall numbers that are stored in any register, you can use the RCL *(recall)* key followed by the number or letter key of the register address. (For secondary storage registers, use the P≥S function to exchange contents of the primary and secondary registers before using the RCL function.) However, when the address currently stored in the I-register is correct, you can recall the contents of a storage register by simply pressing (i) (or RCL (i)). For example:

Press	Display	
RCL 5	1.23	Contents of storage register R_5 recalled to displayed X-register.
(i)	7.700000000 44	Since the I-register still contains the number 12, this operation recalls the contents of the storage register (secondary register R_{S2}) addressed by the number 12.

By changing the number in the I-register, you change the address specified by STO (i) or RCL (i). For example:

Press	Display	
24 h STI	24.00	
RCL (i)	85083.00	Contents of storage register R_E recalled to displayed X-register.
5 h STI	5.00	
RCL (i)	1.23	Contents of storage register R_5 recalled to displayed X-register.

Storage register arithmetic is performed upon the contents of the register addressed by I by using STO + (i), STO − (i), STO × (i), and STO ÷ (i). Again, you can access any storage register, primary or secondary—you never have to use the P≥S function when using the I-register for addressing. For example:

Press	Display	
1 STO + (i)	1.00	One added to number in storage register (R_5) currently addressed by the I-register.

Press	Display
RCL (i)	2.23
2 STO × (i)	2.00
RCL (i)	4.46
CL x	0.00
RCL 5	4.46

Naturally, the most effective use of the I-register as an address for STO and RCL is in a program.

Example: The following program uses a loop to place the number representing its address in storage registers R_0 through R_9, R_{S0} through R_{S9}, and R_A through R_E. During each iteration through the loop, program execution pauses to show the current value of I. When I reaches zero, execution is finally transferred out of the loop by the f DSZ instruction and the program stops.

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display		
f CL PRGM	000		
f LBL A	001	31 25 11	Program initialized.
f CL REG	002	31 43	
f P≷S	003	31 42	
f CL REG	004	31 43	
2	005	02	
5	006	05	
h STI	007	35 33	
f LBL 1	008	31 25 01	Current value in I stored
h RCI	009	35 34	in storage register
STO (i)	010	33 24	addressed by (i).
h PAUSE	011	35 72	Pause to display current value of I.
f DSZ	012	31 33	Subtract one from value in I-register.
GTO 1	013	22 01	If I≠0, execute loop again.

h REG	014 35 74	Otherwise, display the contents of all the primary storage registers.
f P≷S	015 31 42	
h REG	016 35 74	
f P≷S	017 31 42	Restores contents of secondary storage registers for possible later calculations.
h RCL I	018 34 34	
h RTN	019 35 22	

When the program is run, it begins by clearing the storage registers and placing 25 in the I-register. Then execution begins, recalling the current value in the I-register and storing that number in the corresponding address—for example, when the I-register contains the number 17, that number is recalled and stored in the storage register (R_{S7}) that is addressed by the number 17. Each time through the loop, the number in the I-register is decremented, and the result is used both as data and as an address by the STO (i) instruction. When the number in the I-register reaches zero, execution transfers out of the loop and the contents of all primary storage registers are displayed by the automatic register review function.

To run the program:

Slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

Press	Display
A	25.00
	24.00
	etc.
	0.00

Notice that the contents of the I-register have been decremented to zero.

You do not have to address secondary storage registers R_{S0} through R_{S9} indirectly by using STO (i) and RCL (i). In some cases, in fact, using the P≷S function in conjunction with STO (i) and RCL (i) can be a powerful programming tool, since you can use the same instructions to process two sets of data.

For example, suppose you had quantities A_1, A_2, A_3, A_4, A_5 stored in primary storage registers R_1 through R_5, and quantities B_1, B_2, B_3, B_4, and B_5 stored in secondary storage registers R_{S1} through R_{S5}.

If you wanted to find the average value of $\frac{A_1}{B_1} + \frac{A_2}{B_2} + \ldots \frac{A_n}{B_n}$

(where $n = 5$, in this case) you could use RCL (i) and ISZ in conjunction with the P≷S function as shown in the program below.

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display		
f CLPRGM	000		
f LBL C	001	31 25 13	
5	002	05	
h STI	003	35 33	Sets number of iterations through loop.
0	004	00	
STO 0	005	33 00	
f LBL 8	006	31 25 08	
RCL (i)	007	34 24	A_n and B_n brought into Y- and X-registers and displayed.
h PAUSE	008	35 72	
f P≷S	009	31 42	
RCL (i)	010	34 24	
h PAUSE	011	35 72	
÷	012	81	
f P≷S	013	31 42	Original contents of secondary storage registers restored to those registers.
STO + 0	014	33 61 00	Total stored and updated in register R_0.
f DSZ	015	31 33	

GTO 8	016 22 08	If, after decrementing, I has not reached zero, execute the loop again.
RCL 0	017 34 00	Otherwise, compute, format, and pause to display average, and stop.
5	018 05	
÷	019 81	
DSP 9	020 23 09	
f (-x-)	021 31 84	
DSP 2	022 23 02	
h RTN	023 35 22	

Now run the program for the following values of A and B.

A	73	81	97.6	115.9	244.8
B	21	47	68	102.88	179

First initialize the program by placing the values for *B* in secondary storage registers R_{S1} through R_{S5} and the values for *A* in corresponding primary registers R_1 through R_5. To initialize and run the routine:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display
21 STO 1	21.00
47 STO 2	47.00
68 STO 3	68.00
102.88 STO 4	102.88
179 STO 5	179.00

f P≥S	179.00
73 STO 1	73.00
81 STO 2	81.00
97.6 STO 3	97.60
115.9 STO 4	115.90
244.8 STO 5	244.80

Now press C to run the program and display the data and the average.

Press	Display	
C	244.80	Display A_5 and B_5.
	179.00	
	115.90	Display A_4 and B_4.
	102.88	
	97.60	
	68.00	
	81.00	
	47.00	
	73.00	Display A_1 and B_1.
	21.00	
	1.825808365	Display average in FIX 9.
	1.83	Display average in FIX 2.

Although for this illustration we stored the data manually before beginning, it would be a simple matter to create an initialization routine that, when loaded into the calculator, would permit you to key in data during a PAUSE instruction. The routine could use the STO (i) function to store the original data in the proper registers as you keyed it in.

Indirect Incrementing and Decrementing of Storage Registers

In section 11, you learned how to increment or decrement the I-register by using the instructions [ISZ] and [DSZ]. By using the number in the I-register as an *address*, the instructions [g] [ISZ (i)] and [g] [DSZ(i)] increment or decrement the contents of the *storage register* addressed by the number in I.

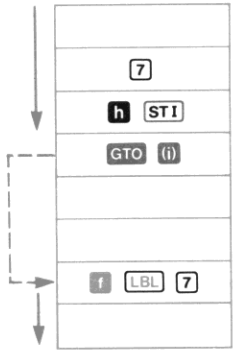
The indirect addressing of the storage registers for [ISZ (i)] and [DSZ(i)] is the same as that for [STO] [(i)], [RCL] [(i)], and storage register arithmetic using [(i)]. When using [ISZ (i)] and [DSZ(i)], the calculator looks at only the integer portion of the absolute value of the number stored in the I-register. An attempted [ISZ (i)] or [DSZ(i)] operation when the number in I is 26 or greater results in an error condition.

[ISZ (i)] and [DSZ(i)] function very similarly to [ISZ] and [DSZ]. When an [ISZ (i)] or [DSZ(i)] instruction is performed in a running program, the calculator first increments (adds 1 to) or decrements (subtracts 1 from) the contents of the storage register addressed by the number in the I-register. If the contents of the storage register addressed by the number in I are then zero (actually, if they are between -1 and $+1$), the calculator skips one step. If the contents of the storage register addressed are *not* then zero, execution continues with the next step of program memory after the [ISZ (i)] or [DSZ(i)] instruction.

Indirect Control of Branches and Subroutines

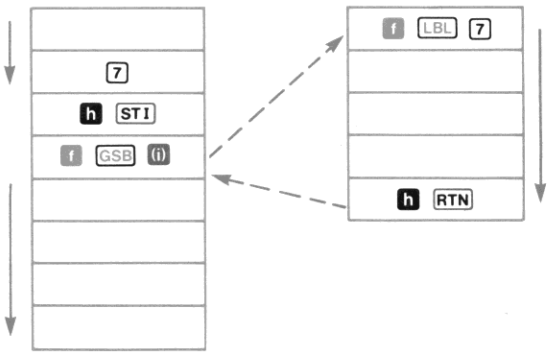
Like display control using [DSP] [(i)] and addressing of storage registers using [STO] [(i)] and [RCL] [(i)], you can address routines, subroutines, even entire programs, with the I-register.

To address a routine using the I-register, use the instruction [GTO] [(i)]. When a running program encounters a [GTO] [(i)] instruction, execution is transferred sequentially downward to the [LBL] that is addressed by the number in the I-register. Thus, with the number 7 stored in I, when the instruction [GTO] [(i)] is encountered, execution is transferred downward in program memory to the next [LBL] 7 instruction before resuming.



Naturally, you can also press GTO (i) from the keyboard to begin execution from the specified LBL.

Subroutines can also be addressed and utilized with the I-register. When GSB (i) is executed in a running program (or pressed from the keyboard), execution transfers to the specified LBL and executes the subroutine. When a RTN is then encountered, execution transfers back to the next instruction after the GSB (i) and resumes. For example, with the number 7 stored in the I-register, GSB (i) causes execution of the subroutine defined by LBL 7 and RTN.



The simple-to-remember addressing using the I-register is the same for GTO (i) and GSB (i). If the I-register contains zero or a positive number from 1 through 9, GTO (i) addresses LBL 0 through LBL 9. When the number in I is a positive 10 through 14, LBL A through

[LBL] [E] are addressed, while positive 15 through 19 address [LBL f] [a] through [LBL f] [e]. Label addressing is illustrated below.

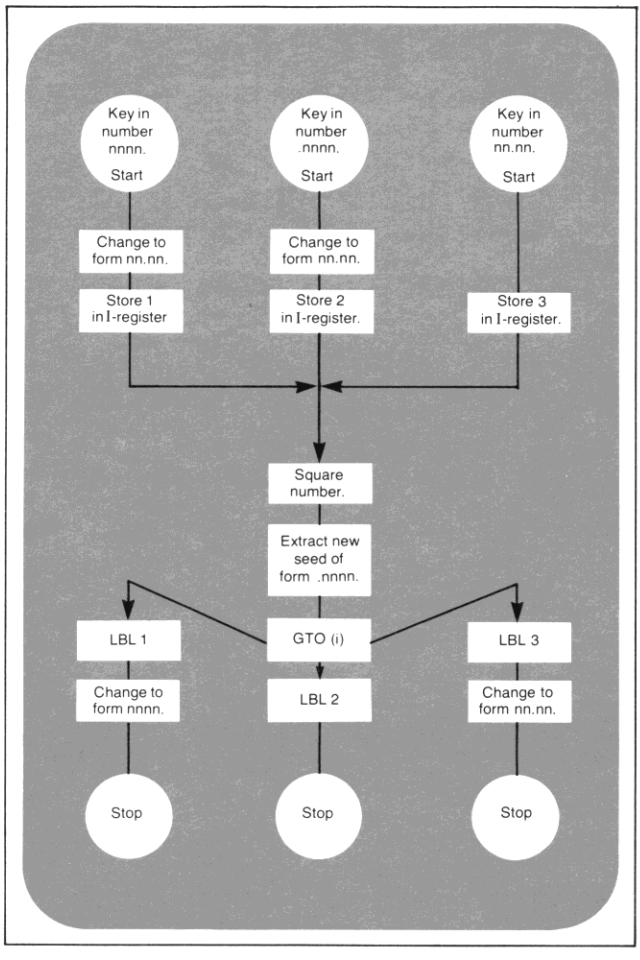
If the number in I is:	GTO (i) or GSB (i) transfers execution to:
0	f LBL 0
1	f LBL 1
2	f LBL 2
3	f LBL 3
4	f LBL 4
5	f LBL 5
6	f LBL 6
7	f LBL 7
8	f LBL 8
9	f LBL 9
10	f LBL A
11	f LBL B
12	f LBL C
13	f LBL D
14	f LBL E
15	g LBL f a
16	g LBL f b
17	g LBL f c
18	g LBL f d
19	g LBL f e

Remember that the numbers in the I-register must be positive or zero (negative numbers cause rapid reverse branching, which we will discuss later), and that the calculator looks at only the integer portion of the number in I when using it for an address.

Example: One method of generating pseudo random numbers in a program is to take a number (called a "seed"), square it, and then remove the center of the resulting square and square *that,* etc. Thus, a seed of 5182 when squared yields 26853124. A random number generator could then extract the four center digits, 8531, and square that value. Continuing for several iterations through a loop would generate several random numbers.

The following program uses the GTO (i) instruction to permit you to key in a four-digit seed in any of three forms: *nnnn*, *.nnnn*, or *nn.nn*. The seed is squared and the square truncated by the main part of the program, and the resulting four-digit random number is displayed in the form of the original seed: *nnnn*, *.nnnn*, or *nn.nn*.

A flowchart for the program might look like this:



The use of the GTO (i) instruction lets you select the operations that are performed upon the number after the main portion of the program.

By storing 1, 2, or 3 in the I-register depending upon the format of the seed, the program selects the form of the result after it is generated by the main portion of the program. Although the program shown here stops after each result, it would be a simple matter to create a loop that would iterate several times, increasing the apparent randomness of the result each time.

To key in the complete program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

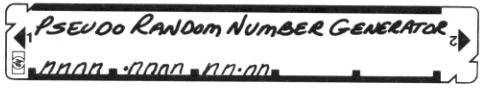
Press	Display	
f CLPRGM	000	
f LBL A	001 31 25 11	
EEX	002 43	
2	003 02	Changes *nnnn* to *nn.nn*.
÷	004 81	
1	005 01	Places 1 in X-register for storage in I.
GTO f d	006 22 31 14	
f LBL B	007 31 25 12	
EEX	008 43	
2	009 02	Changes *.nnnn* to *nn.nn*.
×	010 71	
2	011 02	Places 2 in X-register for storage in I.
GTO f d	012 22 31 14	
f LBL C	013 31 25 13	
3	014 03	Places 3 in X-register for storage in I.
g LBL f d	015 32 25 14	
h STI	016 35 33	Stores address of later operation in I.
h x≷y	017 35 52	Brings *nn.nn* to X-register.

g [x²]	018	32 54	Squares *nn.nn*.
EEX	019	43	Truncates two final digits of square.
2	020	02	
×	021	71	
f [INT]	022	31 83	
EEX	023	43	Truncates two leading digits of square.
4	024	04	
÷	025	81	
g [FRAC]	026	32 83	
GTO (i)	027	22 24	Transfers execution to appropriate operational routine.
f [LBL] 1	028	31 25 01	Result appears as *nnnn*.
EEX	029	43	
4	030	04	
×	031	71	
DSP 0	032	23 00	
h [RTN]	033	35 22	
f [LBL] 2	034	31 25 02	Result appears as *.nnnn*.
DSP 4	035	23 04	
h [RTN]	036	35 22	
f [LBL] 3	037	31 25 03	Result appears as *nn.nn*.
EEX	038	43	
2	039	02	
×	040	71	
DSP 2	041	23 02	
h [RTN]	042	35 22	

We could also have used a subroutine for the digits for 100 (that is, EEX 2) in steps 002-003, 008-009, 019-020, and 038-039, but we have used this more straightforward program to illustrate the use of the GTO (i) instruction.

When you key in a four-digit seed number in one of the three formats shown, an address (1, 2, or 3) is placed in the I-register. This address is used by the GTO (i) instruction in step 027 to transfer program execution to the proper routine so that the new random number is seen in the same form as the original seed.

Were you to record this program on a magnetic card, you might wish to mark your card so that it looked like this:



Now run the program for seeds of 5182, .5182 and 51.82. To run the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
5182 A	8531.	Random number generated in the proper form.
.5182 B	0.8531	
51.82 C	85.31	

The program generates a random number of the same form as the seed you keyed in. To use the random number as a new seed (simulating the operation of an actual random number generator, in which a loop would be used to decrease the apparent predictability of each succeeding number), continue pressing the appropriate user-definable key:

Press	Display	
C	77.79	Each succeeding number appears to be more random.
C	51.28	
C	29.63	

With a few slight modifications of the program, you could have used an f GSB (i) instruction instead of the GTO (i) instruction.

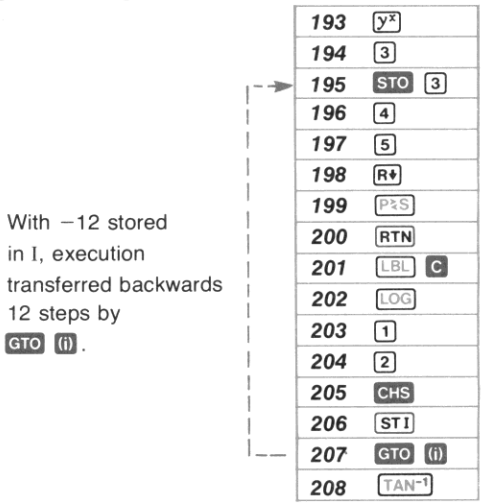
Rapid Reverse Branching

Using GTO (i) and GSB (i), with a negative number stored in I, you can actually branch to any *step number* of program memory.

As you know, when a GTO or GSB instruction is executed, the calculator does not execute further instructions until it has searched downward through program memory and located the next *label* addressed by GTO or GSB. When GTO (i) or f GSB (i) is executed in a running program, with 0 or a positive 1 through 19 stored in the I-register, the running program searches downward through program memory until it locates the next LBL addressed by the number in I. Then execution resumes.

With a *negative* number stored in the I-register, however, execution is actually transferred *backward* in program memory when GTO (i) or f GSB (i) is executed. The calculator does not search for a label, but instead transfers execution *backward* the number of steps specified by the negative number in the I-register. (This is advantageous because the search is often much faster than searching for a label, and because you can thus transfer execution even though all labels in the calculator have been used for other purposes.)

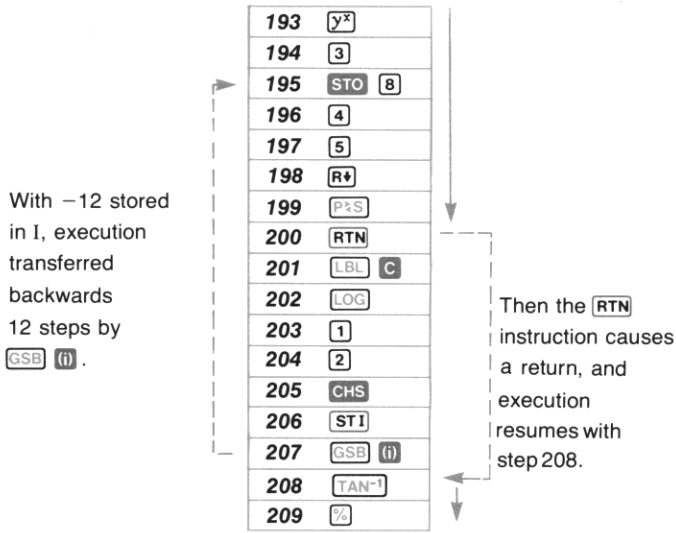
For example, in the section of program memory shown below, −12 is stored in the I-register. Then, when step 207, GTO (i) is executed, the running program jumps backward 12 steps through program memory to step 195 (that is, step 207 − 12 = 195), and execution resumes again with step 195 of program memory.



When GTO (i) has been performed in a running program, execution then continues until the next RTN or R/S instruction is encountered, whereupon the running program stops. Thus, if you pressed C with the instructions shown above loaded into the calculator, the instructions in steps 201 through 207 would be executed in order. Then the program would jump backward and execute step 195 next, continuing with 196, 197, etc., until the RTN instruction was encountered in step 200. The running program would then stop.

With a negative number stored in the I-register, f GSB (i) also transfers execution backward the number of steps specified by the number in I. However, subsequent instructions are then executed as a *subroutine,* so when the next RTN instruction is encountered, execution transfers back to the instruction following the GSB (i) instruction (just like a normal subroutine would be executed.)

The section of program memory below shows how GSB (i) operates. If you press C, −12 will be stored in the I-register. When f GSB (i) is then executed a running program jumps back 12 steps from step 207 and resumes execution with step 195. When the RTN *(return)* instruction in step 200 is encountered, execution returns and continues with step 208.

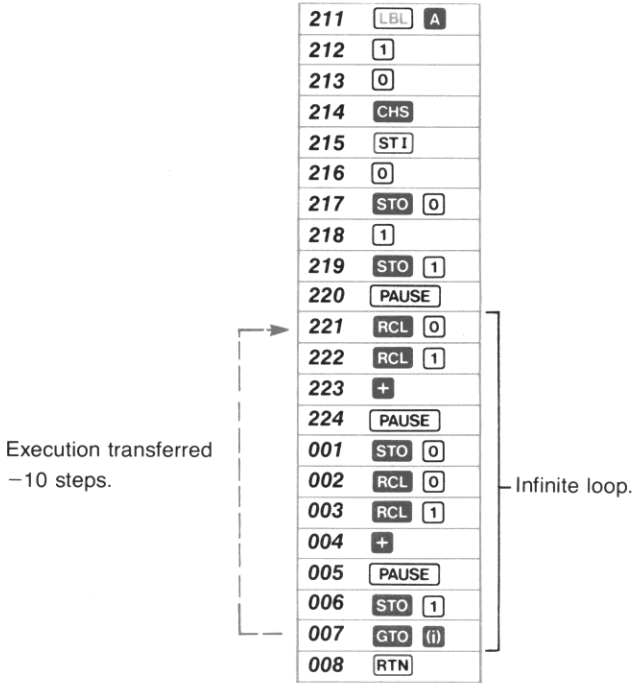


Rapid reverse branching using GTO (i) and f GSB (i) are extremely useful instructions as part of your programs. Rapid reverse branching permits you to transfer execution to *any* step number of program memory. With a negative number stored in the I-register, the resulting step number can always be found by combining the negative number in I with the step number of the GTO (i) or f GSB (i) instruction.

Execution can even be transferred backward past step 000. To find the resulting step number of program memory, find the sum of the negative number in the I-register and the step number containing the GTO (i) or GSB (i) instruction, then add 224. Thus, if the I-register contained −12 and a GTO (i) instruction were encountered in step 007, execution would be transferred to step 219 of program memory (7 − 12 + 224 = 219).

Example: Named after a 13th-century mathematician, the Fibonacci series is a series of numbers that expresses many relationships found in mathematics, architecture, and nature. (For example, in many plants, the proliferation of branches follows a series of Fibonacci numbers.) The series is of the form 0, 1, 1, 2, 3, 5, 8, 13 ..., where each element is the sum of the two preceding elements.

The program on page 248 contains an infinite loop that generates and displays the Fibonacci series. Although you normally would probably not set up a single routine that began in step 211 and continued through step 008, the routine illustrates how the GTO (i) instruction coupled with a negative number in the I-register can transfer program execution back in program memory, even past step 000.



When the program is run, steps 212 through 215 store −10 in the I-register. Thereafter, execution of the GTO (i) instruction in step 007 causes the running program to jump back 10 steps and resume execution with step 221 (that is, 007 − 10 + 224 = 221). Thus, an infinite loop is set up that generates and displays the Fibonacci series until you stop the program by pressing R/S (or any key) from the keyboard.

To load the complete program, you must first load the instructions in steps 001 through 008, then go to step 210 and load the instructions into steps 211 through 224. To load the program into the calculator:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CLPRGM	000	
STO 0	001	33 00
RCL 0	002	34 00
RCL 1	003	34 01
+	004	61
h PAUSE	005	35 72
STO 1	006	33 01
GTO (i)	007	22 24
h RTN	008	35 22

Now go to step 210 and continue loading instructions, beginning with the LBL A contained in step 211:

Press	Display		
GTO .210	210	84	Sets calculator at step 210.
f LBL A	211	31 25 11	
1	212	01	
0	213	00	
CHS	214	42	
h STI	215	35 33	
0	216	00	
STO 0	217	33 00	
1	218	01	
STO 1	219	33 01	
h PAUSE	220	35 72	
RCL 0	221	34 00	
RCL 1	222	34 01	
+	223	61	
h PAUSE	224	35 72	

Now switch to RUN mode and run the program. Press [R/S] (or any key) to stop the program after you have seen how quickly the Fibonacci series increases. To run the program:

Slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

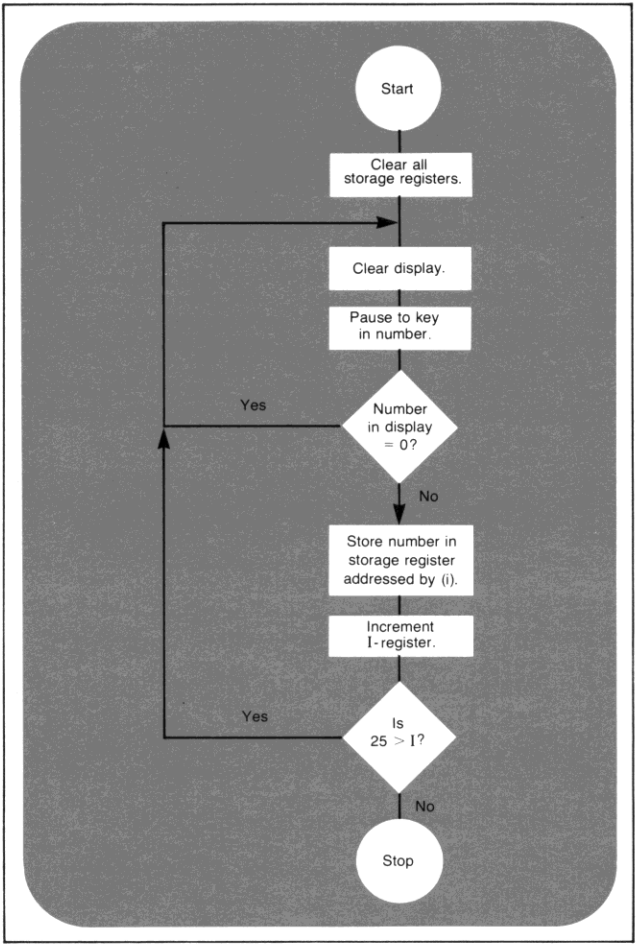
Press	Display
[A]	1.00
	1.00
	2.00
	3.00
	5.00
	8.00
	13.00
	21.00
	34.00
	55.00
	89.00
	144.00
	233.00
	377.00
[R/S]	610.00

Each element in the Fibonacci series is the sum of the previous two elements in the series.

Rapid reverse branching can be specified with numbers from −1 through −999 in the I-register. If the magnitude of the number in I is greater than 224, the search continues backward through program memory the number of steps specified. If you attempt to execute [GTO] [(i)] or [GSB] [(i)] when the magnitude of the integer portion of the negative number in I is greater than 999, the calculator displays Error.

Problems

1. a. Create and load a program using [ISZ] and [STO] [(i)] that permits you to key in a series of values during successive pauses. The values should be stored in storage registers R_0 through R_9, R_{S0} through R_{S9}, and R_A through R_E in the order you key them in. Use the flowchart on page 251 to help you.


Start
Clear all storage registers.
Clear display.
Pause to key in number.
Number in display = 0?
Yes
No
Store number in storage register addressed by (i).
Increment I-register.
Is 25 > I?
Yes
No
Stop

b. Now create and load a program immediately after the first one that will recall and display the contents of each storage register in reverse order (that is, display R_E first, then R_D, etc.). The program should stop running after it has displayed the contents of R_0.

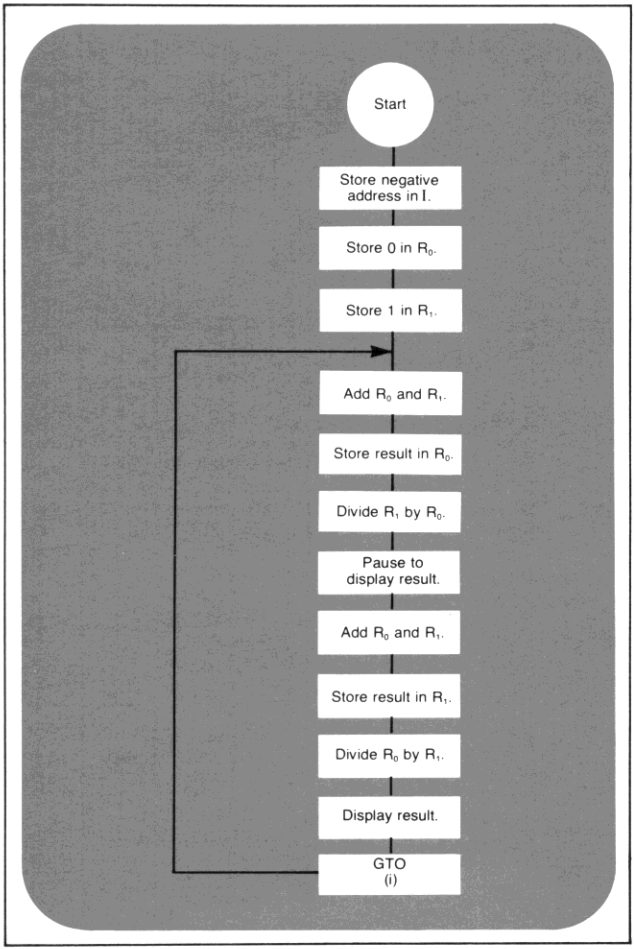
Run the program you loaded for Problem 1a, keying in a series of 25 different values. Then run the program you loaded for 1b. All 25 values should be shown, but the last one you keyed in should be the first displayed, etc.,

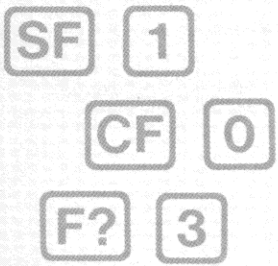
2. Modify the Random Number Generator program on pages 242-243 to use GSB (i) instead of GTO (i) for control. Run the program with the same seed numbers to ensure that it still runs correctly.

3. One curious fact about the Fibonacci series is that the quotients of successive terms converge to a common value. This value was known to the ancient Greeks as the "golden ratio" because it expressed the ideal ratio of width to length that gave the most aesthetically appealing building or room.

Create, load, and run a program that will yield this ideal ratio. You should be able to calculate and display each successive ratio (for example, 2/3, 3/5, 5/8, 8/13, etc.,) until the series converges to the value of the golden ratio. Create a loop by using the rapid reverse branching power of the GTO (i) instruction with a negative number in the I-register. Use the flowchart on page 253 to help you.

When you run the program and are satisfied that the golden ratio has been calculated, you can press R/S from the keyboard to stop the infinite loop. (The value of the golden ratio should be 0.618033989.)


Start
Store negative address in I.
Store 0 in R_0.
Store 1 in R_1.
Add R_0 and R_1.
Store result in R_0.
Divide R_1 by R_0.
Pause to display result.
Add R_0 and R_1.
Store result in R_1.
Divide R_0 by R_1.
Display result.
GTO (i)


SF 1
CF 0
F? 3

Section 13

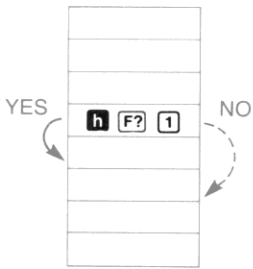
Flags

Besides the conditionals ([x=y], [x>0], etc.) and the tests for zero ([ISZ], [DSZ], [ISZ (i)], [DSZ(i)]), you can also use *flags* for tests in your programs. A flag actually is a memory device that can be either SET (true) or CLEAR (false). A running program can then *test* the flag later in the program and make a decision, depending upon whether the flag was set or clear.

There are four flags, F0, F1, F2, and F3, available for use in your HP-67. To set a flag true, use the instruction [SF] *(set flag)* followed by the digit key ([0], [1], [2], [3]) of the desired flag. The instruction [CF] *(clear flag)* is used to clear flags.

When using flags, decisions are made using the instruction [F?] *(is flag true?)* followed by the digit key ([0], [1], [2], [3]) specifying the flag to be tested. When a flag is tested by a [h] [F?] [n] instruction, the calculator executes the next step if the flag is set (this is the "DO if TRUE" rule again). If the flag is clear, the next step of program memory is skipped before execution resumes.

Is flag F1 true?



If YES, continue execution with next step.

If NO, skip one step before resuming execution.

Command-Cleared Flags

There are two types of flags. Flags F0 and F1 are *command-cleared flags*—that is, once they have been set by an h SF 0 or h SF 1 operation, they remain set until they are commanded to change by the h CF 0 or h CF 1 operations. Command-cleared flags are generally used to remember program status (e.g., are outputs desired?).

Test-Cleared Flags

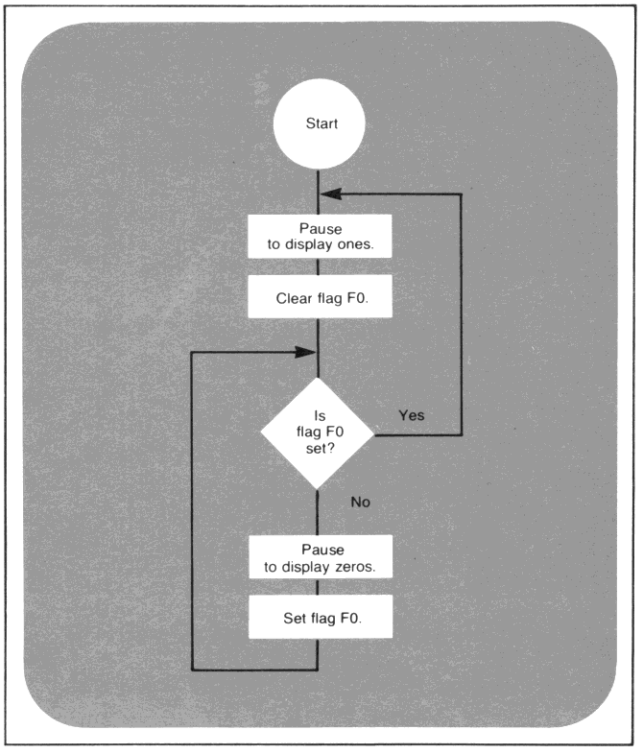
Flags F2 and F3 are *test-cleared flags*. They are cleared by a test operation. For example, if you had set flag F2 with an h SF 2 operation and then it was tested later in a program with an h F? 2 instruction, flag F2 would be cleared by the test—execution would continue with the next step of program memory (the "DO if TRUE" rule), but the flag would then be cleared and would remain cleared until it was set again. The test-cleared flags are used to save the h CF operation after a test. (However, test-cleared flags *can* be cleared by the h CF operation, if desired.)

Besides being a test-cleared flag, flag F3 alone is *set by digit entry*—that is, as soon as you key in a number from the keyboard, flag F3 is set. It is also set when the magnetic card reader is used to load data into the storage registers from a card. Even though you do not test or use flag F3 in a program, it is nevertheless set by digit entry from the keyboard or data loading from the magnetic card reader. Flag F3 is also set if the SST key is used in RUN mode to single step through a program that contains a digit entry as soon as the step containing the digit is reached.

All flags are cleared when the HP-67 is first turned ON or when f CLPRGM is pressed in W/PRGM mode.

Now look at the way these flags can be used in programs.

Example: The following program contains an infinite loop that illustrates the operation of a flag. (In this case, the flag used is command-cleared flag F0.) The program alternately displays all 1's and all 0's by changing the status of the flag, and hence, the result of the test in step 007, each time through the loop. A flowchart for the simple program might look like this:



The program assumes that you have the number 0 in storage register R_0 and the number 1.111111111 has been stored in storage register R_1.

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CL PRGM	000	
f LBL A	001 31 25 11	
DSP 9	002 23 09	Recalls and displays ones from register R_1.
RCL 1	003 34 01	
h PAUSE	004 35 72	
h CF 0	005 35 61 00	Clears flag F0.
f LBL B	006 31 25 12	
h F? 0	007 35 71 00	Test flag F0. If set (true), go to LBL A.
GTO A	008 22 11	
RCL 0	009 34 00	Otherwise, recall and display zeros from register R_0, set flag F0, and go to LBL B.
h PAUSE	010 35 72	
h SF 0	011 35 51 00	
GTO B	012 22 12	
h RTN	013 35 22	

Now switch to RUN mode and initialize and run the program. To run the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
0	0.	Initializes the program.
DSP 9	0.000000000	
STO 0	0.000000000	
1.111111111	1.111111111	
STO 1	1.111111111	

A	1.111111111 0.000000000	All ones and all zeros displayed alternately.

To stop the running program at any time, merely press R/S (or any key) from the keyboard.

How it works. After you have initialized the program by storing all zeros in register R_0 and all ones in register R_1, the program begins running when you press A. The RCL 1 and h PAUSE instructions in steps 003 and 004 pause to display all ones from storage register R_1. The h CF 0 instruction in step 005 clears flag F0. (Since the flag is already clear when you begin the program, the status of the flag simply remains the same.)

There is no RTN after the routine begun by LBL A, so execution continues through the LBL B instruction in step 006 to the test, h F? 0, in step 007. The h F? 0 instruction asks the question "Is flag F0 set (true)?" Since the flag has been cleared earlier, the answer is NO, and execution skips one step of program memory and continues with the RCL 0 instruction in step 009. The RCL 0 and h PAUSE instructions in steps 009 and 010 pause to display all zeros from register R_0. Flag F0 is then *set* by the h SF 0 instruction in step 011, and execution is transferred to LBL B by the GTO B instruction in step 012.

With flag F0 now set, the answer to the test h F? 0 ("Is flag F0 true?") is now YES, so the calculator executes the GTO A instruction in step 008, the next step after the test. After again pausing to display all zeros, the flag is cleared, and the program continues in an endless cycle, alternately displaying ones and zeros, until you stop execution from the keyboard.

The above program utilized one of the two command-cleared flags, so an h CF instruction was required to clear it each time. However, you should also be able to modify this program using one of the test-cleared flags, F2 or F3, and shorten the program, saving one step of memory.

Data Entry Flag

The data entry flag, flag F3, is a flag that is set for data entry and cleared upon test. These features of this flag can be used for interchangeable solutions in a program.

Example: The program below calculates the distance *(d)*, speed *(s)*, or time *(t)* for a moving body according to the following formulas:

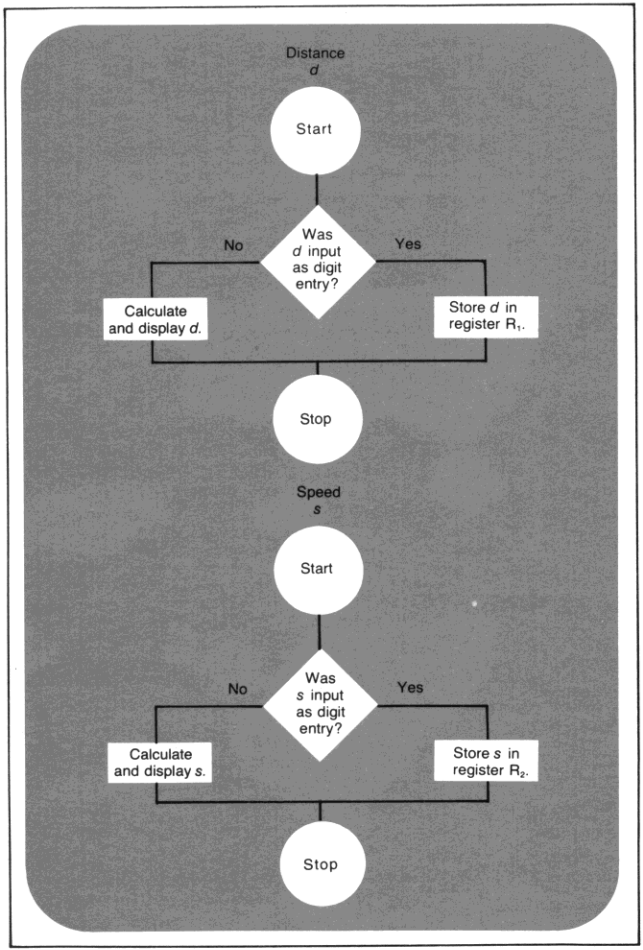
$$d = st \qquad \text{distance} = \text{speed} \times \text{time}$$

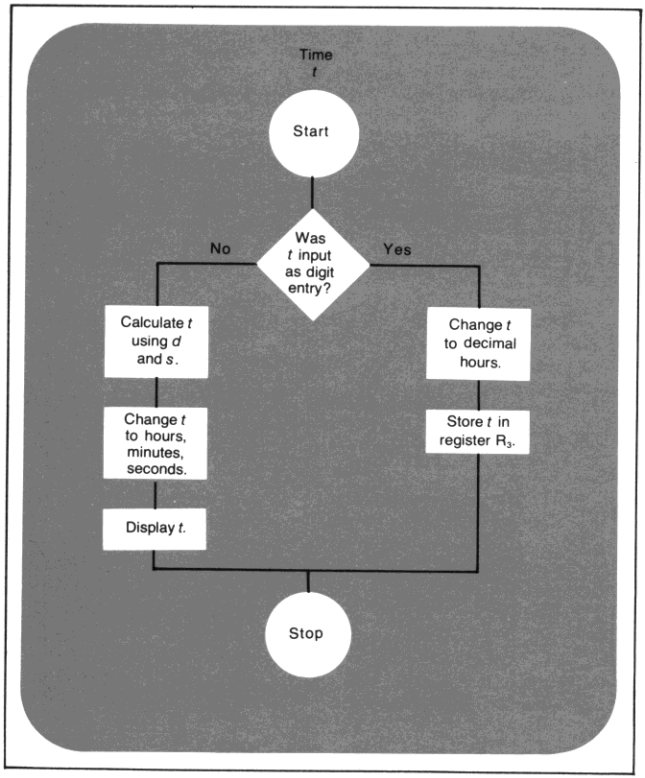
$$s = \frac{d}{t} \qquad \text{speed} = \text{distance} \div \text{time}$$

$$t = \frac{d}{s} \qquad \text{time} = \text{distance} \div \text{speed}$$

Given any two of the quantities *d*, *s*, and *t*, the program will calculate the third. The program uses the test-clearing feature of data entry flag F3 to decide whether to store a quantity away or to use previously stored quantities for calculation. If you recorded the program on a magnetic card, the card might look like this:

As you can see from the flowcharts shown on pages 261 and 262, when the user-definable key A, B, or C is pressed, a decision is made. If you have keyed in a value, that value is stored for further calculations. If you have not keyed in a value, the program calculates the desired quantity. The decision to store or to calculate is made depending upon whether the data entry flag, flag F3, is set or cleared.


Distance
d
Start
Was
d input
as digit
entry?
No
Yes
Calculate
and display d.
Store d in
register R1.
Stop
Speed
s
Start
Was
s input
as digit
entry?
No
Yes
Calculate
and display s.
Store s in
register R2.
Stop


Time
t
Start
Was
t input
as digit
entry?
No
Yes
Calculate t
using d
and s.
Change t
to hours,
minutes,
seconds.
Display t.
Change t
to decimal
hours.
Store t in
register R3.
Stop

To key in the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display	
f CL PRGM	000	
f LBL A	001 31 25 11	If digit entry flag set, distance is stored. If flag is cleared, distance is calculated.
1	002 01	
h STI	003 35 33	
h x≷y	004 35 52	
h F? 3	005 35 71 03	
GTO 1	006 22 01	
RCL 2	007 34 02	
RCL 3	008 34 03	
×	009 71	
f -x-	010 31 84	
h RTN	011 35 22	
f LBL B	012 31 25 12	If digit entry flag set, speed is stored. If flag is cleared, speed is calculated.
2	013 02	
h STI	014 35 33	
h x≷y	015 35 52	
h F? 3	016 35 71 03	
GTO 1	017 22 01	
RCL 1	018 34 01	
RCL 3	019 34 03	
÷	020 81	
f -x-	021 31 84	
h RTN	022 35 22	

Press	Display	
f LBL C	023 31 25 13	If digit entry flag set, time is stored. If flag is cleared, time is calculated.
h F? 3	024 35 71 03	
GTO 2	025 22 02	
RCL 1	026 34 01	
RCL 2	027 34 02	
÷	028 81	
g →H.MS	029 32 74	
f →X←	030 31 84	
h RTN	031 35 22	

f LBL 1	032 31 25 01	Routine to store distance or speed in appropriate storage register.
STO (i)	033 33 24	
h RTN	034 35 22	

f LBL 2	035 31 25 02	Routine to convert time from *hours, minutes, seconds* format to decimal hours for calculation.
f H↔	036 31 74	
STO 3	037 33 03	
h RTN	038 35 22	

Since the data entry flag F3 is also a test-cleared flag, it is cleared as soon as it is tested during each routine. Therefore, you do not have to use an h CF instruction in each routine to prepare the flag for a new case.

Running the program. At this writing, the world speed record for an aircraft over a straight course is 2070.101 miles per hour by a Lockheed YF12A. Run the program to find the time at this speed that it would take the aircraft to travel the 3500 miles from New York to London.

To run the program:

Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

Press	Display	
DSP 6	0.000000	Initializes program.
3500 A	3500.000000	
2070.101 B	2070.101000	
C	1.412666	The time would be 1 hour, 41 minutes, 26.66 seconds.

Now run the program to find out how far an automobile averaging 95 kilometers per hour could travel in 2 days.

Press	Display	
95 B	95.000000	
2 ENTER↑	2.000000	
24 ×	48.000000	
C	48.000000	
A	4560.000000	The automobile would travel 4560 kilometers.

The present Olympic record for the 1500-meter run is 3 minutes, 34.9 seconds, set at the 1968 Olympic Games by Kipchoge Keino of Kenya. What was Keino's speed in kilometers per hour?

(A kilometer is equal to 1000 meters, so key in the distance as 1.5 kilometers.)

Press	Display	
1.5 A	1.500000	Distance keyed in.
.03349 C	0.059694	Time converted to decimal hours.
B	25.127967	Keino's speed was about 25 kilometers per hour.

Notice in the above program how a flag can be used to make a decision and change the execution of a program based upon past events. Remember, too, that the status of any flag can be changed from the keyboard or from a running program.

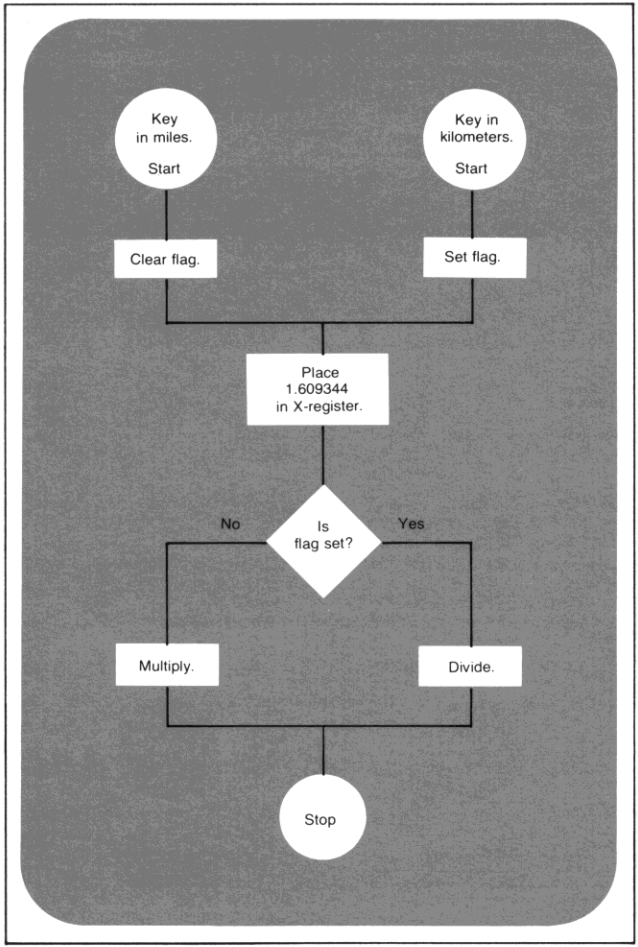
Problems

1. Modify the program on page 258 that alternately displays all zeros and all ones. Use test-cleared flag F2 or F3 instead of command-cleared flag F0. Your program should be one step shorter, since flags F2 and F3 clear when they are tested, and do not require an h CF instruction.

2. One mile is equal to 1.609344 kilometers. Use the flowchart on the opposite page to create and load a program that will permit you to key in distance in either miles (define the routine with f LBL B) or kilometers (define this routine with g LBL f b) and, using a flag and a subroutine, either multiply or divide to convert from one unit of measure to the other. (Hint: × h 1/x yields the same result as ÷.)

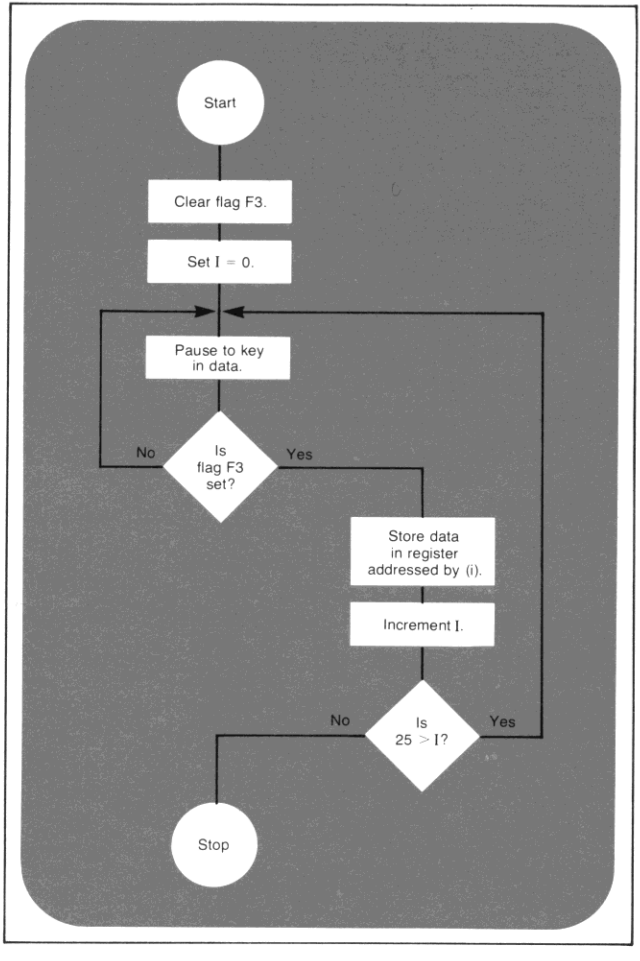
   Run the program to convert 26 miles into kilometers; to convert 1500 meters (1.5 kilometers) into miles.

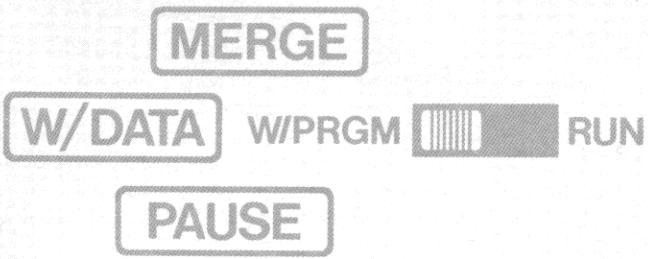
   (Answers: 41.84 kilometers; 0.93 miles.)


Key
in miles.
Start
Key in
kilometers.
Start
Clear flag.
Set flag.
Place
1.609344
in X-register.
No
Is
flag set?
Yes
Multiply.
Divide.
Stop

3. Create and load a program that stores in successive storage registers values that you key in during a pause. Use the data entry flag F3 to make a decision whether to store the number or merely to wait for another input. Use the flowchart on page 269 to help you. By using the data entry flag F3, you can key in values for zero and have them stored too.

   When you have loaded the program, run it to check its operation. You should be able to store up to 26 values (including values of zero) in succeeding storage registers. Manually recall a few random values from some of the storage registers to ensure that the program has operated correctly.


Start
Clear flag F3.
Set I = 0.
Pause to key in data.
Is flag F3 set?
No
Yes
Store data in register addressed by (i).
Increment I.
Is 25 > I?
No
Yes
Stop


MERGE
W/DATA
W/PRGM
RUN
PAUSE

Section 14

Card Reader Operations

The programs that you have manually loaded into the HP-67 can be preserved permanently on magnetic cards. In addition, data from the storage registers can also be preserved on magnetic cards. By using magnetic cards and the card reader in your HP-67 Programmable Pocket Calculator, you can increase the capability of your machine almost infinitely.

Magnetic Cards

The prerecorded magnetic cards and the blank cards that you received with your HP-67 and Standard Pac are all alike—the only difference is the information that is recorded upon them. Each card contains two sides, or tracks, where program information or data can be recorded.

Note: Whether passing side 1 or side 2 of the card through the card reader, always have the printed face of the card up.

Each side of the card is the same, and it does not matter which side is used first. In this handbook, we have adopted the convention of using side 1 first, then side 2; but as you will see, you can record onto or load from a magnetic card in any order you choose. Each side may contain either data *or* program information, but not both at once.

All magnetic cards are alike physically. Depending upon the type of information recorded upon it, however, a card may be considered a *program card,* a *data* card, or even a *mixed* card (where one side contains program information and the other side contains data).

Program Cards

Recording a Program onto a Card

A program that you have loaded into the HP-67 is not permanent—it will be lost when you turn off the calculator. You can, however, save any program permanently by recording it on a magnetic card.

To record a loaded program from program memory onto a magnetic card:

1. Set the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.
2. Select a blank, unprotected (unclipped) magnetic card from the packet of blank cards shipped with your HP-67.
3. Pass side 1 of the card through the card reader exactly as you did when loading a prerecorded program from the card to the calculator.

   a. If the program fills up only 112 steps or fewer of program memory, the contents of *all* of program memory (that is, the program instructions in steps 001 through 112 and the [R/S] instructions in steps 113 through 224) are recorded on side 1 of the card, steps 113 through 224 in a "compressed" form. The calculator displays the current program memory step to show you that the entire program has been recorded.

   b. If the program fills up more than 112 steps of program memory (that is, if steps 113 through 224 contain instructions other than [R/S]) the calculator displays [*Crd*] to prompt you that another side of the card must be passed through the card reader to record the entire program. Pass the second side of the card through the card reader. The calculator then displays the current program memory step to show you that the entire program has been recorded.

4. The entire program is now recorded on the magnetic card, and also remains loaded in program memory of the calculator. The contents of the data storage registers and the stack of the calculator remain unchanged.

When you pass an unprotected card through the card reader with the W/PRGM-RUN switch set to W/PRGM, whatever program instructions or data previously recorded on the card are wiped out and replaced by the contents of the HP-67 calculator's program memory.

Besides the actual program memory step numbers and instructions, the HP-67 also records the following information on a program card on both the *first* pass and the *second* pass through the card reader:

1. The fact that a program (not data) is being recorded.
2. The fact that this is side 1 (or side 2).
3. Whether or not two passes are required.
4. Current status of flags F0, F1, F2, and F3 within the calculator.
5. Current status of trigonometric mode (i.e., DEG, RAD, or GRD) within the calculator.
6. Current display format of the calculator.
7. A checksum (a code to verify that the program is complete when it is reloaded).

All of this information is later read by the card reader when the program is reloaded back into the calculator.

If any of the required information or program memory steps are not recorded during a read, the HP-67 display will show **Error** to indicate that the recording of the card was not complete. Clear the error by pressing any key (the key function is not executed), then pass the same side of the card through the card reader again.

Reloading a Recorded Program from a Card

Once a program has been recorded on a magnetic card, you can reload it into the calculator any number of times. The procedure for reloading a program from a magnetic card is the same as that for loading a prerecorded program from a magnetic card into the calculator (see page 124).

The status information recorded on the magnetic card along with the program makes it unnecessary to load the card in any order—you can load either side 1 or side 2 first. The flag status, trigonometric mode, and display format information recorded on the program card save initialization time and program memory space because when the card is loaded, the calculator's flags, trigonometric mode, and display format are *immediately* specified according to the information of the program card.

If a program card does not read correctly, or if information on the card has been altered (perhaps by a strong magnetic field), the check-sum will be wrong. When you attempt to load the program from the card into the calculator by passing it through the card reader, the calculator will display Error . You can clear the error by pressing any key. If a card read fails after a portion of the card has been loaded, that portion of the calculator's program memory which would have been altered by reading the card is cleared to R/S instructions, and the calculator display indicates Error . Error is also indicated if you attempt to load a blank magnetic card, but the contents of the calculator's program memory are preserved.

The contents of the stack and of the data storage registers in the calculator remain unchanged when a program is loaded, whether from a card or manually from the keyboard.

To clear a program that has been recorded on a magnetic card, simply load another program onto the card.

Merging Programs

Normally, whenever you load a program from a magnetic card into the calculator, that program replaces the entire contents of program memory, either with program instructions or R/S instructions. All 224 steps of program memory are replaced.

However, you can also *merge* programs in your HP-67; that is, you can add a program that is recorded on a magnetic card into the calculator, beginning with any step of program memory. When you merge a program in from a card, steps 000 through *nnn* of the original program are preserved. This feature permits you to add to or alter a program that is already loaded in the calculator.

To merge a program from a magnetic card into program memory:

1. Set the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

2. Use the GTO . n n n operation from the keyboard to set the calculator to the last step of the loaded program that you want to save.

3. Press g MERGE *(merge)*.

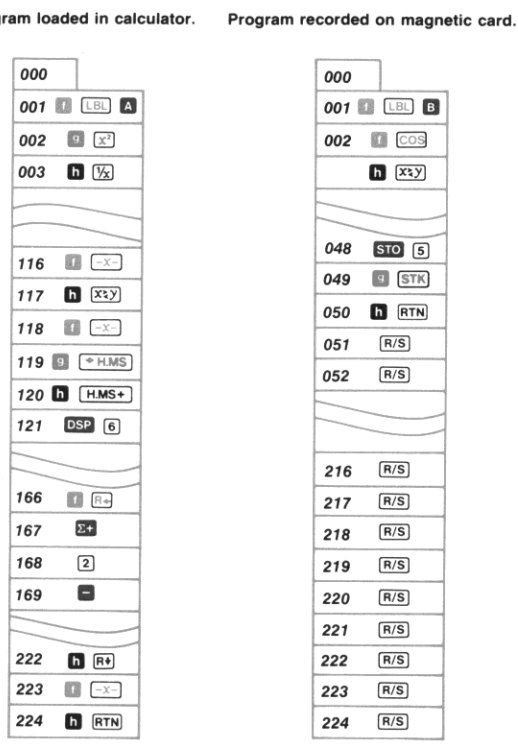
4. Pass one side of the magnetic card containing the new program through the card reader. If the second side of the card must also be loaded, the calculator display will prompt you with Crd .

5. If the calculator display shows Crd , pass the second side of the card through the card reader. The calculator will again display the original contents of the X-register to indicate that the merged load has been completed.

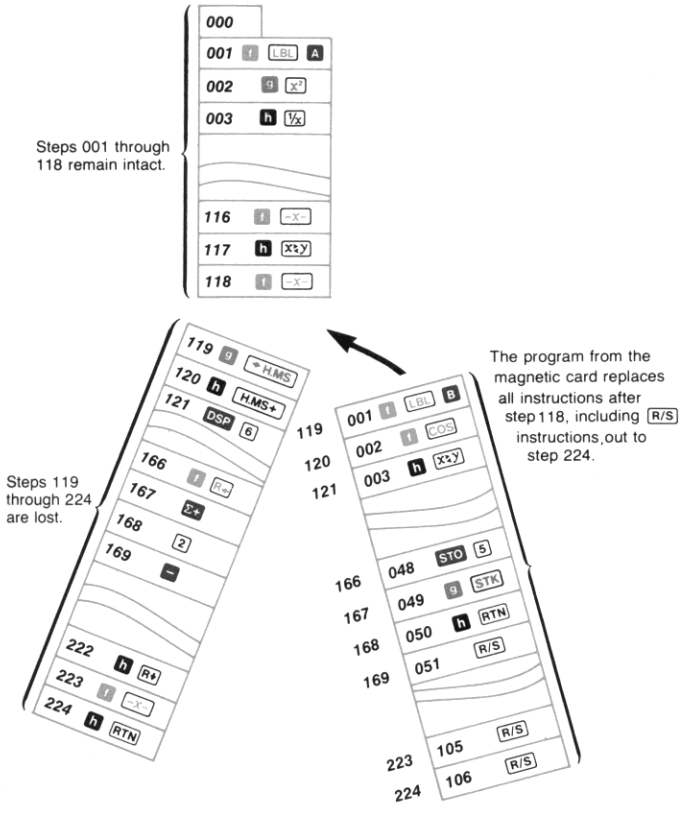
When you merge a program from a card into program memory, the instructions from the card are loaded into the calculator beginning with the step of program memory following the step to which the calculator is set. Thus, if you first set the calculator to step 118 using the operation GTO . 118 from the keyboard, the first instruction from the magnetic card would be loaded into step 119, the second instruction into step 120, etc. All instructions in program memory after the merge step are replaced by instructions from the magnetic card.

Remember, in some cases even one side of a program card may contain 224 steps (although the last 112 steps are compressed R/S instructions).

Thus, a 224-step program loaded in the calculator and a magnetic card containing a 50-step program (and 174 R/S instructions) might look like the illustration below:



If you set the calculator to step 118, press g MERGE, and pass the card through the card reader, the instructions from the card will be merged in beginning with step 119 and continuing through step 168. (That is, 118 + 50 = 168). All instructions after step 118 will be replaced in the original program, either by program instructions or R/S instructions from the magnetic card.



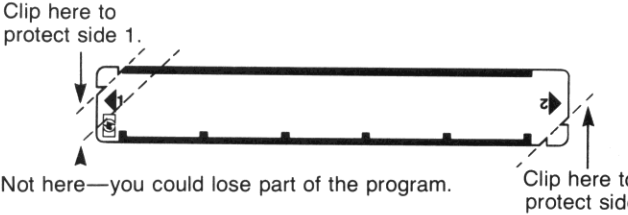
When merging a program from a magnetic card with a program already loaded into the calculator, only the instructions from the card for which there are enough steps of program memory will be loaded. Thus, in the example above, if you had merged the card from step 200 of the loaded program, only the first 24 instructions of the card would be loaded. (That is, 224 − 200 = 24.)

When merging, the instructions that are replaced in program memory by the instructions from the magnetic card are lost. The entire program on the card, of course, remains recorded there permanently, until another program (or data) is recorded upon the card.

Calculator status information (flag, display and trigonometric modes) is not changed when merging a new program with the one in program memory.

Protecting a Card

Information (whether program or data) that you have recorded upon a magnetic card can be cleared or replaced unless the card is protected. To protect a side of a recorded card, clip the notched corner of the card nearest the side you want to protect.



When you have protected a recorded program or recorded data on a side of a card by clipping that corner of the card, you can load that information into the HP-67 any number of times, but you will not be able to replace or add to the program or data on the card.

Marking a Card

After you have recorded a program on a card, you will probably want to assign the program a name and to mark the name onto the card. In addition, you will probably want to mark symbols onto the magnetic card so that when the card is inserted in the window slot, they will appear above the letter keys (A through E, a through e) associated with the labels in the program. These symbols, or mnemonics, should help you remember the use of the letter keys in the program, and they will aid in running the program.

For example, if you had written a program that would convert degrees Celsius to degrees Fahrenheit when C was pressed, and degrees Fahrenheit to degrees Celsius when D was pressed, you might wish to mark the card with the information as shown on the following page.

You can write on the non-magnetic side of a card as shown above using any writing implement that does not emboss the card. Annotating magnetic cards with a typewriter may impair the load/record properties of the cards. To permanently mark a card, you can use India ink or a permanent felt-tip pen.

Data Cards

As you know, you can record programs on magnetic cards for permanent storage, and then simply pass the card containing a program through the card reader whenever you want to run it again. You can also record *data* from the storage registers onto a magnetic card for permanent storage or for use at a later time. Then, a day, a week, a year later, simply pass the data card through the card reader to restore the original contents of the storage registers.

With this feature of the HP-67 you can store extremely large quantities of data for future use, or you can use each card to preserve a series of constants.

Recording Data onto a Card

The f W/DATA function and the card reader on your HP-67 allow you to record as much data as you wish on magnetic cards. To record data on a magnetic card:

1. Set the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

2. Store data in any storage register—R_0 through R_9, R_{S0} through R_{S9}, R_A through R_E, or I.

3. Press f W/DATA *(write data onto card)*. The calculator will display Crd to indicate that you are to pass a card through the card reader.

4. Select an unclipped magnetic card. Pass side 1 of the card through the card reader.

   a. The contents of the primary storage registers (R_0 through R_9, R_A through R_E, I) are recorded on side 1. If the calculator's protected secondary registers (R_{S0} through R_{S9}) all contain zero data, those contents are "compressed" and recorded on side 1 also. The calculator displays the original contents of the X-register to indicate that all data has been correctly recorded.

   b. If any of the secondary storage registers (R_{S0} through R_{S9}) contain *nonzero* data, the display shows Crd to indicate that a second side is necessary to record all the data.

   c. Pass side 2 of the card through the card reader. The actual contents of the secondary storage registers R_{S0} through R_{S9} are recorded on the second side of the card.

5. All data has now been recorded on the magnetic card. In addition, the data remains intact in the calculator.

Besides the data from the storage registers, the HP-67 also records the following information onto a data card on either or both passes through the card reader:

1. The fact that data (not a program) is being recorded.
2. The fact that this is side 1 (or side 2).
3. Whether or not two passes are required.
4. A checksum (a code to verify that the data is complete when it is reloaded).

No calculator status information is recorded when data is recorded onto a magnetic card.

When data is recorded on a side of a magnetic card, it wipes out whatever information was previously on that side. To record data permanently on a card, so that it can never be lost, you can clip a corner of the recorded magnetic card, just as you do to permanently save a recorded program.

Loading Data from a Card

To load data from a recorded card back into the storage registers, simply pass the card through the card reader with the W/PRGM-RUN switch set to RUN. The HP-67 identifies the type of information (whether data or a program) and automatically places it into the proper portion of the calculator. Thus, to load data back into the calculator from a magnetic card:

1. Ensure that the W/PRGM-RUN switch W/PRGM RUN is set to RUN.
2. Select the magnetic card with data recorded upon it.
3. Pass side 1 of the magnetic card through the card reader.

   a. Data from the card has now replaced data in the 16 primary storage registers of the calculator. In addition, if the secondary registers contained all zeros when recorded, those zeros replace the contents of the secondary registers (R_{S0} through R_{S9}) of the calculator. The calculator displays the original contents of the X-register to indicate that by loading only one side, the card was loaded correctly.

   c. If a second side of the card is required, the calculator prompts you by displaying Crd .

   d. Pass side 2 of the card through the card reader to load nonzero data into the secondary storage registers. The calculator then displays the original contents of the X-register to indicate that the data card has been loaded completely.

It does not matter which side of the card you record or load first. The HP-67 records the contents of the primary storage registers on the first side recorded, and the contents of the secondary storage registers on the second side. (If all secondary registers contain only zero, the contents of all storage registers are recorded on the first side.) When the card is then read later, the data is loaded into the proper registers, regardless of which side of the data card you first pass through the reader. However, for ease of later reference, it is generally best to record primary registers on side 1 and secondary registers on side 2.

Whenever the calculator indicates Crd , you can clear the Crd display and return control to the keyboard by pressing CLx or any key from the keyboard. In this way, you can record only *part* of the storage registers onto a card or load only *part* from a card.

Neither the stack nor the contents of program memory are altered in the calculator when you record data onto or load data from a card.

Now let's store data in some of the storage registers and see how these features of your HP-67 work.

Example: Store 1.00 in primary register R_1, 2.00 in secondary register R_{S2}, and 3.00 in the I-register. Record the contents of these registers on a magnetic card, then turn the HP-67 OFF then ON. Finally, restore the data on the magnetic card to the proper registers and display the contents of the registers to verify that the data has been loaded correctly.

Press	Display	
CLx DSP 2	0.00	
f CL REG	0.00	
f P⇄S	0.00	
f CL REG	0.00	All storage registers cleared to zero initially. (Display assumes no results remain from previous examples.)
2 STO 2	2.00	
f P⇄S	2.00	2 stored in secondary storage register R_{S2}.
1 STO 1	1.00	
3 h STI	3.00	

First select a blank and unclipped magnetic card. To then record the contents of the storage registers onto the card:

Press	Display	
f W/DATA	Crd	The calculator prompts you to insert the first side of the card.

Insert side 1 of the magnetic card into the right-hand slot of the card reader and permit it to be passed through the reader.

Display	
Crd	After recording the first side of the card, the calculator prompts you that it has additional data to record on side 2.

Insert side 2 of the magnetic card into the right-hand slot of the card reader and allow it to pass through the reader.

Display	
3.00	Indicates that all data has been recorded on the magnetic card.

The data that is stored in the registers remains there now, and is also recorded on the magnetic card. Even though you turn the calculator OFF or otherwise clear the storage registers, the data is recorded upon the magnetic card for future use. For example:

Turn the HP-67 power switch OFF, then ON.

Press	Display	
h REG	0.00	
f P↔S	0.00	
h REG	0.00	Successive displays of zero verify that none of the storage registers, primary or secondary, contain data.

Now load the data back into the storage registers by passing the data card through the card reader. No special instructions are necessary to the HP-67—the calculator automatically recognizes that the card contains data, and reloads the data into the proper storage registers.

To load the data from the card into the calculator:

Insert side 1 of the magnetic card into the right card reader slot. Allow the card to pass through the reader.

	Display	
	Crd	Data loaded into primary storage registers. The calculator prompts you that the card contains data for the secondary registers as well.

Insert side 2 of the magnetic card into the right card reader slot. Allow the card to pass through the reader.

	Display	
	0.00	Original contents of X-register again displayed to indicate that entire card has been loaded.
h REG	0.00	
f P≷S	0.00	
h REG	0.00	Reviewing the registers verifies that contents of data card have been loaded into the proper storage registers.

You can see that all the data contained on the magnetic card has been loaded into the proper storage registers. The data also remains recorded on the magnetic card, and can be loaded into the calculator over and over, until you record other data or a program on that card. Data (like programs) may be loaded into the calculator from a card in any order—no matter which side you first pass through the card reader, the calculator identifies it and places the contents in the proper storage registers of the calculator.

Press	Display	
f CL REG	0.00	
f P≷S	0.00	
f CL REG	0.00	All primary and secondary storage registers again cleared to zero.

This time, insert side 2 of the magnetic card into the right card reader slot first. Allow the card to pass through the card reader.

	Display	
	Crd	Display indicates that the card contains more data to be loaded.

Now insert side 1 of the data card into the right card reader slot and allow it to pass through the card reader.

Press	Display	
	0.00	Original contents of X-register returned to indicate that contents of entire magnetic card have been loaded.
h REG	0.00	
f P≷S	0.00	
h REG	0.00	Verifies that data from the magnetic card has again been loaded into the proper storage registers.

If only the primary registers contain nonzero data when you press f W/DATA, the calculator will display Crd only until you have passed *one* side of the magnetic card through the card reader. Then the calculator will display the original contents of the X-register to indicate that you again have control from the keyboard. Likewise, if data is contained on only one side (side 1 or side 2) of a magnetic card, you need load only that side.

You have seen how you can store data temporarily or permanently on magnetic cards with the HP-67. Because you are able to record data on magnetic cards, the storage capacity of your HP-67 is increased by 26 registers on each card. The amount of data you want to store is limited only by the number of cards you have!

Now let's see how you can load the contents of only *part* of the storage registers into the calculator from a card by using the I-register and the [MERGE] function.

Merged Loading of Data

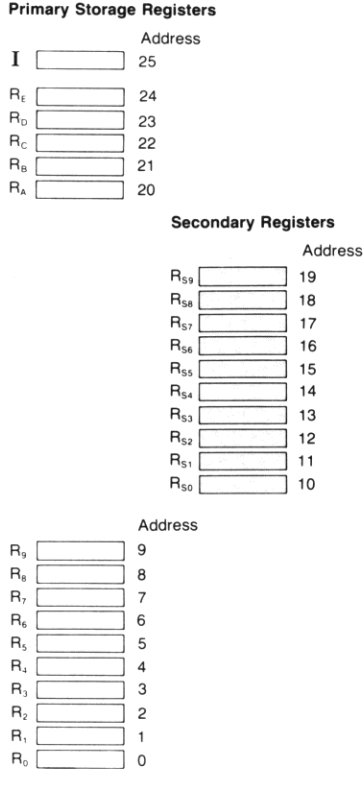
The numbers 0 through 9 in I, when used as an address for merged data, refer to primary storage registers R_0 through R_9. The numbers 10 through 19 refer to secondary storage registers R_{S0} through R_{S9}, while the numbers 20 through 24 refer to registers R_A through R_E, and the number 25 addresses the I-register itself. As is normal for I-register operations, only the absolute value of the integer part of the number in I is significant in addressing. Also, if the absolute value of the number in I is 26 or greater, all registers will be read in just as in an unmerged data read.

However, you can also replace the contents of *some* of the storage registers in the calculator with data from a magnetic card, while preserving the contents of the rest of the storage registers. To load only a portion of the data from magnetic card into the calculator's storage registers, first store a number from 0 through 25 as an address in the I-register. Then press [g] [MERGE] *(merge)* and pass the card containing data through the card reader. Data will be loaded from the card into the storage registers, beginning with register R_0 and continuing up to and including the register addressed by the number in I.

When using your HP-67 there may be occasions when you want to load into the calculator the contents of only *some* of the storage registers recorded on a card. The [g] [MERGE] function and the I-register permit you to select the number of registers that you want to load.

Normally, when a magnetic card containing data is passed through the card reader, the contents of *all* primary registers and *all* secondary registers in the calculator are replaced with the contents of the data card.

The illustration below should refresh your memory of the addressing scheme for the storage registers:



To merge data from a magnetic card into selected storage registers:

1. Store in I the number address of the last storage register you want loaded from the card.
2. Press g MERGE *(merge)* to select the merge mode.
3. Pass either side of the magnetic card containing data through the card reader. If more data is to be loaded, the calculator will display *Crd* .

4. If the HP-67 display shows [Crd], pass the other side of the data card through the card reader.
5. Data will be loaded from the card beginning with register R_0 up to and including the storage register specified by the number in I.

Thus, if you had stored the number 7 in I, then pressed g [MERGE] and loaded a magnetic card containing data, the contents of the first 8 registers in the calculator (R_0 through R_7) would have been replaced by contents from the data card. The remainder of the storage registers in the calculator would remain intact. If you had stored the number 15 in I, calculator registers R_0 through R_9 and R_{S0} through R_{S5} (the register addressed by the number 15) would have had their contents replaced by data from the card. This includes registers containing only zero data.

Example: Store 1×10^{10} in register R_1, 1×10^{-20} in register R_9, 1×10^{30} in register R_{S5}, 1×10^{-40} in register R_{S6}, and 1×10^{50} in register R_B in the calculator. Record this data on a magnetic card.

Press	Display
f [CL REG]	0.00
EEX 30	1. 30
STO 5	1.000000000 30
EEX 40 CHS	1. -40
STO 6	1.000000000-40
f [P≷S]	1.000000000-40
f [CL REG]	1.000000000-40
EEX 10	1. 10
STO 1	1.000000000 10
EEX 20 CHS	1. -20
STO 9	1.000000000-20
EEX 50	1. 50
STO B	1.000000000 50

Now record this data on a magnetic card. You can record it onto any unclipped magnetic card—it will replace whatever is on the card with the contents of the storage registers.

Press	Display	
f W/DATA	Crd	Calculator prompts you to insert a magnetic card.

Pass side 1 of the card through the card reader.

Display

Crd

Now pass side 2 of the magnetic card through the card reader.

Display

1.000000000 50

The calculator again displays the contents of the X-register to indicate that all data in the calculator's storage registers has been recorded onto the card as well.

Now change the data in the calculator. Store 1.11 in R_1, 2.22 in R_9, 5.55 in R_{S5}, 6.66 in R_{S6}, and 7.77 in R_B. Review the contents of all the registers when you are through.

Press	Display	
f CL REG	1.000000000 50	All storage registers cleared to zero.
f P≷S	1.000000000 50	
f CL REG	1.000000000 50	
5.55 STO 5	5.55	Data stored in secondary registers.
6.66 STO 6	6.66	
f P≷S	6.66	
1.11 STO 1	1.11	
2.22 STO 9	2.22	
7.77 STO B	7.77	
h REG	7.77	Reviewing stack registers shows you the data in the various registers. The original X-register contents return to the display when the review is completed.
f P≷S	7.77	
h REG	7.77	
f P≷S		

Now store the number 15 in I, press the g MERGE function, and load the contents of the first 16 storage registers from the magnetic card into the calculator, while preserving the contents of the last 10 storage registers in the calculator.

Press	Display	
15 h STI	15.00	Merge address stored in I.
g MERGE	15.00	

Now pass side 1 of the data card through the card reader.

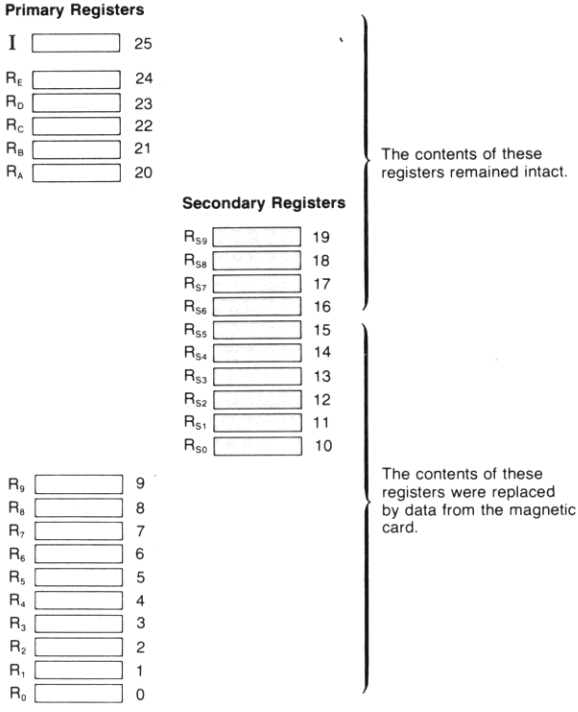
	Display	
	Crd	Calculator prompts you that additional data must be loaded from the card.

Pass side 2 of the data card through the card reader. Review the new contents of the storage registers and compare them with the old.

Press	Display	
	15.00	Contents of X-register returned to display to indicate that all necessary data has been loaded from the card into the calculator's storage registers.
h REG	15.00	After automatically reviewing the contents of the storage registers, the original contents of the X-register are returned there.
f P≷S	15.00	
h REG	15.00	

You can see that the contents of the storage registers addressed by numbers 0-15 (that is, storage registers R_0 through R_9 and secondary storage registers R_{S0} through R_{S5}) have had their contents replaced by data from the magnetic card, while the contents of the remaining storage registers are preserved intact.

When you stored an address of 15 in the I-register, pressed g MERGE, and passed a magnetic card containing data through the card reader:



If you do not wish to load or record data when the calculator displays Crd , you can press any key to return the contents of the X-register to the display, then continue with your calculations. This allows you to load only the primary or only the secondary registers from a card without pressing g MERGE.

As soon as you have finished loading data or pressed any key from the keyboard, the g MERGE function is forgotten. You must press it each time just before you merge data.

For example, if you load data from the magnetic card now without pressing g MERGE first, the contents of *all* storage registers in the calculator will be replaced by data from the card.

Pass side 1 of the data card through the card reader.

	Display
	Crd

Now pass side 2 of the data card through the card reader.

Press	Display	
	15.00	
h REG	15.00	Register review verifies that all data from card is now loaded into the calculator.
f P/S	15.00	
h REG	15.00	

Note that when the card was recorded many storage registers, including I, contained zero. When the card was then read and data loaded into the calculator, the zeros in these registers replaced the previous contents of their corresponding registers in the calculator.

Pausing to Read a Card

As you know, the h PAUSE instruction in a program returns control from the running program to the keyboard for the length of a pause (about one second). You have already seen how h PAUSE can be used in a program for output (to display information contained in the X-register) or input (to key in numbers). You can also use a PAUSE to load data or a program from a magnetic card into the calculator.

You can pause in a program for any or all of the following operations:

1. Loading a program from a card into program memory.
2. Merging a program from a card into a selected part of program memory.
3. Loading data from a card into the storage registers.
4. Merging data from a card into selected storage registers.

These operations are used the same way as part of a program as you would use them from the keyboard. If you desire to merge data or a program from a magnetic card into the calculator, a merge instruction, g MERGE, must be executed as an instruction or pressed immediately before the magnetic card is passed through the card reader. In addition, for a merged data load from a card, the proper address must be first placed in the I-register at some point, whether from the keyboard or as part of the program.

To use PAUSE to load a program or data from a magnetic card into the calculator while a program is running:

1. a. Place an h PAUSE instruction at the point in the program where you want to load the data or program.

   b. If the data or the program from the magnetic card is to be *merged* with that in the calculator, insert a g MERGE instruction immediately preceding the h PAUSE instruction.

   c. If *data* is to be merged into the registers, ensure that the proper address number has been placed in I, either from the keyboard or from the program.

2. Slide the W/PRGM-RUN switch W/PRGM RUN to RUN.

3. Initialize and run the program.

   You may go ahead and insert the leading edge of the first side to be read into the card reader now, while the program is running. (Insert the tip of the card firmly into the right card reader slot, but do not attempt to force the card in. This may take practice.) You need not hold the card, merely allow it to rest in the card reader slot.

4. Using a PAUSE, when the calculator pauses, the side of the card you have previously inserted in the card reader slot will automatically be read during the PAUSE. If more data or program instructions are to be loaded from the card, the calculator will stop and prompt you with a display of Crd .

5. If the calculator display shows [Crd], insert the second side of the magnetic card into the card reader.
6. Execution will resume automatically when the card is read.

The automatic card read during [PAUSE] allows the programmer to even be absent when the card is read! If no card is read, naturally, the program continues execution after the 1-second pause. If a complete card is not accurately read, the program stops and the calculator displays [Error] to indicate that the read was not successful.

If you wish, instead of utilizing an automatic read during a [PAUSE], you can simply hold the magnetic card poised in your hand and insert it during a [PAUSE].

The data entry flag, flag F3, is set either by digit entry from the keyboard or by the loading of data from a magnetic card. Thus you could also set up a loop using [PAUSE] and the data entry flag F3 that would hold up the program until you pass a data card through the card reader, then resume execution automatically.

If you wish a program to stop execution to record data on a card, simply insert the [f] [W/DATA] instruction in the program at the point where you wish to record data. The program will stop at that point and display [Crd] to prompt you to pass a card through the card reader slot. After you start a program running, you can even have a card "waiting" in the card reader for an automatic recording of data onto the card.

Example: The example shown here illustrates how you can pause to read a program from a magnetic card and how a program from a card may be merged into a program already loaded into the calculator. The program that you record onto the magnetic card calculates the area of a circle from its radius. The program that you then load into the calculator performs 100 iterations, then merges the program from the card that you have waiting in the card reader into the calculator, and finally calculates the area of a circle.

To record the program for calculating the area of a circle onto a magnetic card:

Slide the W/PRGM-RUN switch W/PRGM RUN to W/PRGM.

Press	Display
f CL PRGM	000
f LBL B	001 31 25 12
RCL 9	002 34 09
g x^2	003 32 54
h π	004 35 73
×	005 71
h RTN	006 35 22

Now select an unprotected (unclipped) side of a magnetic card and pass side 1 of it through the card reader to record the above program onto the magnetic card.

When you have recorded the program for the area of a circle, clear the program from the calculator and record the program that will perform 100 iterations, then will merge the program from the card with the program in the calculator:

Press	Display	
f CL PRGM	000	
f LBL A	001 31 25 11	
STO 9	002 33 09	
1	003 01	
0	004 00	
0	005 00	
h STI	006 35 33	
f LBL 1	007 31 25 01	
f DSZ	008 31 33	When I = 0, skip to step 010.
GTO 1	009 22 01	Otherwise, go back to LBL 1.
g MERGE	010 32 41	Sets merge mode.
h PAUSE	011 35 72	Pause to merge program into calculator.
h RTN	012 35 22	

To run the program to find the area of a circle with a radius of 15 centimeters:

Slide the W/PRGM-RUN switch W/PRGM ▮▮▮ RUN to RUN.

Press	Display	
15	15.	The radius keyed in.
A		The program running.

While the program is running, insert side 1 of the card containing the program for the area of a circle into the card reader slot. Insert the card until you just feel pressure against the end, then stop and let go of the card, permitting it to "wait" in the card reader slot.

When the program in the calculator has gone through 100 iterations and the value in I reaches zero, the card waiting in the card reader slot will be read, that program merged with the program already in the calculator, and the area of the circle calculated.

If you see Error after the card is read, or if the card does not pass through the card reader and you see Error, remove the card, clear the error by pressing any key, then key in the radius again and restart the program by pressing A. Then reinsert the card while the program is running. When the program has run correctly, you will see the area of the circle, 706.86 centimeters, displayed.

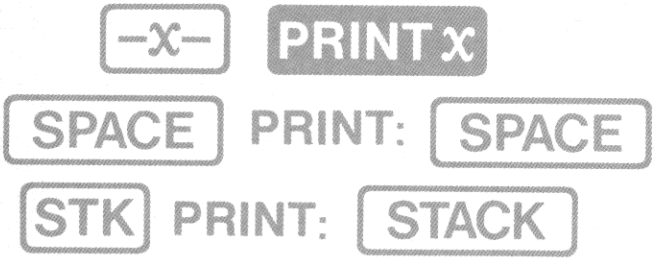
The program from the card has merged after the PAUSE instruction, and the contents of your calculator's program memory should now look like this:

001	f LBL A	31 25 11
002	STO 9	33 09
003	1	01
004	0	00
005	0	00
006	h STI	35 33
007	f LBL 1	31 25 01
008	f DSZ	31 33
009	GTO 1	22 01
010	g MERGE	32 41

011	h PAUSE	35	72
012	f LBL B	31 25	12
013	RCL 9	34	09
014	g x^2	32	54
015	h π	35	73
016	×		71
017	h RTN	35	22

You can verify that program memory in your HP-67 contains the instructions shown here by examining the contents with the SST key.

When merging programs, any instruction executed after a g MERGE instruction cancels the merge mode *except* a PAUSE. Notice, too, that while normally instructions after a MERGE are overwritten by a new program, a PAUSE after a MERGE in a program is not overwritten.


–x–
PRINT x
SPACE
PRINT:
SPACE
STK
PRINT:
STACK

Section 15

The HP-67 and the HP-97: Interchangeable Software

Programs that have been recorded onto cards by your calculator can be loaded and run in your calculator as often as you like. They can also be run on *any* HP-67 Programmable Pocket Calculator or on *any* HP-97 Programmable Printing Calculator. In fact, software (i.e., a group of programs) is completely interchangeable between these two Hewlett-Packard calculator models—any programs that have been recorded onto a card using the HP-97 can be loaded into and run on the HP-67, and vice versa. Data cards are also interchangeable between the two calculators. All functions and switches operate alike on the two calculators, with the exception of the printing functions on the HP-97 and the automatic list functions of the HP-67.

Keycodes

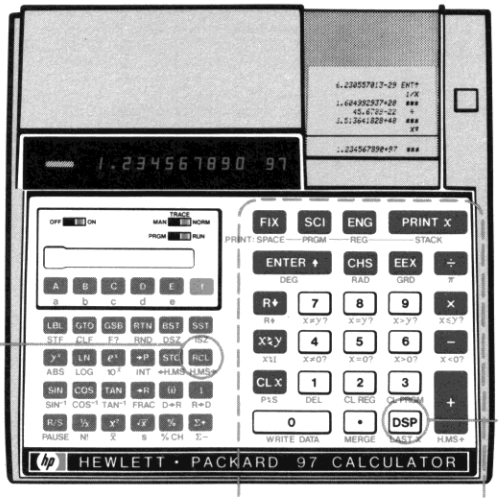
You can see the similarities of the HP-67 and the HP-97 in the illustrations shown on pages 300–301. Although some of the nomenclature on the keys varies, the difference is so slight that you will find it easy to operate either model of calculator if you are familiar with the other. For example, PAUSE on the HP-97 operates exactly the same as PAUSE on the HP-67, and h STI on the HP-67 is the same as STO I on the HP-97.

When a program from one model of calculator is loaded into the other model, the keycode is transmuted to reflect the location of the function on the new model. Keycodes are read alike on both models; first the row, then the number of the key in the row, from the top down and from left to right. Digit keys are represented by keycodes 00 through 09.

HP-67 Programmable Pocket Calculator

On the HP-67, keycodes for functions that are selected by first pressing a prefix key and then a digit key are referenced by the keycode matrix address, not by 00 through 09. On the HP-97, however, the prefixed functions that are below the digit keys are referenced by keycodes of 00 through 09. On the HP-97, the keycodes for the keys on the right-hand keyboard (except for the digit keys) are generated with minus signs before them. For example, if you had loaded the operation DSP 9 into the HP-67, the keycode would be 23 09 (that is, 2nd row, 3rd key, followed by the keycode 09 for the [9] key). If you recorded that operation on a magnetic card, then read the card to load the same operation into an HP-97, the keycode for the operation on the HP-97 would be −63 09 (that is, 6th row, 3rd key of the right-hand keyboard, followed by the [9] key).

HP-97 Programmable Printing Calculator



Keycodes representing keys on the left keyboard of the HP-97 have keycodes with no sign before them, so a RCL 3 instruction loaded into the HP-97 would have a keycode of 36 03. If that operation were recorded onto a magnetic card, and then loaded from the card into an HP-67, the keycode for the operation in the HP-67 would be 34 03.

Although the keycodes are altered, the operations are the same from calculator to calculator, from HP-67 to HP-97. And since each operation, no matter how many keystrokes it takes to perform, is loaded into a single step of program memory, the steps of program memory into which a program is loaded are the same when a program is changed from one calculator to another.

For example, if you loaded the program for the area of a sphere into an HP-67 from the keyboard, then recorded it onto a magnetic card, and finally passed the card through the card reader of an HP-97, the contents of the program memory of the two calculators might look like this:

HP-67 Program Memory

Step	Instruction	Keycode
001	f LBL A	31 25 11
002	g x^2	32 54
003	h π	35 73
004	×	71
005	h RTN	35 22

HP-97 Program Memory

Step	Instruction	Keycode
001	LBL A	21 11
002	x^2	53
003	f π	16-24
004	×	-35
005	RTN	24

You can see that the program is exactly the same in the two calculators, even though some operations are prefixed in one calculator and not in the other. Operations are always loaded correctly for the particular calculator, so you can examine and edit the program, no matter the model calculator into which it is loaded. For a complete list of keycodes and corresponding functions on the two calculators, refer to appendix E.

Print and Automatic Review Functions

The only functions that operate differently between the two calculators are the automatic review functions and [-x-] pause on the HP-67, and the print functions on the HP-97. For example, you can print a list of the stack contents with the printer on the HP-97 by using the PRINT: [STACK] function. Since the HP-67 Programmable Pocket Calculator does not have a printer, however, the stack contents are reviewed by passing them through the display, one register at a time, with the [STK] *(automatic stack review)* function.

Since the purpose of the two operations is essentially the same (review of the stack contents), these two operations are interchangeable between the two models of calculators. If you load a program containing a g STK instruction into an HP-67 Programmable Pocket Calculator, then record that program onto a magnetic card and use the card to load the same program into an HP-97 Programmable Printing Calculator, the g STK instruction from the HP-67 will automatically be loaded into the HP-97 as an f PRINT: STACK instruction.

Similiarly, the PRINT x function on the HP-97 and the 5-second -x- pause on the HP-67 have the same purpose—to allow you to record the current contents of the X-register while a program is running. Thus, a PRINT x instruction in a program recorded onto a magnetic card by an HP-97 printing calculator will be loaded into an HP-67 as an -x- pause when the card is passed through the card reader on the HP-67. In the HP-67, this 5-second -x- pause is designed to give you enough time to write down or view the contents of the X-register while a program is running.

Note: Within the HP-67 only, the five default functions 1/x √x y^x R↓ x≷y above the top-row keys are present in the calculator to enhance its usability in RUN mode and cannot be recorded in program memory. However, these same functions are duplicated elsewhere on the calculator by prefixed functions, and these prefixed operations *can* be recorded.

The chart below illustrates the keys that are different yet interchangeable between the HP-67 and the HP-97.

Operation on: HP-67	Operation on: HP-97	When encountered as an instruction by the HP-67:	When encountered as an instruction by the HP-97:
[-x-]	[PRINT x]	Causes program execution to pause for about 5 seconds, displaying current contents of X-register with decimal point blinking eight times.	Prints current contents of X-register.
[STK]	PRINT: [STACK]	Displays current contents of each stack register sequentially; T, Z, Y, and X, with decimal point blinking twice for each stack register.	Prints current contents of stack registers.
[REG]	PRINT: [REG]	Displays contents of each primary storage register, beginning with registers R_0 through R_9, then R_A through R_E, and finally I. Each display is preceded by a displayed number indicating the register's address.	Prints contents of all primary storage registers; R_0 through R_9, R_A through R_E, I.
[SPACE]	PRINT: [SPACE]	Performs no operation.	Prints a blank space on paper tape.

Naturally, all other keys perform exactly the same function on the HP-67 as on the HP-97.

Notice that the [SPACE] function on the HP-67 Programmable Pocket Calculator performs no operation on that calculator. It is used only in programs which may be recorded onto magnetic cards and later

loaded and run on the HP-97 with its built-in printer. On the HP-97 [SPACE] prints a blank space on the paper tape, just as if you had pressed the paper advance pushbutton, and it is extremely useful in separating answers or portions of your HP-97 print-out.

Remember: Any program or data recorded on a magnetic card can be loaded from that card and used in *either* the Hewlett-Packard HP-67 Programmable Pocket Calculator or the HP-97 Programmable Printing Calculator. Because the design of these two calculators has been integrated, you can use your own program cards, or preprogrammed cards like those in your Standard Pac or any of the optional application pacs, in *any* HP-67 or HP-97.

A Word about Programming

You have now been exposed to the features of the HP-67 Programmable Pocket Calculator. But exposure is not enough—to gain confidence in and fully appreciate the power of this small computer, you must *use* it to solve your problems, simple and complex. Although the best program for a given application is usually the most straightforward, don't be afraid to experiment, to forge into the unknown, to stamp upon your programs your own personal trademarks. And you'll probably want to learn some of the "tricks" of sophisticated programmers to apply in your own software.

A good place to begin is with the *HP-67 Standard Pac*. At the end of the text you will find detailed explanations for some of the techniques used in actual programs in the Pac. You can also learn a great deal about programming by "reading" the programs in the Pac—following them, step-by-step, to see what makes them tick, to attempt to find out why the programmer used the steps he did.

With the HP-67 the problems of the world can be solved!

Appendix A

Accessories

Standard Accessories

Your HP-67 comes equipped with one each of the following standard accessories:

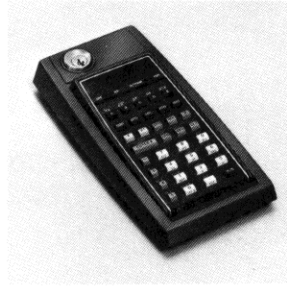
Accessory	HP Number
Battery Pack (installed in calculator before shipping)	82001A
AC Adapter/Recharger	82002A
HP-67 Owner's Handbook and Programming Guide	00067-90011
HP-67 Quick Reference Card	00067-90001
Soft Carrying Case	82053A
Standard Pac, including:	00067-13101
• *HP-67 Standard Pac* (instruction book) • 14 Prerecorded Program Cards • 1 Prerecorded Magnetic Card containing Diagnostic Program • 1 Head Cleaning Card • 24 Blank Magnetic Cards • Card Holder for Magnetic Cards	
Programming Pad	00097-13154

Optional Accessories

In addition to the standard accessories shipped with your HP-67, Hewlett-Packard also makes available the optional accessories seen below. These accessories have been created to help you maximize the usability and convenience of your calculator.

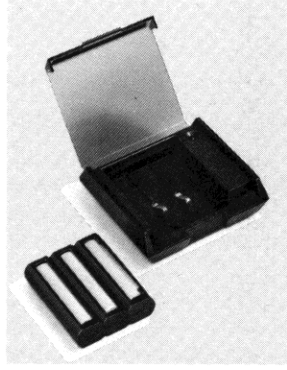
Security Cradle 82015A

A durable locking cradle with a tough 6-foot long steel cable that prevents unauthorized borrowing or pilferage of your calculator by locking it to a desk or work surface. The cable is plastic-covered to eliminate scarring of furniture, and you have full access to all features of your HP-67 at all times.



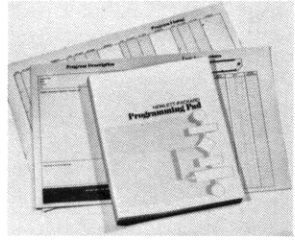
Reserve Power Pack 82004A

The reserve power pack attaches to the calculator's ac adapter/recharger to keep an extra battery pack freshly charged and ready for use. Comes complete with extra battery pack.



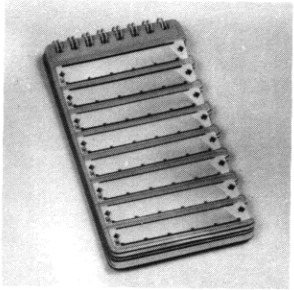
Programming Pad 00097-13154

Each pad provides 40 worksheets to help you develop programs for your HP-67.



Blank Magnetic Cards 00097-13141

Each pack of blank magnetic cards contains 40 HP program cards for recording of your programs. Any card can be labeled to indicate program title and functions of user-definable keys. Includes personal card holder.

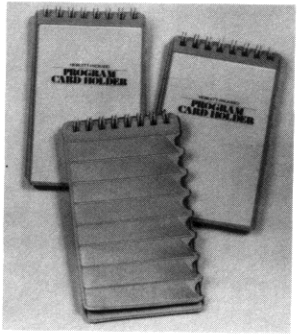


Multiple Card Packs 00097-13143

Consists of three packs of blank magnetic cards (120 cards total) with three personal card holders.

Program Card Holder 00097-13142

Each package contains three program card holders like the one shipped with your calculator for carrying extra magnetic cards.



Field Case 82016A

A sturdy weather-and-shock protector, the field case keeps you mobile by allowing you to carry your calculator on your hip—any time, any place. Constructed of a rugged leather-like material, the field case has belt loops for convenient attachment and extra pouches for program cards and Quick Reference Card.

HP Application Pacs

Each pac provides approximately 20 prerecorded programs in a particular field or discipline. Each comes complete with a detailed instruction book and prerecorded magnetic cards.

To order additional standard or optional accessories for your HP-67 see your nearest dealer or fill out an Accessory Order Form and return it with check or money order to:

HEWLETT-PACKARD
Corvallis Division
1000 N.E. Circle Blvd.
Corvallis, Oregon 97330

If you are outside the U.S., please contact the Hewlett-Packard Sales Office nearest you.

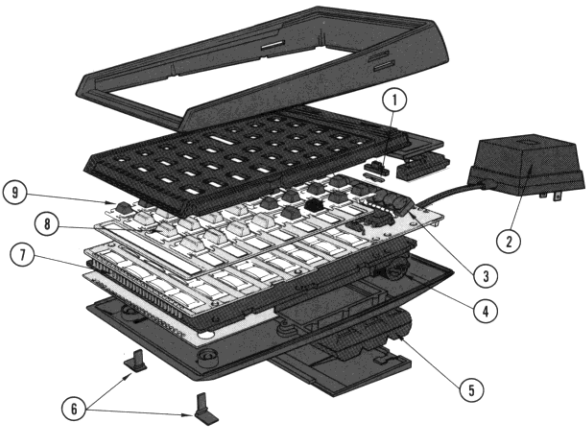
Availability of all accessories, standard or optional, is subject to change without notice.

Appendix B

Service and Maintenance

Your Hewlett-Packard Calculator

Your HP-67 is another example of the award-winning design, superior quality, and attention to detail in engineering and construction that have marked Hewlett-Packard electronic instruments for more than thirty years. Each Hewlett-Packard calculator is precision-crafted by people who are dedicated to giving you the best possible product at any price.



① Switches silicon greased for long life.

② Simultaneous ac line operation and battery pack charging from recharger. Charger terminals sealed to keep out moisture and dust.

③ High-intensity light-emitting-diode display.

④ "Smart" card reader for accurate reading of magnetic cards under manual or program control.

⑤ One-piece rechargeable battery pack needs no tools for replacement.

⑥ Non-skid PVC feet.

⑦ Gold-plated contacts resist corrosion.

⑧ Positive keyboard feel.

⑨ Keys double injection-molded for permanent, precise symbols.

After construction, every calculator is thoroughly inspected for electrical or mechanical flaws, and each function is checked for proper operation.

When you purchase a Hewlett-Packard calculator, you deal with a company that stands behind its products. Besides an instrument of unmatched professional quality, you have at your disposal many extras—a host of accessories to make your calculator more usable, service that is available worldwide, and support expertise in many application areas.

Battery Operation

A rechargeable battery pack is provided with your calculator. **Be sure to charge the battery pack before portable use of your calculator.** A fully charged battery pack provides approximately 3 hours of continuous operation. By turning the power OFF when the calculator is not in use, the HP-67's battery pack should easily last throughout a normal working day. You can extend battery operation time by reducing the number of digits in the display. Press [•] between calculations and [CLx] prior to starting a new calculation if the wait between entries is extensive.

> **Note:** If you use your HP-67 extensively in field work or during travel, you may want to order the Reserve Power Pack, consisting of a battery charging attachment and spare battery pack. This enables you to charge one pack while using the other.

Recharging and AC Line Operation

To avoid any transient voltage from the charger, the HP-67 should be turned OFF before plugging it in. It can be turned ON again after the charger is plugged into the power outlet and used during the charging cycle.

A discharged battery will be fully charged after being connected to the charger for a period of 14 hours; overnight charging is recommended.

If desired, the HP-67 can be operated continuously from the ac line. The battery pack is in no danger of becoming overcharged. If a battery is fully discharged, it must be charged for at least 5 minutes before a card can be read.

CAUTION
Operating the HP-67 from the ac line with the battery pack *removed* may result in damage to your calculator.

The procedure for using the ac adapter/recharger is as follows:

1. If your recharger has a line-voltage select switch, make sure the switch is set to the proper voltage. The two line voltage ranges are 86 to 127 volts and 172 to 254 volts.

CAUTION
Your HP-67 may be damaged if it is connected to the charger when the charger is not set for the correct line voltage.

2. Set the HP-67 power switch to OFF.
3. Insert the recharger plug into the rear connector of the HP-67 and insert the power plug into a live power outlet.
4. Set the power switch to ON. If the W/PRGM-RUN switch is set to RUN, you should see a display of 0.00 .
5. Set the power switch to OFF if you don't want to use the calculator while it is charging.
6. At the end of the charging period, you may continue to use your HP-67 with ac power or proceed to the next step for battery-only operation.
7. With the power switch set to OFF, disconnect the battery charger from both the power receptable and the HP-67.

CAUTION
The use of a recharger other than an HP recharger like the one provided with your HP-67 may result in damage to your calculator.

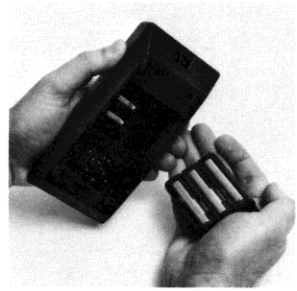
Battery Pack Replacement

If it becomes necessary to replace the battery pack, use only another Hewlett-Packard battery pack like the one shipped with your calculator.

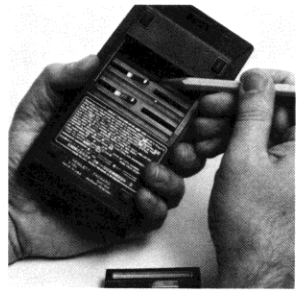
> **CAUTION**
> Use of any batteries other than the Hewlett-Packard battery pack may result in damage to your calculator.

To replace your battery pack use the following procedure:

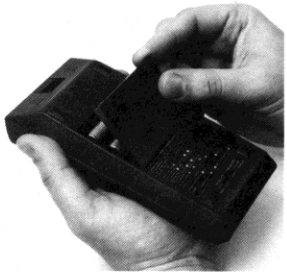
1. Set the power switch to OFF and disconnect the battery charger.
2. Slide the two battery door latches toward the bottom of the calculator.
3. Let the battery door and battery pack fall into the palm of your hand.



4. See if the battery connector springs have been inadvertently flattened inward. If so, bend them out and try the battery again.



5. Insert the new battery pack so that its contacts face the calculator and contact is made with the battery connectors.



6. Insert the top of the battery door behind the retaining groove and close the door.

7. Secure the battery door by pressing it gently while sliding the two battery door latches upward.

Battery Care

When not being used, the batteries in your HP-67 have a self-discharge rate of approximately 1% of available charge per day. After 30 days, a battery pack could have only 50 to 75% of its charge remaining, and the calculator might not even turn on. If a calculator fails to turn on, you could substitute a charged battery pack, if available, for the one in the calculator. The discharged battery pack should be charged for at least 14 hours.

If a battery pack will not hold a charge and seems to discharge very quickly in use, it may be defective. The battery pack is warranted for one year, and if the warranty is in effect, return the defective pack to Hewlett-Packard according to the shipping instructions. (If you are in doubt about the cause of the problem, return the complete HP-67 along with its battery pack and ac adapter/recharger.) If the battery pack is out of warranty, see your nearest dealer or use the Accessory Order Form provided with your HP-67 to order a replacement.

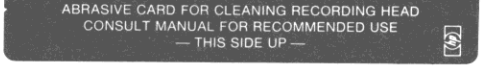
WARNING

Do not attempt to incinerate or mutilate your HP-67 battery pack—the pack may burst or release toxic materials.

Magnetic Card Maintenance

Try to keep your cards as clean and free of oil, grease, and dirt as possible. Dirty cards can only degrade the performance of your card reader. Cards may be cleaned with alcohol and a soft cloth.

Minimize the exposure of your calculator to dusty, dirty environments by storing it in the soft carrying case when not in use. Each card pack contains one head cleaning card.

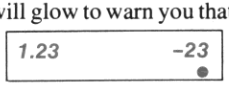


The magnetic recording head is similar to magnetic recording equipment. As such, any collection of dirt or other foreign matter on the head can prevent contact between the head and card, with consequent failure to read the card. The head cleaning card consists of an abrasive underlayer designed to remove such foreign matter. However, the use of the card without the presence of a foreign substance will remove a minute amount of the head itself; thus, extensive use of the cleaning card can reduce the life of the card reader in your HP-67. If you suspect that the head is dirty, or if you have trouble reading or recording cards, by all means use the cleaning card; that's what it is for. If one to five passes of the cleaning card does not clear up the situation, refer to Improper Card Reader Operation in this appendix.

Service

Low Power

When you are operating from battery power, a bright red lamp inside the display will glow to warn you that the battery is close to discharge.



Low Power Display

You must then either connect the ac adapter/recharger to the calculator as described under Recharging and AC Line Operation, or you must substitute a fully charged battery pack for the one in the calculator.

Blank Display

If the display blanks out, turn the HP-67 OFF, then ON. If 0.00 does not appear in the display in RUN mode, check the following:

1. If the ac adapter/recharger is attached to the HP-67, make sure it is plugged into an ac outlet. If not, turn the calculator OFF before plugging the recharger into the ac outlet.
2. Examine battery pack to see if the contacts are dirty.
3. Substitute a fully charged battery pack, if available, for the one that was in the calculator.
4. If display is still blank, try operating the HP-67 using the recharger (with the batteries in the calculator).
5. If, after step 4, display is still blank, service is required. (Refer to Warranty paragraphs.)

Blurring Display

During execution of a program, the display continuously changes and is purposely illegible to indicate that the program is running. When the program stops, the display is steady.

Improper Card Reader Operation

If your calculator appears to be operating properly except for the reading or loading of program cards, check the following:

1. Make sure that the W/PRGM-RUN switch is in the correct position for desired operation: RUN position for loading cards, W/PRGM for recording cards.
2. If the drive motor does not start when a card is inserted, make sure the battery pack is making proper contact and has ample charge. A recharger may be used in conjunction with a partially charged battery in order to drive the card reader motor. If the battery has been completely discharged, plug in the recharger and wait 5 minutes before attempting to operate the card reader.
3. If the card drive mechanism functions correctly, but your HP-67 will not read or record program cards, the trouble may be due to dirty record/playback heads. Use the head cleaning card as directed. Then, test the calculator using the diagnostic program card furnished with it, following the instructions provided. If difficulty persists your HP-67 should be taken or sent to an authorized Hewlett-Packard Customer Service Facility.
4. Cards must move freely past the record/playback heads. Holding a card back or bumping a card after the card drive mechanism engages could cause a card to be misread.

> **CAUTION**
> Cards can be accidentally erased if subjected to strong magnetic fields. (Magnetometers at airports are in the safe range.)

5. Check the condition of your magnetic cards. Cards that are dirty or that have deep scratches will sometimes not read properly.
6. If you are trying to operate the calculator outside the recommended temperature range, you may experience problems with the card reader. Low temperatures may cause the calculator to register *Error* when a magnetic card is read.

Temperature Range

Temperature ranges for the calculator are:

Operating	+10° to 40°C	+50° to 104°F
Charging	+10° to 40°C	+50° to 104°F
Storage	−40° to +55°C	−40° to +131°F

Warranty

Full One-Year Warranty

All Hewlett-Packard calculators and their accessories are warranted against defects in materials and workmanship for one (1) year from the date of delivery. During the warranty period Hewlett-Packard will repair or, at its option, replace at no charge components that prove to be defective, provided the calculator or accessory is returned, shipping prepaid, to Hewlett-Packard's Customer Service Facility. (Refer to Shipping Instructions.)

This warranty does not apply if the calculator or accessory has been damaged by accident or misuse or as a result of service or modification by other than an authorized Hewlett-Packard Customer Service Facility. No other expressed warranty is given by Hewlett-Packard. **Hewlett-Packard shall not be liable for consequential damages.**

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

WARRANTY INFORMATION TOLL-FREE NUMBER:
800/648-4711 (In Nevada call collect 702/323-2704.)

Repair Policy

Repair Time

Hewlett-Packard calculators are normally repaired and reshipped within five (5) working days of receipt at any Customer Service Facility. This is an average time and could possibly vary depending upon time of year and work load at the Customer Service Facility.

Shipping Instructions

The calculator should be returned, along with completed Service Card, in its shipping case (or other protective package) to avoid in-transit damage. Such damage is not covered by warranty, and Hewlett-Packard suggests that the customer insure shipments to the Customer Service Facility. A calculator returned for repair should include the ac adapter/recharger and the battery pack. Send these items to the address shown on the Service Card.

Shipping Charges

Whether the calculator is in-warranty or out-of-warranty, the customer should prepay shipment to the Hewlett-Packard Customer Service Facility. During warranty, Hewlett-Packard will prepay shipment back to the customer.

Further Information

Service contracts are not available. Calculator circuitry and design are proprietary to Hewlett-Packard, and Service Manuals are not available to customers.

Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard Sales Office or Customer Service Facility.

Appendix C

Improper Operations

If you attempt a calculation containing an improper operation—say, division by zero—the calculator display will show Error. The following are improper operations:

÷	where x = 0
y^x	where y = 0 and x ≤ 0
y^x	where y < 0 and x is non-integer
$\sqrt{x}$	where x < 0
$1/x$	where x = 0
LOG	where x ≤ 0
LN	where x ≤ 0
SIN^{-1}	where |x| is > 1
COS^{-1}	where |x| is > 1
STO ÷	where x = 0
$\bar{x}$	where n = 0
s	where n ≤ 1

STO + n, STO − n, STO × n, STO ÷ n, where magnitude of number in storage register n would then be larger than $9.999999999 \times 10^{99}$.

%CH	where y = 0
DSP (i)	where ABS (INT I) > 9
STO (i)	where ABS (INT I) > 25
RCL (i)	where ABS (INT I) > 25

STO + (i), STO − (i), STO × (i), STO ÷ (i), where ABS (INT I) > 25, or where magnitude of number in storage register addressed by I would be larger than $9.999999999 \times 10^{99}$.

ISZ (i), DSZ(i), where ABS (INT I) > 25

GTO (i), GSB (i), where −999 > INT I > 19

Card reader malfunction.

Attempting to record on a protected side of a magnetic card.

Appendix D

Stack Lift and LAST X

Your HP-67 calculator has been designed to operate in a natural, normal manner. As you have seen as you worked through this handbook, you are seldom required to think about the operation of the automatic memory stack—you merely work through calculations in the same way you would with a pencil and paper, performing one operation at a time.

There may be occasions, however, particularly as you program the HP-67, when you wish to know the effect of a particular operation upon the stack. The following explanation should help you.

Digit Entry Termination

Most operations on the calculator, whether executed as instructions in a program or pressed from the keyboard, terminate digit entry. This means that the calculator knows that any digits you key in after any of these operations are part of a new number.

Stack Lift

There are three types of operations on the calculator, depending upon how they affect the stack lift. These are stack *disabling* operations, stack *enabling* operations, and *neutral* operations.

Disabling Operations

There are only four stack disabling operations on the calculator. These operations disable the stack lift, so that a number keyed in after one of these disabling operations writes over the current number in the displayed X-register and the stack does not lift. These special disabling operations are:

ENTER↑ CLx Σ+ Σ−

Enabling Operations

The bulk of the operations on the keyboard, including one- and two-number mathematical functions like x^2 and ×, are stack *enabling* operations. These operations enable the stack lift, so that a number keyed in after one of the enabling operations lifts the stack.

Neutral Operations

Some operations, like STK and FIX, are neutral; that is, they do not alter the previous status of the stack lift. Thus, if you have previously disabled the stack lift by pressing ENTER↑, then press STK and key in a new number, that number will write over the number in the X-register and the stack will not lift. Similiarly, if you have previously enabled the stack lift by executing, say, x^2, then execute a FIX instruction followed by a digit entry sequence, the stack will lift.

The following operations are neutral on the HP-67:

FIX
SCI
ENG
DSP n, (i) — Display Control

-x-
STK
SPACE
REG — HP-97 Printer Compatability Commands

CL PRGM
DEL — In RUN Mode

MERGE

LAST X

The following operations save x in LAST X:

−
+
×
÷
→H.MS
H→
ABS
RND
→R
D→
H.MS+

Σ+
Σ−
%CH
RCL Σ+
$\bar{x}$
s
FRAC
INT
LN
LOG
SIN

SIN^{-1}
N!
%
COS
COS^{-1}
TAN
TAN^{-1}
$\sqrt{x}$
x^2

$1/x$
y^x
e^x
10^x
R→
→P

Appendix E

Calculator Functions and Keycodes

This table shows the corresponding functions that can be loaded into program memory on the HP-67 Programmable Pocket Calculator and the HP-97 Programmable Printing Calculator.

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
0	0	00	0	00
1	1	01	1	01
2	2	02	2	02
3	3	03	3	03
4	4	04	4	04
5	5	05	5	05
6	6	06	6	06
7	7	07	7	07
8	8	08	8	08
9	9	09	9	09
.	•	-62	•	83
1/X	1/x	52	h 1/x	35 62
10*	f 10^x	16 33	g 10^x	32 53
ABS	f ABS	16 31	h ABS	35 64
CF0	f CLF 0	16 22 00	h CF 0	35 61 00
CF1	f CLF 1	16 22 01	h CF 1	35 61 01
CF2	f CLF 2	16 22 02	h CF 2	35 61 02
CF3	f CLF 3	16 22 03	h CF 3	35 61 03
CHS	CHS	-22	CHS	42
CLRG	f CL REG	16-53	f CL REG	31 43
CLX	CL x	-51	CL x	44
COS	COS	42	f COS	31 63
COS-1	f COS^-1	16 42	g COS^-1	32 63
DEG	f DEG	16-21	h DEG	35 41
÷	÷	-24	÷	81
D→R	f D→R	16 45	g →R	32 73

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
DSP0	DSP 0	-63 00	DSP 0	23 00
DSP1	DSP 1	-63 01	DSP 1	23 01
DSP2	DSP 2	-63 02	DSP 2	23 02
DSP3	DSP 3	-63 03	DSP 3	23 03
DSP4	DSP 4	-63 04	DSP 4	23 04
DSP5	DSP 5	-63 05	DSP 5	23 05
DSP6	DSP 6	-63 06	DSP 6	23 06
DSP7	DSP 7	-63 07	DSP 7	23 07
DSP8	DSP 8	-63 08	DSP 8	23 08
DSP9	DSP 9	-63 09	DSP 9	23 09
DSPi	DSP (i)	-63 45	DSP (i)	23 24
DSZI	f DSZ I	16 25 46	f DSZ	31 33
DSZi	f DSZ (i)	16 25 45	g DSZ(i)	32 33
EEX	EEX	-23	EEX	43
ENG	ENG	-13	h ENG	35 23
ENT↑	ENTER↑	-21	ENTER↑	41
e^x	e^x	33	g e^x	32 52
F0?	f F? 0	16 23 00	h F? 0	35 71 00
F1?	f F? 1	16 23 01	h F? 1	35 71 01
F2?	f F? 2	16 23 02	h F? 2	35 71 02
F3?	f F? 3	16 23 03	h F? 3	35 71 03
FRC	f FRAC	16 44	g FRAC	32 83
FIX	FIX	-11	f FIX	31 23
GRAD	f GRD	16-23	h GRD	35 43
GSB0	GSB 0	23 00	f GSB 0	31 22 00
GSB1	GSB 1	23 01	f GSB 1	31 22 01
GSB2	GSB 2	23 02	f GSB 2	31 22 02
GSB3	GSB 3	23 03	f GSB 3	31 22 03
GSB4	GSB 4	23 04	f GSB 4	31 22 04
GSB5	GSB 5	23 05	f GSB 5	31 22 05
GSB6	GSB 6	23 06	f GSB 6	31 22 06
GSB7	GSB 7	23 07	f GSB 7	31 22 07
GSB8	GSB 8	23 08	f GSB 8	31 22 08
GSB9	GSB 9	23 09	f GSB 9	31 22 09
GSBA	GSB A	23 11	f GSB A	31 22 11
GSBB	GSB B	23 12	f GSB B	31 22 12

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
GSBC	GSB C	23 13	f GSB C	31 22 13
GSBD	GSB D	23 14	f GSB D	31 22 14
GSBE	GSB E	23 15	f GSB E	31 22 15
GSBa	GSB f a	23 16 11	g GSB f a	32 22 11
GSBb	GSB f b	23 16 12	g GSB f b	32 22 12
GSBc	GSB f c	23 16 13	g GSB f c	32 22 13
GSBd	GSB f d	23 16 14	g GSB f d	32 22 14
GSBe	GSB f e	23 16 15	g GSB f e	32 22 15
GSBi	GSB (i)	23 45	f GSB (i)	31 22 24
GTO0	GTO 0	22 00	GTO 0	22 00
GTO1	GTO 1	22 01	GTO 1	22 01
GTO2	GTO 2	22 02	GTO 2	22 02
GTO3	GTO 3	22 03	GTO 3	22 03
GTO4	GTO 4	22 04	GTO 4	22 04
GTO5	GTO 5	22 05	GTO 5	22 05
GTO6	GTO 6	22 06	GTO 6	22 06
GTO7	GTO 7	22 07	GTO 7	22 07
GTO8	GTO 8	22 08	GTO 8	22 08
GTO9	GTO 9	22 09	GTO 9	22 09
GTOA	GTO A	22 11	GTO A	22 11
GTOB	GTO B	22 12	GTO B	22 12
GTOC	GTO C	22 13	GTO C	22 13
GTOD	GTO D	22 14	GTO D	22 14
GTOE	GTO E	22 15	GTO E	22 15
GTOa	GTO f a	22 16 11	GTO f a	22 31 11
GTOb	GTO f b	22 16 12	GTO f b	22 31 12
GTOc	GTO f c	22 16 13	GTO f c	22 31 13
GTOd	GTO f d	22 16 14	GTO f d	22 31 14
GTOe	GTO f e	22 16 15	GTO f e	22 31 15
GTOi	GTO (i)	22 45	GTO (i)	22 24
→HMS	f →H.MS	16 35	g →H.MS	32 74
HMS→	f H.MS→	16 36	f H→	31 74
HMS+	f H.MS+	16–55	h H.MS+	35 83
INT	f INT	16 34	f INT	31 83
ISZI	f ISZ I	16 26 46	f ISZ	31 34
ISZi	f ISZ (i)	16 26 45	g ISZ (i)	32 34

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
*LBL0	LBL 0	21 00	f LBL 0	31 25 00
*LBL1	LBL 1	21 01	f LBL 1	31 25 01
*LBL2	LBL 2	21 02	f LBL 2	31 25 02
*LBL3	LBL 3	21 03	f LBL 3	31 25 03
*LBL4	LBL 4	21 04	f LBL 4	31 25 04
*LBL5	LBL 5	21 05	f LBL 5	31 25 05
*LBL6	LBL 6	21 06	f LBL 6	31 25 06
*LBL7	LBL 7	21 07	f LBL 7	31 25 07
*LBL8	LBL 8	21 08	f LBL 8	31 25 08
*LBL9	LBL 9	21 09	f LBL 9	31 25 09
*LBLA	LBL A	21 11	f LBL A	31 25 11
*LBLB	LBL B	21 12	f LBL B	31 25 12
*LBLC	LBL C	21 13	f LBL C	31 25 13
*LBLD	LBL D	21 14	f LBL D	31 25 14
*LBLE	LBL E	21 15	f LBL E	31 25 15
*LBLa	LBL f a	21 16 11	g LBL f a	32 25 11
*LBLb	LBL f b	21 16 12	g LBL f b	32 25 12
*LBLc	LBL f c	21 16 13	g LBL f c	32 25 13
*LBLd	LBL f d	21 16 14	g LBL f d	32 25 14
*LBLe	LBL f e	21 16 15	g LBL f e	32 25 15
LN	LN	32	f LN	31 52
LOG	f LOG	16 32	f LOG	31 53
LSTX	f LAST x	16-63	h LST x	35 82
-	−	-45	−	51
MRG	f MERGE	16-62	g MERGE	32 41
N!	f N!	16 52	h N!	35 81
→P	→P	34	g →P	32 72
%	%	55	f %	31 82
%CH	f %CH	16 55	g %CH	32 82
PI	f π	16-24	h π	35 73
+	+	-55	+	61
PREG	f REG	16-13	h REG	35 74
PRST	f STACK	16-14	g STK	32 84
PRTX	PRINT x	-14	f -x-	31 84
P≥S	f P≥S	16-51	f P≥S	31 42
PSE	f PAUSE	16 51	h PAUSE	35 72

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
→R	→R	44	f R←	31 72
R↓	R↓	−31	h R↓	35 53
R↑	f R↓	16−31	h R↓	35 54
RAD	f RAD	16−22	h RAD	35 42
R→D	f R→D	16 46	f D←	31 73
RCL0	RCL 0	36 00	RCL 0	34 00
RCL1	RCL 1	36 01	RCL 1	34 01
RCL2	RCL 2	36 02	RCL 2	34 02
RCL3	RCL 3	36 03	RCL 3	34 03
RCL4	RCL 4	36 04	RCL 4	34 04
RCL5	RCL 5	36 05	RCL 5	34 05
RCL6	RCL 6	36 06	RCL 6	34 06
RCL7	RCL 7	36 07	RCL 7	34 07
RCL8	RCL 8	36 08	RCL 8	34 08
RCL9	RCL 9	36 09	RCL 9	34 09
RCLA	RCL A	36 11	RCL A	34 11
RCLB	RCL B	36 12	RCL B	34 12
RCLC	RCL C	36 13	RCL C	34 13
RCLD	RCL D	36 14	RCL D	34 14
RCLE	RCL E	36 15	RCL E	34 15
RCLI	RCL I	36 46	h RCL I	35 34
RCL(	RCL (i)	36 45	RCL (i)	34 24
RCLΣ	RCL Σ+	36 56	RCL Σ+	34 21
RND	f RND	16 24	f RND	31 24
R/S	R/S	51	R/S	84
RTN	RTN	24	h RTN	35 22
S	f S	16 54	g S	32 21
SCI	SCI	−12	g SCI	32 23
SF0	f STF 0	16 21 00	h SF 0	35 51 00
SF1	f STF 1	16 21 01	h SF 1	35 51 01
SF2	f STF 2	16 21 02	h SF 2	35 51 02
SF3	f STF 3	16 21 03	h SF 3	35 51 03
Σ+	Σ+	56	Σ+	21
Σ−	f Σ−	16 56	h Σ−	35 21
SIN	SIN	41	f SIN	31 62

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
SIN⁻¹	f SIN⁻¹	16 41	g SIN⁻¹	32 62
SPC	f SPACE	16-11	h SPACE	35 84
√x	√x	54	f √x	31 54
ST÷0	STO ÷ 0	35-24 00	STO ÷ 0	33 81 00
ST÷1	STO ÷ 1	35-24 01	STO ÷ 1	33 81 01
ST÷2	STO ÷ 2	35-24 02	STO ÷ 2	33 81 02
ST÷3	STO ÷ 3	35-24 03	STO ÷ 3	33 81 03
ST÷4	STO ÷ 4	35-24 04	STO ÷ 4	33 81 04
ST÷5	STO ÷ 5	35-24 05	STO ÷ 5	33 81 05
ST÷6	STO ÷ 6	35-24 06	STO ÷ 6	33 81 06
ST÷7	STO ÷ 7	35-24 07	STO ÷ 7	33 81 07
ST÷8	STO ÷ 8	35-24 08	STO ÷ 8	33 81 08
ST÷9	STO ÷ 9	35-24 09	STO ÷ 9	33 81 09
ST-0	STO − 0	35-45 00	STO − 0	33 51 00
ST-1	STO − 1	35-45 01	STO − 1	33 51 01
ST-2	STO − 2	35-45 02	STO − 2	33 51 02
ST-3	STO − 3	35-45 03	STO − 3	33 51 03
ST-4	STO − 4	35-45 04	STO − 4	33 51 04
ST-5	STO − 5	35-45 05	STO − 5	33 51 05
ST-6	STO − 6	35-45 06	STO − 6	33 51 06
ST-7	STO − 7	35-45 07	STO − 7	33 51 07
ST-8	STO − 8	35-45 08	STO − 8	33 51 08
ST-9	STO − 9	35-45 09	STO − 9	33 51 09
ST+0	STO + 0	35-55 00	STO + 0	33 61 00
ST+1	STO + 1	35-55 01	STO + 1	33 61 01
ST+2	STO + 2	35-55 02	STO + 2	33 61 02
ST+3	STO + 3	35-55 03	STO + 3	33 61 03
ST+4	STO + 4	35-55 04	STO + 4	33 61 04
ST+5	STO + 5	35-55 05	STO + 5	33 61 05
ST+6	STO + 6	35-55 06	STO + 6	33 61 06
ST+7	STO + 7	35-55 07	STO + 7	33 61 07
ST+8	STO + 8	35-55 08	STO + 8	33 61 08
ST+9	STO + 9	35-55 09	STO + 9	33 61 09
ST×0	STO × 0	35-35 00	STO × 0	33 71 00
ST×1	STO × 1	35-35 01	STO × 1	33 71 01
ST×2	STO × 2	35-35 02	STO × 2	33 71 02

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
STx3	STO × 3	35-35 03	STO × 3	33 71 03
STx4	STO × 4	35-35 04	STO × 4	33 71 04
STx5	STO × 5	35-35 05	STO × 5	33 71 05
STx6	STO × 6	35-35 06	STO × 6	33 71 06
STx7	STO × 7	35-35 07	STO × 7	33 71 07
STx8	STO × 8	35-35 08	STO × 8	33 71 08
STx9	STO × 9	35-35 09	STO × 9	33 71 09
ST÷i	STO ÷ (i)	35-24 45	STO ÷ (i)	33 81 24
ST-i	STO − (i)	35-45 45	STO − (i)	33 51 24
ST+i	STO + (i)	35-55 45	STO + (i)	33 61 24
STxi	STO × (i)	35-35 45	STO × (i)	33 71 24
ST00	STO 0	35 00	STO 0	33 00
ST01	STO 1	35 01	STO 1	33 01
ST02	STO 2	35 02	STO 2	33 02
ST03	STO 3	35 03	STO 3	33 03
ST04	STO 4	35 04	STO 4	33 04
ST05	STO 5	35 05	STO 5	33 05
ST06	STO 6	35 06	STO 6	33 06
ST07	STO 7	35 07	STO 7	33 07
ST08	STO 8	35 08	STO 8	33 08
ST09	STO 9	35 09	STO 9	33 09
STOA	STO A	35 11	STO A	33 11
STOB	STO B	35 12	STO B	33 12
STOC	STO C	35 13	STO C	33 13
STOD	STO D	35 14	STO D	33 14
STOE	STO E	35 15	STO E	33 15
STOI	STO I	35 46	h STI	35 33
STOi	STO (i)	35 45	STO (i)	33 24
TAN⁻¹	f TAN⁻¹	16 43	g TAN⁻¹	32 64
TAN	TAN	43	f TAN	31 64
x	×	-35	×	71
WDTA	f W/DATA	16-61	f W/DATA	31 41
X≠0?	f X≠0?	16-42	f X≠0	31 61
X=0?	f X=0?	16-43	f X=0	31 51
X>0?	f X>0?	16-44	f X>0	31 81
X<0?	f X<0?	16-45	f X<0	31 71

HP-97 Tape Symbol	HP-97 Keystrokes	HP-97 Keycode	HP-67 Keystrokes	HP-67 Keycode
$X \neq Y?$	f [x≠y?]	16–32	g [x≠y]	32 61
$X = Y?$	f [x=y?]	16–33	g [x=y]	32 51
$X > Y?$	f [x>y?]	16–34	g [x>y]	32 81
$X \leq Y?$	f [x≤y?]	16–35	g [x≤y]	32 71
$\overline{x}$	f [$\overline{x}$]	16 53	f [$\overline{x}$]	31 21
x^2	[x^2]	53	g [x^2]	32 54
$x \rightleftarrows I$	f [x≷I]	16–41	h [x≷I]	35 24
$x \rightleftarrows y$	[x≷y]	–41	h [x≷y]	35 52
y^x	[y^x]	31	h [y^x]	35 63

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Service Card

Refer to the appendix of your Owner's Handbook to diagnose a calculator malfunction. The warranty period for your calculator is one year from date of purchase. Unless **Proof of Purchase** is enclosed (sales slip or validation) Hewlett-Packard will assume any unit over 12 months old is out of warranty. **(Proof of Purchase** will be returned with your calculator.) Should service be required, please return your calculator, charger, batteries and this card protectively packaged to avoid in-transit damage. Such damage is not covered under warranty.

Inside the U.S.A.
Return items safely packaged directly to:

Hewlett-Packard
APD Service Department
P.O. Box 999
Corvallis, Oregon 97330

We advise that you insure your calculator and use priority (AIR) mail for distances greater than 300 miles to minimize transit times. All units will be returned by fastest practical means.

Outside the U.S.A.
Where required please fill in the validation below and return your unit to the nearest designated Hewlett-Packard Sales and Service Office. Your warranty will be considered invalid if this completed card is not returned with the calculator.

Model No. _____ Serial No. _____

Date Received _____

Invoice No./Delivery Note No. _____

Sold by:

Calculator Catalog and Buying Guide Request Card

Primary Interest:

- ☐ *Scientific Calculators*
- ☐ *Business Calculators*
- ☐ *Fully Scientific Printing Calculator*
- ☐ *All the above*

Valid in U.S. only

HEWLETT hp PACKARD

430H

Thank you for your order. A friend or associate might also like to know about Hewlett-Packard calculators. If you would like us to send him/her the *new* **HEWLETT-PACKARD PERSONAL CALCULATOR DIGEST** *(the HP Magazine and Product Catalog)*, please write his/her name and address on this postage paid Request Card.

Name _____

Title _____

Company _____

Street _____

City _____ State _____ Zip _____

Useful Conversion Factors

The following factors are provided to 10 digits of accuracy where possible. Exact values are marked with an asterisk. For more complete information on conversion factors, refer to *Metric Practice Guide E380-74* by the American Society for Testing and Materials (ASTM).

Length

1 inch	= 25.4 millimeters*
1 foot	= 0.304 8 meter*
1 mile (statute)†	= 1.609 344 kilometers*
1 mile (nautical)†	= 1.852 kilometers*
1 mile (nautical)†	= 1.150 779 448 miles (statute)†

Area

1 square inch	= 6.451 6 square centimeters*
1 square foot	= 0.092 903 04 square meter*
1 acre	= 43 560 square feet
1 square mile†	= 640 acres

Volume

1 cubic inch	= 16.387 064 cubic centimeters*
1 cubic foot	= 0.028 316 847 cubic meter
1 ounce (fluid)†	= 29.573 529 56 cubic centimeters
1 ounce (fluid)†	= 0.029 573 530 liter
1 gallon (fluid)†	= 3.785 411 784 liters*

Mass

1 ounce (mass)	= 28.349 523 12 grams
1 pound (mass)	= 0.453 592 37 kilogram*
1 ton (short)	= 0.907 184 74 metric ton*

Energy

1 British thermal unit	= 1 055.055 853 joules
1 kilocalorie (mean)	= 4 190.02 joules
1 watt-hour	= 3 600 joules*

Force

1 ounce (force)	= 0.278 013 85 newton
1 pound (force)	= 4.448 221 615 newtons

Power

1 horsepower (electric)	= 746 watts*

Pressure

1 atmosphere	= 760 mm Hg at sea level
1 atmosphere	= 14.7 pounds per square inch
1 atmosphere	= 101 325 pascals

Temperature

Fahrenheit	= 1.8 Celsius + 32
Celsius	= 5/9 (Fahrenheit − 32)
kelvin	= Celsius + 273.15
kelvin	= 5/9 (Fahrenheit + 459.67)
kelvin	= 5/9 Rankine

† U.S. values chosen. * Exact values.

1000 N.E. Circle Blvd., Corvallis, OR 97330

For additional Sales and Service Information contact your local Hewlett-Packard Sales Office or call 503/757-2000 (ask for Calculator Customer Service).

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