

HEWLETT-PACKARD

HP-25

Owner's Handbook



"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 pocket calculator in 1972, we've sold over 700,000 world-wide. Their owners include Nobel laureates, astronauts, mountain climbers, businessmen, doctors, students, and housewives.

Each of our pocket 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.

(Cover background courtesy of NASA)

RELeYon



HP-25

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The HP-25 Programmable Scientific Calculator

Function Key Index

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

Function keys pressed from the keyboard execute individual functions as they are pressed. Input numbers and answers are displayed.

- FIX** Fixed display. Followed by a number key, selects fixed point notation display (page 26).
- SCI** Scientific display. Followed by a number key, selects scientific notation display (page 27).
- ENG** Engineering display. Followed by a number key, selects engineering notation display (page 28).
- f** Prefix key. Press before function key to select function printed in gold on the keyboard above function key (page 13).
- g** Prefix key. Press before function key to select function printed in blue on slanted face of function key (page 13).
- $\bar{x}$** Mean. Calculates mean (average) of the numbers totaled by $\Sigma+$ in storage register R_7 (page 67).
- $x \leftrightarrow y$** x exchange y. Exchanges contents of X- and Y-registers (page 37).
- %** Percent. Calculates x% of y (page 54).
- S** Standard deviation. Calculates standard deviation using numbers totaled by $\Sigma+$ in storage registers R_3 through R_7 (page 68).
- R↓** Roll down. Rolls down contents of stack for viewing in displayed X-register (page 36).
- $1/x$** Reciprocal. Calculates reciprocal of the number in the display (page 52).
- STO** Store. Followed by number key, stores displayed number in storage register (0-7) specified. Followed by arithmetic operator key, performs storage register arithmetic (page 55).
- RCL** Recall. Followed by number key, recalls value from storage register (0-7) specified into the displayed X-register (page 55).
- $\Sigma-$** Summation minus. Subtracts values from storage registers R_3 through R_7 for correcting $\Sigma+$ summation entries (page 69).
- $\Sigma+$** Summation. Sums numbers in X- and Y-registers into storage registers R_3 through R_7 (page 66).
- PREFIX** Clear prefix. After **f**, **g**, **STO**, **RCL** or **GTO**, cancels that key (page 50).
- ENTER↗** Copies number in displayed X-register into Y-register (page 16).
- CHS** Change sign. Changes sign of displayed number or exponent of 10 (page 14).
- DEG** Degrees. Sets decimal degree mode for trigonometric functions (page 59).
- REG** Clear registers. Replaces contents of storage registers R_0 through R_7 with zeros (page 56).

EE^x Enter exponent. After pressing, next numbers keyed in are exponents of 10 (page 31).

RAD Radians. Sets radians mode for trigonometric functions (page 59).

STK Clear stack. Replaces contents of X-, Y-, Z-, and T-registers with zeros (page 37).

CLX Clear x. Clears the displayed X-register to zero (page 15).

GRD Grads. Sets grads mode for trigonometric functions (page 59).

+ **-** **x** **÷**
Arithmetic operators (page 16).

ln Natural logarithm. Computes natural logarithm (base e, 2.718. . .) of value in displayed X-register (page 63).

e^x Natural antilog. Raises e (2.718. . .) to the power of value in displayed X-register (page 63).

log Common logarithm. Computes common logarithm (base 10) of value in displayed X-register (page 63).

10^x Common antilogarithm. Raises 10 to the power of number in displayed X-register (page 63).

→R Rectangular coordinate conversion. Converts polar magnitude and angle in X- and Y-registers to rectangular x and y coordinates (page 62).

→P Polar coordinate conversion. Converts x, y rectangular coordinates placed in X- and Y-registers to polar magnitude and angle (page 62).

sin **cos** **tan** Sine, cosine, and tangent. Calculate the sine, cosine, or tangent of value in displayed X-register (page 59).

sin⁻¹ **cos⁻¹** **tan⁻¹**
Arc sine, arc cosine, arc tangent. Calculate inverse trigonometric function of value in display (page 59).

INT Integer. Leaves only integer portion of number in displayed X-register by truncating fractional portion (page 51).

FRAC Fraction. Leaves only fractional portion of number in displayed X-register by truncating integer portion (page 51).

√x Computes square root of number in displayed X-register (page 52).

x² Computes square of number in displayed X-register (page 53).

y^x Raises number in Y-register to the power of the number in the displayed X-register (page 64).

ABS Absolute. Gives the absolute value of the displayed number (page 51).

→H.MS Converts displayed decimal hours or degrees to *hours, minutes, seconds* format (page 60).

→H Converts displayed value in *hours, minutes, seconds* format to decimal hours or degrees (page 60).

LAST X Recalls number displayed before the previous operation back into the displayed X-register (page 49).

π Pi. Places value of pi (3.14159. . .) into displayed X-register (page 53).

HP-25 Memory

Automatic Memory Stack

T	0.00	} Stack Registers
Z	0.00	
Y	0.00	

Sign Mantissa Exponent of 10 sign
 Exponent of 10

X {  } Display



Storage Registers

R ₀	0.00
R ₁	0.00
R ₂	0.00
R ₃	0.00
R ₄	0.00
R ₅	0.00
R ₆	0.00
R ₇	0.00

Program Memory

Automatic

Stop	00		
	01	13	00
	02	13	00
	03	13	00
	04	13	00
	05	13	00
	06	13	00

47	13 00
48	13 00
49	13 00

Programming Key Index

PROGRAM Mode

PRGM-RUN switch
set to: PRGM  RUN

Function keys are recorded in program memory. Display shows program memory step number and the keycode (keyboard row and location in row) of the function key.

Active keys:

In *program* mode only three keys are active. These keys cannot be recorded in program memory.

PRGM Clear program. Clears program memory to GTO 00 instructions and resets calculator so operations begin at step 00 of program memory (**page 78**).

Automatic RUN Mode

PRGM-RUN switch
set to: PRGM  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, except where indicated.

Pressed from keyboard:

PRGM Clear program. Resets calculator so operations begin at step 00 of program memory (**page 78**).

R/S Run/stop. Begins execution of a stored program. Stops execution if program is running (**page 83**).

GTO Go to. Followed by two-digit number, positions calculator to that step number of program memory. No instructions are executed (**page 82**).

Executed as a recorded program instruction:

R/S Run/stop. Stops program execution (**page 83**).

GTO Go to. Followed by a two-digit number, causes calculator to execute the instruction at the specified step number next, and continue program execution sequentially from there (**page 87**).

PROGRAM Mode

Active keys :

SST Single step.
Displays step number and contents of next program memory step (page 81).

BST Back step.
Displays step number and contents of previous program memory step (page 81).

Automatic RUN Mode

Pressed from keyboard:

SST Single step.
Displays step number and keycode of current program memory step when pressed; executes instruction, displays result, and moves to next step when released (page 92).

BST Back step.
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 93).

Any key. Pressing any key on the keyboard stops execution of a program.

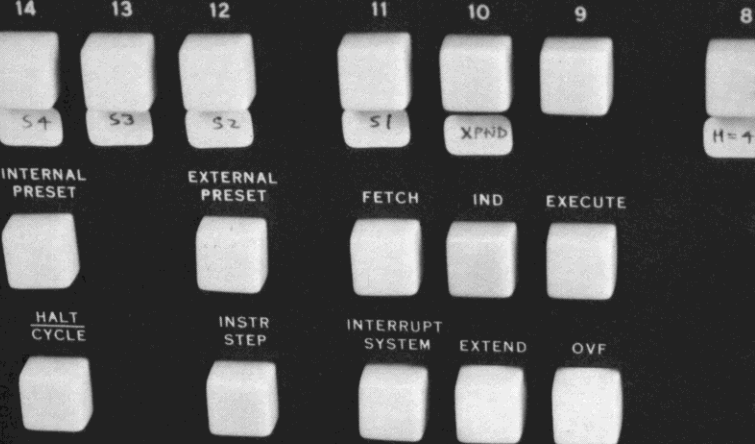
Executed as a recorded program instruction:

PAUSE Pause.
Stops program execution for 1 second and displays contents of X-register, then resumes program execution (page 84).

$x < y$	$x \geq y$	$x \neq y$	$x = y$
$x < 0$	$x \geq 0$	$x \neq 0$	$x = 0$

Conditionals. Each tests value in X-register against that in Y-register or 0 as indicated. If true, calculator executes instruction in next program memory step. If false, calculator skips next step (page 90).

NOP No operation.
Calculator executes no operation and continues program execution sequentially with the instruction in the next program memory step (page 94).



The HP-25 Means Painless Programming

Your HP-25 is a versatile, handheld electronic calculator that uses the powerful Hewlett-Packard logic system to compute answers to complex mathematical problems in either of two modes:

- **Manual problem solving.** You work step-by-step through the toughest of problems, choosing from among the dozens of functions available to calculate the correct answer quickly and easily.
- **Programmed problem solving.** The HP-25 memorizes a sequence of up to 49 different functions as you press them, and then repeats that sequence automatically as often as you wish to solve a particular type of problem.

That's all there is to it! A *program* is nothing more than a sequence of manual keystrokes that is remembered by the calculator. You can then *execute* the program as often as you like. *No prior computer programming experience is necessary for HP-25 calculator programming.*

To see the close relationship between the manual solution to a problem and a programmed solution, let's solve a problem manually, and then use a program to solve the same problem and others like it.

Manual Problem Solving

To calculate the surface area of a sphere, the formula $A = \pi d^2$ can be used, where: A is the surface area, π is the value of pi, 3.1415..., and d is the diameter of the sphere.

Ganymede, one of Jupiter's 12 moons, has a diameter of 3200 miles. To use the HP-25 to manually compute the area of Ganymede, you can press the following keys in order:

First, slide the calculator OFF  ON switch to ON, and slide the PRGM  RUN switch to RUN.

Then press

Display



3200.

Diameter of Ganymede.



10240000.00

Square of the diameter.



3.14

The quantity π .

32169908.78

Area of Ganymede in square miles.

Programmed Problem Solving

If you wanted the surface areas of each of Jupiter's 12 moons, you could repeat the above procedure 12 times. However, you might wish to write a *program* that would calculate 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 *write* the program, then you must *record* the program into the calculator, and finally you *run* the program to calculate the answer.

Writing the Program: You have already written it! A program is nothing more than the series of keystrokes you would execute to solve the same problem manually.

Recording the Program: To record the keystrokes of the program into the calculator:

1. Slide the PRGM-RUN switch  to PRGM (*program*).
2. Press   to clear the calculator.
3. Press the following keys in order. (When you are recording a program, the display gives you information that you will find useful later, but you can ignore the display for now.)



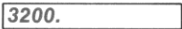
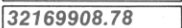
These keys are the same keys you pressed to solve the problem manually.

Running the Program: Slide the PRGM-RUN switch  back to RUN and press in order

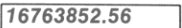


Now all you have to do to calculate the area of any sphere is key in the value for its diameter and press the  (run/stop) key. When you press  the sequence of keystrokes you recorded is automatically executed by the calculator, giving you the same answer you would have obtained manually:

For example, to calculate the area of Ganymede:

Press	Display	
3200		
		Square miles.

With the program you have recorded, 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 that you wish to compute, then press . For example, to compute the surface area of Jupiter's moon Io with a diameter of 2310 miles:

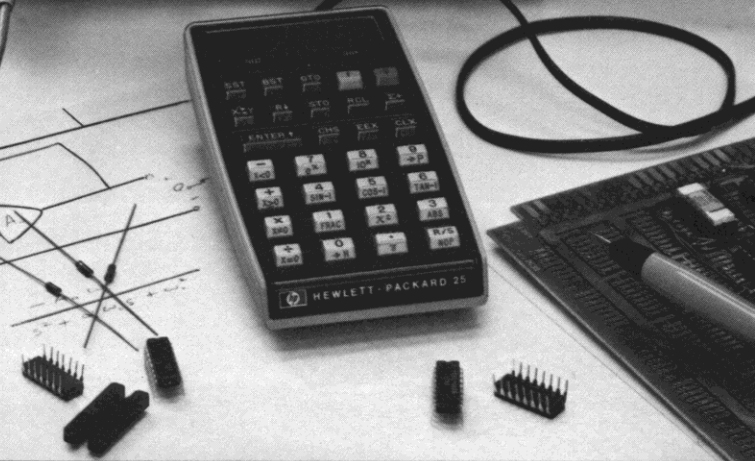
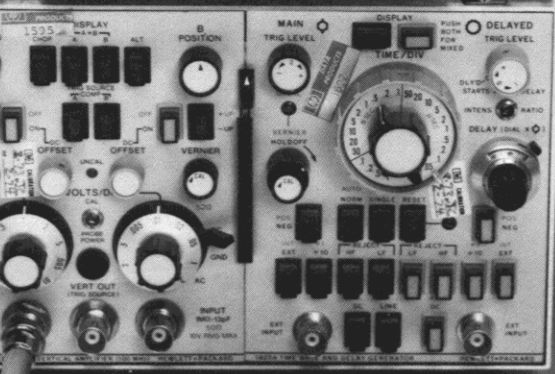
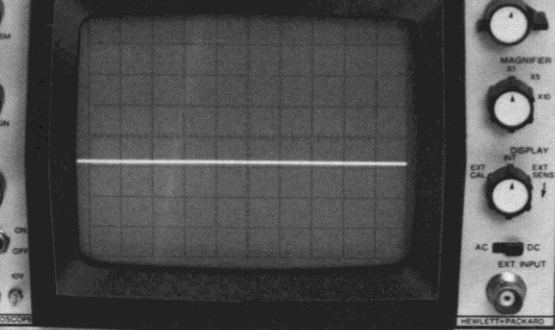
Press	Display	
2310 		Square miles.

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

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

Programming the HP-25 is *that* easy! The calculator remembers a series of keystrokes and then executes them when you press the  key.

The early portions of this handbook show you how easy it is to manually use the power of the HP-25; while in section 5, Programming, you will find a complete guide to HP-25 calculator programming. Even if you have used other pocket calculators or programmed large computers, you will want to take a good look at this handbook. It explains the unique HP logic system that makes simple answers out of complex problems, and HP-25 features that make programming painless. When you see the simple power of your HP-25, you'll become an apostle just as have some 700,000 HP calculator owners before you.



Getting Started

Your HP-25 is shipped fully assembled, including a battery. You can begin using your calculator immediately by connecting the cord from the ac adapter/battery charger to the calculator and plugging the charger into an ac outlet. If you want to use your HP-25 on battery power alone, you should charge the battery for 6 hours first. Whether you operate from battery power or from power supplied by the charger, *the battery must always be in the calculator.*

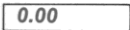
To begin:

- Slide the PRGM-RUN switch  to RUN.
- Slide the OFF-ON switch  to ON.

Display

With the PRGM-RUN switch set to RUN, the bright red display that you see when you turn the calculator ON gives you two kinds of information:

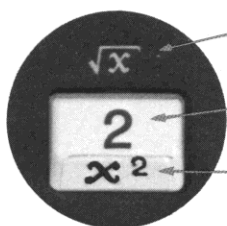
1. You see numbers as you key them in.
2. You see all intermediate and final answers as they are calculated.

When you first turn the calculator ON, the display is set to  to show you that all zeros are present there.

Keyboard

Most keys on the keyboard perform three functions. One function is indicated by the symbol on the flat face of the key, another by the blue symbol on the slanted key face, and a third by the gold symbol written above the key on the calculator case.

- To select the function printed in blue on the slanted face of the key, first press the blue prefix key , then press the function key.
- To select the function printed on the flat face of the key, press the key.
- To select the function printed in gold above the key, first press the gold prefix key , then press the function key.



To execute this function, first press **1**, then press **√x**.

To place this number into the display, press **2**.

To execute this function, first press **9**, then press **x²**.

In this handbook, the selected key function will appear in the appropriate color (either gold or blue), like this: **√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.

For 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 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 **CLX** (*clear x*). This key erases the number in the display and replaces it with 0.

Press	Display
CLX	0.00

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

Functions

In spite of the dozens of functions available on the HP-25 keyboard, you will find the calculator simple to operate by using a single, all-encompassing rule: *When you press a function key, the calculator immediately executes the function written on that key.*

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

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

Press	Display
148.84	148.84
f	148.84
$\sqrt{x}$	12.20

To square the result:

Press	Display
g	12.20
x^2	148.84

$\sqrt{x}$ and x^2 are examples of one-number function keys; that is, keys that execute upon a *single* number. All function keys in the HP-25 operate upon either one number or two numbers at a time (except for statistics keys like $\Sigma+$ and $\bar{S}$ —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 applicable prefix key, then the function key).

For example, to use the one-number function $\boxed{1/x}$ key, you first key in the number represented by x , then press the function key. To calculate $1/4$, key in 4 (the x -number) and press $\boxed{g} \boxed{1/x}$.

Press	Display
4	4.
$\boxed{g}$	4.
$\boxed{1/x}$	0.25

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

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

Two-Number Functions

Two-number functions are functions that must have two numbers present in order for the operation to be performed. $\boxed{+}$ $\boxed{-}$ $\boxed{\times}$ and $\boxed{\div}$ are examples of two-number function keys because 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 $\boxed{\text{ENTER}}$ 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, you add 12 and 3 by pressing:

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 x	36.00
$12 \div 3$	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 **y^x** , then **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, $\boxed{\sqrt{x}}$ means square root of the displayed number, $\boxed{1/x}$ means $\frac{1}{\text{displayed number}}$, etc.

Thus, to calculate 3^6 :

Press	Display
3	$\boxed{3.}$
ENTER $\blacktriangledown$	$\boxed{3.00}$
6	$\boxed{6.}$
f	$\boxed{6.}$
$\boxed{y^x}$	$\boxed{729.00}$

X, the displayed number, is now 6.

The answer.

Now try the following problems using the $\boxed{y^x}$ key, keeping in mind the simple rules for two-number functions:

$$16^4 \quad (16 \text{ to the 4th power}) = \boxed{65536.00}$$

$$81^2 \quad (81 \text{ squared}) = \boxed{6561.00}$$

(You could also have done this as a one-number function using $\boxed{x^2}$.)

$$225^{.5} \quad (\text{Square root of } 225) = \boxed{15.00}$$

(You could also have done this as a one-number function by using $\boxed{\sqrt{x}}$.)

$$2^{16} \quad (2 \text{ to the 16th power}) = \boxed{65536.00}$$

$$16^{.25} \quad (4\text{th root of } 16) = \boxed{2.00}$$

Chain Calculations

The speed and simplicity of operation of the HP-25's 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 $(12 + 3)$

$$\begin{array}{r} \cancel{(12 + 3)} \times 7 = \\ 15 \end{array}$$

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

$$\begin{array}{r} \cancel{(12 + 3)} \times 7 = 105 \\ 15 \times 7 \end{array}$$

You work through the problem exactly the same way with the HP-25, 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-25 automatically stores it inside the calculator when you key in the next number. To continue. . . .

Press	Display
7	7.
×	105.00

The intermediate result from the preceding operation is automatically stored inside the calculator when you key in this number.

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
$3(16 - 4)$	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:

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

First solve for the contents of these parentheses. . . .

. . . . and then for these parentheses

. . . . and then you would multiply the two intermediate answers together.

You work through the problem the same way with the HP-25. First you solve for the intermediate result of $(2 + 3)$. . .

	Press	Display	
$(2 + 3) \times (4 + 5)$ 5	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
$(2 + 3) \times (4 + 5)$ 5 9	4 ENTER ↵ 5 +	9.00

Then multiply the intermediate answers together for the final answer:

Procedure	Press	Display
$(2 + 3) \times (4 + 5)$ 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-25 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:

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

Press	Display	
9 ENTER 8 ×	72.00	Intermediate result of (9×8) .
7 ENTER 2 ×	14.00	Intermediate result of (7×2) .
+	86.00	(9×8) added to (7×2) .
4 ENTER 5 ×	20.00	Intermediate result of (4×5) .
÷	4.30	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.

Problems

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

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

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

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

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

A Word About the HP-25

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-25 program or using the HP-25 under manual control:

- *You never have to work with more than one function at a time.* The HP-25 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 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-25 solves the longest, most complex equations. With HP, the investment of a few moments of learning yields a lifetime of mathematical bliss.



Controlling the Display

In the HP-25, numbers in the display normally appear rounded to only two decimal places. For example, the fixed constant π , which is *actually* in the calculator as 3.141592654, normally *appears in the display as* 3.14 (unless you tell the calculator to show you 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-25 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 calculator *actually* calculates using full 10-digit numbers:

2.000000000 $\times 10^{00}$ ENTER 3.000000000 $\times 10^{00}$ ×

yields an answer that is actually carried to 10 digits:

You see only these digits. . .	6.000000000 $\times 10^{00}$	. . . but these digits are also present.

Display Control Keys

FIX allows numbers to be displayed in fixed decimal point format, SCI displays numbers in scientific notation format, and ENG displays numbers in engineering notation, with exponents of 10 shown in multiples of three (e.g., 10^3 , 10^{-6} , 10^9).

Display control alters only the *manner* in which numbers are displayed in the HP-25. The actual number itself is not altered by any of the display control keys. No matter what notation you select, these rounding options affect the display only—the HP-25 always calculates internally with a full 10-digit number (multiplied by 10 raised to a two-digit exponent).

Fixed Point Display



Using fixed point display you can specify the number of places to be shown after the decimal point. It is selected by pressing **f** **FIX**, followed by a number key to specify the number of decimal places (0-9) to which the display is to be rounded. The displayed number begins at the left side of the display and includes trailing zeros within the setting selected. When the calculator is turned OFF, then ON, it “wakes up” in fixed point notation with the display rounded to two decimal places. For example:

Press

(Turn the calculator OFF, then ON.)

123.4567 **ENTER** **↵**

Display

0.00

123.46

Display is rounded off to two decimal places. Internally, however, the number maintains its original value of 123.4567.

f **FIX** 4

123.4567

f **FIX** 7

123.4567000

f **FIX** 0

123.

f **FIX** 2

123.46

Normal FIX 2 display.

Scientific Notation Display



Scientific Notation Display

(This means $-1.2345678 \times 10^{-23}$)

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 seven) to the right of the decimal point and multiplied by a power of 10. It is particularly useful when working with very large or small numbers.

Scientific notation is selected by pressing **f** **[SCI]** followed by a number key to specify the number of decimal places to which the number is rounded. The display is left-justified and includes trailing zeros within the selected setting. For example:

Press	Display	
123.4567 ENTER	123.46	Normal FIX 2 display.
f [SCI] 2	1.23 02	Displays 1.23×10^2 .
f [SCI] 4	1.2346 02	Displays 1.2346×10^2 .
f [SCI] 7	1.2345670 02	Displays 1.2345670×10^2 .

In scientific notation, although the calculator displays a maximum of seven digits after the decimal point, it always maintains the full 10-digit number and the two-digit exponent of 10 internally. The portion of the number that is not displayed affects the rounding of the displayed portion.

For example, if you key in 1.000000094 and specify full scientific notation display (**f** **[SCI]** 7), the calculator display rounds off to the seventh digit after the decimal point:

1.0000000⁹4

Calculator rounds to this digit in SCI 7.

Press	Display
1.000000094	1.000000094
 SCI 7	1.0000001 00

In SCI 8, the display would round off to the eighth digit after the decimal point, but you can see only out to seven digits after the decimal:

1.000000094

You see to here . . .  . . . but the calculator display rounds to here in SCI 8.

Press	Display
 SCI 8	1.0000000 00

You can see that if you had keyed in 1.000000095, SCI 8 would also have caused the display to round the seventh and final digit after the decimal to a one (1).

Engineering Notation Display

Specified Digits

12.345678 - 09

First Three Digits
Always Present

Exponent of Ten Always
a Multiple of Three

Engineering Notation Display

Engineering notation allows all numbers to be shown with exponents of ten that are multiples of three (e.g., 10^3 , 10^{-6} , 10^9). This 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 **f** **ENG** followed by a number key. In engineering notation, the first three digits are always present, and the number key specifies the number of *additional* digits displayed after the first three. For example:

Press	Display	
0.000012345	0.000012345	
f ENG 0	12.3 -06	Engineering notation display. First three digits visible and power of 10 is the proper multiple of three.
f ENG 2	12.345 -06	The number key specifies the number of digits displayed beyond the first three.
f ENG 4	12.34500 -06	

Notice that because the first three digits are always present, the greatest number of additional digits that can be specified in engineering notation is five.

Press	Display	
f ENG 5	12.345000 -06	Maximum number of digits displayed.
f ENG 6	12.345000 -06	No change in display.
f ENG 7	12.345000 -06	No change in display.

Rounding of displayed numbers in ENG 5 and ENG 6 is similar to the rounding of numbers in SCI 7 and SCI 8, discussed earlier. As with all display formats, engineering notation display does not affect the *actual* number as it is held internally by the calculator, but only alters the manner in which the number is displayed.

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	
f ENG 0	12.3 -06	
10 x	123. -06	Decimal point shifts. Power of 10 remains at 10^{-6} .

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:

Press	Display	
10 $\times$	1.23 -03	Decimal point shifts. Power of 10 shifts to 10^{-3} .

Automatic Display Switching

The HP-25 switches the display from fixed point notation to full scientific notation (SCI 7) 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	0.00 00	ENG 0 from previous example.
f FIX 2	0.00	Normal FIX 2 display.
.05 ENTER	0.05	
3 f y^x	1.2500000 -04	Display automatically switched to SCI 7 to show answer.

Another way of displaying the answer would be 0.000125, but in normal FIX 2 display, you would have seen only 0.00 displayed.

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-25 also switches to scientific notation if the answer is too large ($> 10^{10}$) for fixed point display. The display will not switch from fixed if you solve 1582000×1842 :

Press	Display	
1582000 ENTER	1582000.00	
1842 $\times$	2914044000.	Fixed decimal point display.

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

Press

Display

10 $\times$

2.9140440 10

 Scientific notation display.

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 ten*). 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 $\uparrow$

1.5600000 13

25 $\times$

3.9000000 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 $\uparrow$

1000000.00

Since you have not specified scientific notation, the answer reverts to fixed point notation when you press

ENTER $\uparrow$.52 $\div$

19230.77

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

Press

Display

f **SCI** 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 2	0.00
6.625 EEX	6.625 00
CHS	6.625 -00
27	6.625 -27
ENTER ↑	6.6250000 -27
50 x	3.3125000 -25 Erg sec.

Using the **EEX** key, you can key in numbers made up of 10-digit mantissas and two-digit exponents of 10. However, when you use the **EEX** key, the HP-25 displays each number as an eight-digit mantissa and a two-digit exponent of 10. In a few cases, a number may have to be altered slightly in form before you can key it in using the **EEX** key:

- If you key in a number whose mantissa contains more than eight digits to the left of the decimal point, the **EEX** key is overridden and does not operate. Begin again and key in the number in a form that displays the mantissa with eight digits or less to the left of the decimal point before pressing the **EEX** key. (Thus, $123456789.1 \times 10^{23}$ could be keyed in as $12345678.91 \times 10^{24}$.)
- If you key in a number whose first significant digit occurs *after* the first eight digits of the display, the **EEX** key does not operate upon that number. To key in the number correctly, begin again and place the number in a form such that its first significant digit is one of the first eight digits of the display, then proceed using the **EEX** key. (Thus, $0000.000025 \times 10^{55}$ cannot be keyed in in that form. It could be keyed in as $0000.00025 \times 10^{54}$, or as 0.000025×10^{55} , for example.)

Calculator Overflow

When the number in the display would be greater than 9.9999999×10^{99} , the HP-25 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-25 will display the answer:

Press	Display
EEX 49 ENTER↑	1.0000000 49
EEX 50 ×	1.0000000 99

But if you attempt to multiply the above result by 100, the HP-25 display indicates overflow by showing you all 9's:

Press	Display
100 ×	9.9999999 99

A display of **OF** indicates that one of the calculator's *storage registers* has overflowed. See section 4, Function Keys, for a description of the HP-25 storage registers.

Error Display

If you happen to key in an improper operation, the word *Error* will appear in the display.

For example, try to divide 1 by 0 (the HP-25 will recognize this as an improper operation):

Press	Display
1 ENTER↑	1.00
0 ÷	Error

You can clear the error by pressing **CLX** or by keying another number into the displayed X-register.

Press	Display
CLX	0.00

All those operations that cause **Error** to appear in the display are listed in appendix B.



The Automatic Memory Stack

The Stack

Automatic storage of intermediate results is the reason that the HP-25 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. This represents the contents of the display, or X-register.

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 0.00.

Name	Register
T	0.00
Z	0.00
Y	0.00
X	0.00

Always displayed.

Manipulating Stack Contents

The **R↓** (roll down) and **↔xy** (*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

Each time you press the **R↓** key, 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 **R↓**.

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

. . . from this . . .

T	4.00
Z	3.00
Y	2.00
X	1.

Display

. . . to this.

T	1.00
Z	4.00
Y	3.00
X	2.00

Display

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

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

. . . from this . . .

T	1.00
Z	4.00
Y	3.00
X	2.00

Display

. . . to this.

T	2.00
Z	1.00
Y	4.00
X	3.00

Display

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

. . . through this . . .

T	3.00
Z	2.00
Y	1.00
X	4.00

Display

. . . back to the start again.

T	4.00
Z	3.00
Y	2.00
X	1.00

Display

Once again the number 1.00 is in the displayed X-register. Now that you know how the stack is rotated, you can use the **R↓** key to review the contents of the stack at any time so that you can always tell what is in the calculator. Always remember, though, that it takes four presses of the **R↓** key to return the contents to their original registers.

Exchanging X and Y

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

. . . from this . . .

T	4.00
Z	3.00
Y	2.00
X	1.00

. . . to this.

T	4.00
Z	3.00
Y	1.00
X	2.00

Similarly, pressing **x↔y** again will restore the numbers in the X- and Y-registers to their original places. This key is used to position numbers in the stack or simply to view the Y-register.

Clearing the Stack

To clear the displayed X-register only, press **CLX**. To clear the entire automatic memory stack, including the displayed X-register, press **f** **STK** (*clear stack*). This replaces all numbers in the stack with zeros. When you turn the calculator OFF, then ON, it “wakes up” with all zeros in the stack registers.

Although it may be comforting, *it is never necessary to clear the stack or 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.

Press **CLX** now, and the stack contents are changed . . .

. . . from this . . .

T	4.00
Z	3.00
Y	1.00
X	2.00

Display

. . . to this.

T	4.00
Z	3.00
Y	1.00
X	0.00

Display

You can verify that only the X-register contents are affected by **CLX** by using the **R↔** key to review the other stack contents.

If you press **f** **STK**, the contents of the stack are changed . . .

. . . from this . . .

T	4.00
Z	3.00
Y	1.00
X	0.00

Display

. . . to this.

T	0.00
Z	0.00
Y	0.00
X	0.00

Display

The Key

When you key a number into the calculator, its contents are written into the displayed X-register and the other registers remain unchanged. For example, if you keyed in the number 314.32, your stack registers would look like this:

Name	Register
T	0.00
Z	0.00
Y	0.00
X	314.32

Display

In order to key in a second number at this point, you must separate the digits of the first number from the digits of the second.

One way to separate numbers is to press **ENTER↵**. Press **ENTER↵** to change the contents of the registers . . .

. . . from this . . .

T	0.00
Z	0.00
Y	0.00
X	314.32

Display

. . . to this.

T	0.00
Z	0.00
Y	314.32
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. But this will be more apparent when we have different numbers in all four registers.)

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 . . .

T	0.00
Z	0.00
Y	314.32
X	314.32

Display

. . . to this.

T	0.00
Z	0.00
Y	314.32
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 . . .

T	0.00
Z	0.00
Y	314.32
X	543.28

Display

. . . to this.

T	0.00
Z	0.00
Y	314.32
X	0.00

Display

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

. . . from this . . .

T	0.00
Z	0.00
Y	314.32
X	0.00

Display

. . . to this.

T	0.00
Z	0.00
Y	314.32
X	689.4

Display

Notice that numbers in the stack do not move when a number is keyed in immediately after pressing **ENTER↑** or **CLX**. (However, the numbers in the stack *do* lift when a new number is keyed in immediately after pressing **R↓**.)

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 the **f** **√X** keys changes the stack contents . . .

. . . from this . . .

T	0.00
Z	0.00
Y	314.32
X	689.4

Display

. . . to this.

T	0.00
Z	0.00
Y	314.32
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 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:

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

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-25. Here's how it is done. (If you clear the previous number entries first by pressing **f** **STK** the numbers in the stack will correspond to those shown in the example below.)

Press **Display**

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.

To subtract 21 from 34:

$$\begin{array}{r} 34 \\ -21 \\ \hline \end{array}$$

Press **Display**

34 34.

34 is keyed into X.

ENTER 34.00

34 is copied into Y.

21 21.

21 writes over the 34 in X.

- 13.00

The answer.

To multiply 34 by 21:

$$\begin{array}{r} 34 \\ \times 21 \\ \hline \end{array}$$

Press **Display**

34 34.

34 is keyed into X.

ENTER 34.00

34 is copied into Y.

21 21.

21 writes over the 34 in X.

x 714.00

The answer.

To divide 34 by 21:

$$\begin{array}{r} 34 \\ 21 \overline{) } \end{array}$$

Press	Display	
34	34.	34 is keyed into X.
ENTER →	34.00	34 is copied into Y.
21	21.	21 writes over the 34 in X.
÷	1.62	The answer.

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. For example, calculate $16 + 30 + 11 + 17 = ?$

Note: If you press **f** **STK** first, you will begin with zeros in all of the stack registers, as the example below.

Press	Stack Contents	
16	T 0.00	16 is keyed into the displayed X-register.
	Z 0.00	
	Y 0.00	
	X 16.	
ENTER →	T 0.00	16 is copied into Y.
	Z 0.00	
	Y 16.00	
	X 16.00	

30	T	0.00
	Z	0.00
	Y	16.00
	X	30.

30 writes over the 16 in X.

+	T	0.00
	Z	0.00
	Y	0.00
	X	46.00

16 and 30 are added together.
The answer, 46, is displayed.

11	T	0.00
	Z	0.00
	Y	46.00
	X	11.

11 is keyed into the displayed
X-register. The 46 in the stack
is automatically raised.

+	T	0.00
	Z	0.00
	Y	0.00
	X	57.00

46 and 11 are added together.
The answer, 57, is displayed.

17	T	0.00
	Z	0.00
	Y	57.00
	X	17.00

17 is keyed into the X-register.
57 is automatically entered
into Y.

+	T	0.00
	Z	0.00
	Y	0.00
	X	74.00

57 and 17 are added together
for the final answer.

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

the X- and Y-registers. It happened in the above example, but let's do the problems differently to see this feature more clearly. First press **CLX** to clear the X-register. Now, again solve $16 + 30 + 11 + 17 = ?$

Press	Stack Contents		
16	T	0.00	16 is keyed into the displayed X-register.
	Z	0.00	
	Y	0.00	
	X	16.	
ENTER ↓	T	0.00	16 is copied into Y.
	Z	0.00	
	Y	16.00	
	X	16.00	
30	T	0.00	30 is written over the 16 in X.
	Z	0.00	
	Y	16.00	
	X	30.	
ENTER ↓	T	0.00	30 is entered into Y. 16 is lifted up to Z.
	Z	16.00	
	Y	30.00	
	X	30.00	
11	T	0.00	11 is keyed into the displayed register.
	Z	16.00	
	Y	30.00	
	X	11.	
ENTER ↓	T	16.00	11 is copied into Y. 16 and 30 are lifted up to T and Z respectively.
	Z	30.00	
	Y	11.00	
	X	11.00	
17	T	16.00	17 is written over the 11 in X.
	Z	30.00	
	Y	11.00	
	X	17.	

+

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 $\square$, $\times$ and $\div$. The number in T is duplicated in T and Z, the number in Z *drops* to Y, and the numbers in 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:

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

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

Hewlett-Packard applications engineers have determined that by starting *every* problem at its innermost number or parentheses and working outward, you maximize the efficiency and power of your HP calculator. Of course, with the HP-25 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	0.213	
×	0.64	Intermediate answer for $(3 \times .213)$.
÷	16.04	
5	5.	The first number is keyed in.
×	80.20	The final 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 $\boxed{\times}$.

Press	Display	
1.15	$\boxed{1.15}$	Growth factor.
$\boxed{\text{ENTER}\uparrow}$	$\boxed{1.15}$	
$\boxed{\text{ENTER}\uparrow}$	$\boxed{1.15}$	
$\boxed{\text{ENTER}\uparrow}$	$\boxed{1.15}$	Growth factor now in T.
1000	$\boxed{1000.}$	Starting population.
$\boxed{\times}$	$\boxed{1150.00}$	Population after 1st day.
$\boxed{\times}$	$\boxed{1322.50}$	Population after 2nd day.
$\boxed{\times}$	$\boxed{1520.88}$	Population after 3rd day.
$\boxed{\times}$	$\boxed{1749.01}$	Population after 4th day.
$\boxed{\times}$	$\boxed{2011.36}$	Population after 5th day.
$\boxed{\times}$	$\boxed{2313.06}$	Population after 6th day.

When you press $\boxed{\times}$ 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 $\boxed{\times}$ causes the number in the T-register to be duplicated each time the stack is dropped. However, the $\boxed{\text{R}\uparrow}$ 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.

$$\frac{dV}{dz} = 2\Gamma \rightarrow V = V_1 - \sqrt{2\Gamma} z + V_2 e^{\sqrt{2\Gamma} z}$$

$$\sqrt{2\Gamma} = \pm j\sqrt{-2\Gamma} = j\beta$$

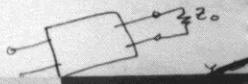
$$\frac{d^2 V}{dz^2} = 2\Gamma V$$

$$I = \frac{1}{2} \frac{dV}{dz} = \frac{V_1}{\sqrt{2\Gamma}} e^{-\sqrt{2\Gamma} z} + \frac{V_2}{\sqrt{2\Gamma}} (+\sqrt{2\Gamma}) e^{+\sqrt{2\Gamma} z}$$

$$= \frac{V_1}{\sqrt{2\Gamma}} e^{-j\beta z} - \frac{V_2}{\sqrt{2\Gamma}} e^{+j\beta z}$$

$$V_1 e^{j\beta z} - \frac{V_2}{\sqrt{2\Gamma}}$$

characteristic impedance

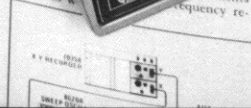


side couplers to accomplish...
ion. Reflectometers permit...
oscilloscope displays or permanent...
orderings of reflection coefficient...
loss across complete of...

The waveguide reflectometer...
own in Figure 3 is designed to...
incident power constant by leveling...
automatic leveling, only the rela...
amplitude of the reflected wave need...
measured to determine reflection...
cient.

calibrate the reflectometer, a short...
is placed at the output port, thus...
incident power constant by leveling...
automatic leveling, only the rela...
amplitude of the reflected wave need...
measured to determine reflection...
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for...
25...
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measurements of attenuation and return...
over a continuous 60 dB dynamic...
Readout is either on a CRT disal...
calibrated directly in dB or a X-Y...
The 8755A has a frequency...
100 MHz to 18 GHz.

Substitution technique
Attenuation measurements up...
dB can be made using the...
ation, X-Y recorder system...
Figure 6. Coupler tracking and...
are eliminated by plotting...
grid on the X-Y recorder...
actual measurement. The...
determined by setting in specific values...
attenuation on the 382A near the...
anticipated test device attenuation. The...
382A is then set to 0 dB and the test...
device inserted as shown in Figure 6. A...
final sweep plots attenuation of the test...
device over the calibration grid.

IF substitution technique
The IF substitution technique of at...
tenuation measurement involves con...
version of the microwave frequency to...
constant, much lower frequency...

Function Keys

The HP-25 function keys can be used manually or keyed in as part of a program. In this section, each key is individually explained. To use function keys manually, ensure that the PRGM-RUN switch  is set to RUN.

LAST X

In addition to the four stack registers that automatically store intermediate results, the HP-25 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  **LAST X**.

Recovering from Mistakes

LAST X 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 $\div$	3.80
 LAST X	3.16
$\times$	12.00
2.157 $\div$	5.56

Oops! You made a mistake.
Retrieves that last entry.
You're back at the beginning.
The correct answer.

In the above example, when you pressed **f** **LAST X**, the contents of the stack and LAST X registers were changed . . .
 . . . from this . . .

T	0.00
Z	0.00
Y	0.00
X	3.80
LAST X	
	3.16

. . . to this.

T	0.00
Z	0.00
Y	3.80
X	3.16
LAST X	
	3.16

This made possible the correction illustrated in the example above.

Recovering a Number

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

Example: Calculate

$$\begin{array}{r} 7.32 + 3.650112331 \\ \hline 3.650112331 \end{array}$$

Press	Display
7.32	7.32
ENTER	7.32
3.650112331	3.650112331
+	10.97
f LAST X	3.65
÷	3.01

Intermediate answer.

Recalls 3.650112331 to X-register.

The answer.

Prefix Clear

The **PREFIX** (clear prefix) key will clear a blue **g** prefix key, a gold **f** prefix key, **STO**, **RCL**, or **GTO** (**GTO** is explained in section 5, Programming). To clear a prefix you have mistakenly pressed, merely press **f** **PREFIX** as the next keystrokes, then press the correct key. For example, to change a blue prefix keystroke to that of another key during a calculation:

Press	Display
2 g	2.

Oops! You meant to change the sign of the number in the display, but you pressed the blue prefix key by mistake.

f PREFIX	2.00
CHS	-2.00

Clears the blue prefix keystroke.

The correct operation, change sign, is performed.

Number Alteration Keys

Besides **CHS** there are three keys provided on the HP-25 for altering numbers. These keys are **ABS**, **FRAC** and **INT**, and they are most useful when performing operations as part of a program.

Absolute Value

Some calculations require the absolute value, or magnitude, of a number. To obtain the absolute value of the number in the display, press the **g** prefix key followed by the **ABS** (*absolute value*) key. For example, to calculate the absolute value of -3 :

Press	Display
3 CHS	-3.
g ABS	3.00 -3

To see the absolute value of $+3$:

Press	Display
g ABS	3.00 +3

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 place only the fractional portion of a number into the displayed X-register, press the **g** prefix key followed by the

FRAC (*fraction*) key. For example, to see the fractional portion of 123.456 used above:

Press	Display
123.456	123.456
g FRAC	0.46

Only the fractional portion of the number is displayed, rounded here to normal 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, then press **g** $\frac{1}{x}$. For example, to calculate the reciprocal of 25:

Press	Display
25 g $\frac{1}{x}$	0.04

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

$$\frac{1}{1/3 + 1/6}$$

Press	Display	
3 g $\frac{1}{x}$	0.33	Reciprocal of 3.
6 g $\frac{1}{x}$	0.17	Reciprocal of 6.
+	0.50	Sum of reciprocals.
g $\frac{1}{x}$	2.00	Reciprocal of sum.

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-25. Merely press **g** **π** whenever you need it in a calculation. For example, to calculate 3π :

Press	Display
3 g π $\times$	9.42

Example: Trencherman Buck Mulligan looks into a recent edition of the *Guinness Book of Records* and finds that the largest pizza ever baked had a diameter of 21 feet. If his appetite were equal to the task, how many square feet of pizza would Mulligan have to devour in order to consume all of the world's largest pizza?

$$\text{Area} = \pi \left(\frac{d}{2} \right)^2 = \pi \left(\frac{21}{2} \right)^2$$

Press	Display
21 ENTER	21.00
2 $\div$	10.50
g x^2	110.25
g π	3.14
$\times$	346.36

Square feet of pizza.

Pressing **g** **π** causes the results in the automatic memory stack to lift.

Percentages

The $\boxed{\%}$ key is a two-number function that 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 **g** $\boxed{\%}$.

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.
g $\boxed{\%}$	97.50	The answer.

6.5% of \$1500 is \$97.50.

In the above example, when the **g** $\boxed{\%}$ keys are 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 **g** $\boxed{\%}$, the stack contents were changed . . .

. . . from this . . .

T	0.00
Z	0.00
Y	1500.00
X	6.5

. . . to this.

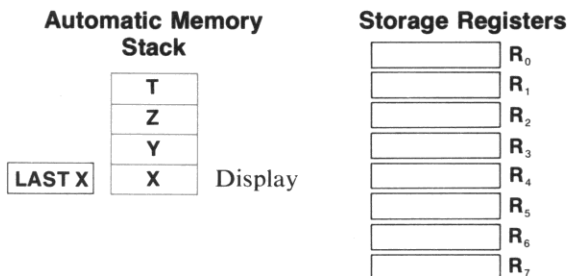
T	0.00
Z	0.00
Y	1500.00
X	97.50

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.

Storage Registers

In addition to automatic storage of intermediate results that is provided by the four-register automatic memory stack, the HP-25 also has eight addressable storage registers that are unaffected by operations within the stack. These storage registers allow you to set aside numbers as constants or for use in later calculations, and they can be used either manually or as part of a program.



The addresses of the storage registers are indicated by number keys **[0]** through **[7]**, as shown above.

Storing and Recalling Data

To store a value appearing in the display, press **[STO]** (*store*) followed by a number key (**[0]** through **[7]**) specifying the register address where the value is to be stored. For example, to store Avogadro's number (approximately 6.02×10^{23}) in register R₂:

Press	Display	
6.02 [EEX] 23	6.02 23	
[STO] 2	6.0200000 23	The number is now stored in register R ₂ .

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 copy a number from one of the storage registers into the display, press the **[RCL]** (*recall*) key followed by the number key of the register address.

For example, to recall Avogadro's number:

Press	Display
CLX	0.00
RCL 2	6.020000 23

Recalling a number causes the stack to lift unless the preceding keystroke was **ENTER** , **CLX** or **Σ+** (more about **Σ+** later).

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.

Example: Three tanks have capacities in U.S. units of 2.0, 14.4, and 55.0 gallons, respectively. If one U.S. gallon is approximately equal 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	
CLX	0.00	
f FIX 3	0.000	Display mode set.
3.785 STO 0	3.785	Constant placed in register R_0 .
2 ×	7.570	Capacity of 1st tank in liters.
14.4 RCL 0 ×	54.504	Capacity of 2nd tank in liters.
55 RCL 0 ×	208.175	Capacity of 3rd tank in liters.
f FIX 2	208.18	Display mode reset.

Clearing Storage Registers

To clear the number from a single storage register, simply store the quantity zero in the register by pressing **0** **STO** followed by the number key (**0** through **7**) of the register address.

To clear data from *all* manual storage registers at once, without affecting data in other portions of the calculator, press **f** **REG**. This places zero in all eight of the storage registers. Of course, turning the calculator OFF also clears all registers.

Storage Register Arithmetic

Arithmetic is performed *upon the contents of the storage register* by pressing **STO** followed by the arithmetic function key followed in turn by the register address. For example:

Press	Result
STO + 1	Number in displayed X-register added to contents of 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 storage register R_2 , and difference placed into R_2 : ($r_2 - x \rightarrow R_2$).
STO x 3	Number in displayed X-register multiplied by contents of 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 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 displayed X-register and the rest of the stack remain unchanged.

Example: During harvest, a farmer 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 he 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 the farmer's total net income?

Method: Keep total amount in a storage register while using the stack to add tonnages and calculate amounts of loss.

Press	Display	
25 ENTER 27 +		
19 + 23 +	94.00	Total of Monday's and Tuesday's tonnage.
55 x	5170.00	Gross amount for Monday and Tuesday.

STO 5 5170.00

Gross placed in storage register R_5 .

2 **g** **%** 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 **x** 3105.00

Gross amount for Wednesday.

STO **+** 5 3105.00

Wednesday's gross amount added to total in storage register R_5 .

3 **g** **%** 93.15

Deduction for Wednesday.

STO **-** 5 93.15

Wednesday deduction subtracted from total in storage register R_5 .

RCL 5 8078.45

The farmer's total net income from his tomatoes.

(You could also work this problem using the stack alone, but it illustrates how storage register arithmetic works.)

Storage Register Overflow

If the magnitude of a number in any of the eight storage registers exceeds $9.999999999 \times 10^{99}$, the HP-25 display immediately shows **OF** (*overflow*) to indicate that a storage register has overflowed.

For example, if you use storage register arithmetic to attempt to calculate the product of 1×10^{50} and 7.5×10^{50} in register R_0 , the register overflows and the display shows **OF**. To see the result of storage register overflow:

Press

Display

EEX 50 1. 50

1×10^{50} placed into storage register R_0 .

STO 0 1.0000000 50

7.5 **EE**X 50 7.5 50

When you multiplied using storage register arithmetic, register R_0 overflowed.

STO **x** 0 OF

To clear a storage register overflow display, merely press

CLX .

Trigonometric Functions

Your HP-25 provides you with six trigonometric functions. It also calculates angles in decimal degrees, radians, or grads; and it converts between decimal degrees and degrees, minutes, seconds.

Trigonometric Modes

When the HP-25 is first turned ON, it “wakes up” with angles specified in decimal degrees. To set radians or grads mode, press the **g** shift key followed by either **[RAD]** (radians) or **[GRD]** (grads). To switch back to the decimal degrees mode again, press the **g** shift key followed by the **[DEG]** (degrees) key.

Note: 360 degrees = 2π radians = 400 grads

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 angles in decimal degrees, radians, or grads. Trigonometric functions are one-number functions, so to use them you key in the number, then press the function keys.

Example 1: Find the cosine of 35°.

Press	Display	
35	35.	Calculator “wakes up” in decimal degrees mode.
f [cos]	0.82	The answer.

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

Press	Display	
.964	0.964	
g [GRD]	0.96	Grads mode is set.
g [sin⁻¹]	82.87	Grads.

Hours, Minutes, Seconds

The $\boxed{\rightarrow\text{H.MS}}$ (*to hours, minutes, seconds*) key converts decimal hours to the format of hours, minutes and seconds. To see the digits for *seconds*, you should specify FIX 4 display format. For example, to convert 12.56 hours to hours, minutes, seconds:

Press	Display	
12.56	$\boxed{12.56}$	Decimal hours.
$\boxed{f} \boxed{\text{FIX}} 4$	$\boxed{12.5600}$	Sets display format.
$\boxed{f} \boxed{\rightarrow\text{H.MS}}$	$\boxed{12.3336}$	This is read as 12 hours, 33 minutes, 36 seconds.

Conversely, the $\boxed{\rightarrow\text{H}}$ (*to decimal hours*) key is used to change hours, minutes, seconds into decimal hours. For example, to convert 12 hours, 33 minutes, 36 seconds back into decimal hours:

Press	Display	
$\boxed{g} \boxed{\rightarrow\text{H}}$	$\boxed{12.5600}$	Decimal hours.

Hours to hours, minutes, seconds conversion is accurate to 10^{-5} decimal hours.

The $\boxed{\rightarrow\text{H}}$ and $\boxed{\rightarrow\text{H.MS}}$ keys also permit you to change degrees, minutes, seconds to decimal degrees, and vice versa.

For example, to change $137^{\circ}45'12''$ to decimal degrees:

Press	Display	
137.4512	$\boxed{137.4512}$	
$\boxed{g} \boxed{\rightarrow\text{H}}$	$\boxed{137.7533}$	Decimal degrees.

The conversion is important because trigonometric functions in the HP-25 operate on angles in *decimal degrees*, but not in *degrees, minutes, seconds*. In order to calculate any trigonometric functions of an angle given in degrees, minutes, seconds, you must first convert the angle to decimal degrees.

Example: Lovesick sailor Oscar Odysseus dwells on the island of Tristan da Cunha ($37^{\circ}03' \text{ S}$, $12^{\circ}18' \text{ W}$), 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 ($15^{\circ}55' \text{ S}$, $5^{\circ}43' \text{ W}$), 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:

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

Press

Display

f FIX 2

0.00

Display mode is set.
(Assumes no results remain from previous example.)

g DEG

0.00

Sets decimal degree mode for trigonometric functions.

5.43 g →H

5.72

12.18 g →H -

-6.58

f COS

0.99

15.55 g →H STO 1

15.92

f COS

0.96

x

0.96

37.03 g →H STO 0

37.05

f COS

0.80

x

0.76

RCL 0 f sin

0.60

RCL 1 f sin

0.27

x

0.17

+

0.93

g COS⁻¹

21.92

60 x

1315.41

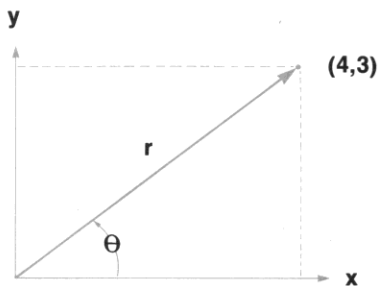
Distance in nautical miles that Odysseus must sail to visit Penelope.

Polar/Rectangular Coordinate Conversion

Two functions are provided for polar/rectangular coordinate conversion. To convert values in the X- and Y-registers, (representing rectangular x , y coordinates, respectively) to polar r , θ coordinates (magnitude and angle, respectively), press **g** **→P**. Magnitude r then appears in the X-register and angle is placed in the Y-register.

Conversely, to convert values in the X- and Y-registers (representing polar r , θ , respectively) to rectangular coordinates (x , y respectively), press **f** **→R**.

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



Press

g **RAD**

Display

0.00

Specifies radians mode.
(Assumes no results remain
from previous example.)

3 **ENTER** 4

4.

Rectangular coordinates
placed in X- and Y-registers.

g **→P**

5.00

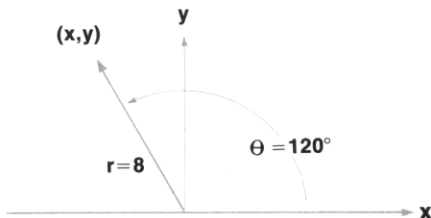
Magnitude r .

x↔y

0.64

Angle θ in radians.

Example 2: Convert polar coordinates $(8, 120^\circ)$ to rectangular coordinates.



Press

g **DEG**

Display

0.00

Specifies degrees mode.
(Assumes no results remain from previous example.)

120 **ENTER** 8

8.

Polar coordinates θ and r placed in Y- and X-registers, respectively.

f **→R**

-4.00

x-coordinate.

x↔y

6.93

y-coordinate.

Logarithmic and Exponential Functions

Logarithms

The HP-25 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 ($2.718 \dots$).

g **e^x**

is antilog_e (natural antilog). It raises e ($2.718 \dots$) 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: 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 ft).

Raising Numbers to Powers

f **y^x** permits you to raise a positive number (either an integer or a decimal) to any power. For example, calculate 2^9 (i.e., $2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$).

Press**Display**2 **ENTER**↑ 9 **f** **y^x**

512.00

Now find $8^{-1.2567}$.**Press****Display**8 **ENTER**↑

8.00

1.2567 **CHS** **f** **y^x**

0.07

In conjunction with **1/x**, **f** **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 **g** $\frac{1}{x}$

0.33

Reciprocal of 3.

f y^x

1.71

Cube root of 5.

Example: An aircraft pilot 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?

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

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**↑ 661.5 **÷**

0.53

g x^2

0.28

Square of bracketed quantity.

.2 **x** 1 **+**

1.06

3.5 **f** y^x 1 **-**

0.21

Contents of left-hand set of brackets are in the stack.

1 **ENTER**↑ 6.875 **EEX**

6.875 00

CHS 6 **ENTER**↑

6.8750000 -06

25500 **x** **-**

0.82

5.2656 **CHS** **f** y^x

2.76

Contents of right-hand set of brackets are in the stack.

x 1 **+**

1.58

.286 **f** y^x 1 **-**

0.14

5 **x** **f** $\sqrt{x}$

0.84

Mach number of the flight.

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

Summations

Pressing the $\Sigma+$ 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 storage registers R_3 through R_7 . *The only time that information is automatically accumulated in the storage registers is when the $\Sigma+$ key is used.* Before you begin any calculations using the $\Sigma+$ key, you should first clear the storage registers of data by pressing $\text{f} \text{REG}$.

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

- The number that you keyed into the X-register is added to the contents of storage register R_7 .
- The square of the number that you keyed into the X-register is added to the contents of storage register R_6 .
- The number that you keyed into the X-register is multiplied by the contents of the Y-register, and the product added to storage register R_5 .
- The number in the Y-register of the stack is added to the contents of storage register R_4 .
- The number 1 is added to storage register R_3 , and the total number in R_3 is then written into the display (The stack does not lift).

Thus, each press of the $\Sigma+$ key updates these summations and multiplications. The contents of the displayed X-register and the applicable storage registers are as follows:

Register	Data
Displayed X	n Number of entries.
R_3	n Number of entries.

R_4	Σy	Summation of y values.
R_5	Σxy	Summation of products of x and y values.
R_6	Σx^2	Summation of x^2 values.
R_7	Σx	Summation of x values.

In addition, the y-value present before the last press of the $\Sigma+$ key is retained in the Y-register, while the x-value present before $\Sigma+$ was pressed is retained in the LAST X register.

To see any of the summations at any time, you have only to recall the contents of the desired storage register. (In the case of the $\Sigma+$ key, recalling storage register contents or keying in a number simply writes over the number of entries (n) that is displayed. The stack does not lift.)

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

y	7	5	9
x	5	3	8

Press	Display	
f REG	0.00	Ensures that all storage registers are cleared to zero initially. (Assumes no results remain from previous example.)
7 ENTER	7.00	
5 $\Sigma+$	1.00	First pair is summed; $n = 1$.
5 ENTER	5.00	
3 $\Sigma+$	2.00	Second pair is summed; $n = 2$.
9 ENTER	9.00	
8 $\Sigma+$	3.00	All the data is summed; $n = 3$.
RCL 7	16.00	Sum of x values from register R_7 .
RCL 6	98.00	Sum of squares of x values from register R_6 .
RCL 5	122.00	Sum of products of x and y values from register R_5 .
RCL 4	21.00	Sum of y values from register R_4 .
RCL 3	3.00	Number of entries ($n = 3$).

Mean

The mean (arithmetic average) of data entered and summed using the $\Sigma+$ key is available by using the $\bar{x}$ (mean) key. When you

press **f** **$\bar{x}$** , the mean of the values of x is calculated using the data in storage registers $R_3(n)$ and $R_7(\Sigma x)$ and the formula:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

The easiest way to accumulate the required data in the applicable registers is through the use of the **$\Sigma+$** key as described above. However, the required data may also be stored directly in storage registers $R_3(n)$ and $R_7(\Sigma x)$, if desired.

Example: A survey found ten of the wealthiest persons in the United States to have the following ages:

62 84 47 58 68 60 62 59 71 73

To find the average (mean) age of this sample of wealthy persons:

Press

CLX **f** **REG**

Display

0.00

Storage registers
and X-register
cleared to zero.

62 **$\Sigma+$** , 84 **$\Sigma+$** , 47 **$\Sigma+$** , 58 **$\Sigma+$** ,
68 **$\Sigma+$** , 60 **$\Sigma+$** , 62 **$\Sigma+$** , 59 **$\Sigma+$** ,
71 **$\Sigma+$** , 73 **$\Sigma+$**

10.00

Number of entries.

f **$\bar{x}$**

64.40

Average (mean) age
in years.

Standard Deviation

The standard deviation (a measure of dispersion around the mean) is calculated using data in the applicable storage registers and the **s** (standard deviation) key. Pressing **f** **s** uses the data in registers $R_3(n)$, $R_6(\Sigma x^2)$, and $R_7(\Sigma x)$ to calculate the standard deviation according to the formula:

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

For example, to obtain the sample deviation in the above problem:

Press

Display

f [S]

10.10

Standard deviation.

If the 10 persons used in the sample were actually *the 10 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 (s') is illustrated by the following equation:

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

Since n is automatically accumulated in register R_3 when the data are accumulated by the $\Sigma+$ key, it is a simple matter to convert the sample standard deviation, which has already been calculated, to population standard deviation.

For example, if the accumulations in registers R_3 through R_7 are still intact from the previous example, you can calculate the population standard deviation this way:

Press

Display

f [S]

10.10

Sample standard deviation (s).

RCL 3

10.00

Recalls n .

1 [-]

9.00

Calculates $n-1$.

RCL 3 [÷]

0.90

Divides $n-1$ by n .

f [√x] [x]

9.58

Population standard deviation (s').

Deleting and Correcting Data

If you key in an incorrect value and have not pressed $\Sigma+$, press CLX and key in the correct value.

If one of the values is changed, or if you discover after you have pressed the $\Sigma+$ key that one of the values is in error, you can correct the summations by using the $\Sigma-$ key as follows:

1. Key the *incorrect* data pair into the X- and Y- registers.
2. Press f $\Sigma-$ 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 $\Sigma+$.

The correct values for mean and standard deviation are now obtainable by pressing $\text{f} \text{ } \overline{x}$ and $\text{f} \text{ } s$.

For example, suppose the 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:

Press	Display	
62	62.	Data to be replaced.
$\text{f} \text{ } \Sigma$	9.00	Number of entries (n) is now nine.
21	21.	The new data.
$\Sigma +$	10.00	Number of entries (n) is ten again.

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

Press	Display	
$\text{f} \text{ } \overline{x}$	60.30	The new average (mean) age.
$\text{f} \text{ } s$	17.09	The new standard deviation.

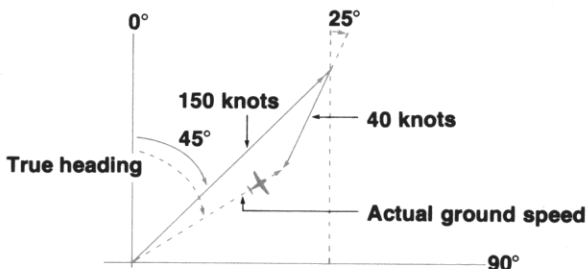
Vector Summations

The $\Sigma +$ key can be used to sum any quantities that are in the X- and Y-registers. You can even perform vector addition and subtraction using rectangular to polar coordinate conversion and the $\Sigma +$ and $\Sigma -$ keys.

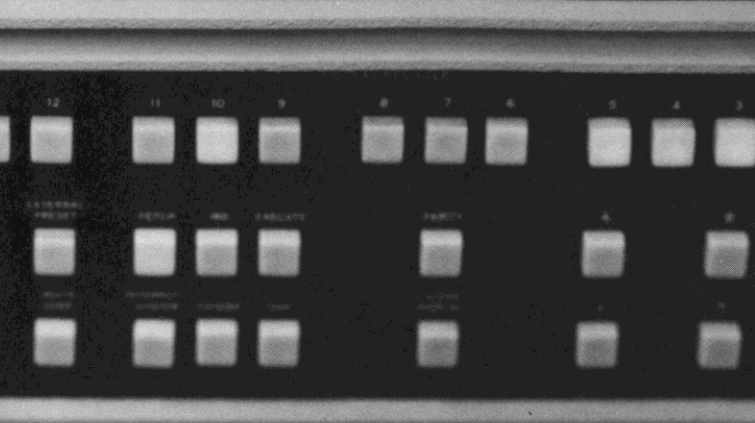
Example: In his converted Swordfish aircraft, grizzled bush pilot Apeneck Sweeney reads an air speed of 150 knots and a heading of 045° from his instruments. The Swordfish is also being buffeted by a headwind of 40 knots from a bearing of 025° . What is the actual ground speed and true heading of the Swordfish?

Method: The true heading and ground speed are equal to the sum of the instrument vector and the wind vector. The vectors are converted to rectangular coordinates and summed using the $\Sigma +$ and $\Sigma -$ keys. Their sum is recalled by recalling the values in storage registers R_4 (Σy) and R_7 (Σx), and the new rectangular coordinates are then converted back to polar coordinates to

give the vector of the actual ground speed and true heading.



Press	Display	
f REG	0.00	Clears storage registers. (Display assumes no results remain from previous examples.)
g DEG	0.00	Sets degrees mode.
45 ENTER	45.00	θ for the Swordfish instrument vector.
150	150.	r for the Swordfish instrument vector.
f →R	106.07	Converted to rectangular coordinates.
Σ+	1.00	Instrument coordinates accumulated in storage registers R_4 and R_7 .
25 ENTER	25.00	θ for wind vector.
40	40.	r for wind vector.
f →R	36.25	Converted to rectangular coordinates.
f Σ-	0.00	Coordinates for wind vector subtracted from coordinates for Swordfish's instrument vector.
RCL 4	89.16	Recalls sum of y-coordinates from register R_4 .
RCL 7	69.81	Recalls sum of x-coordinates from register R_7 . (Sum of y-coordinates lifted to Y-register.)
g →P	113.24	Actual ground speed of the Swordfish in knots.
x↔y	51.94	True heading of the Swordfish in degrees.



HEWLETT-PACKARD
HP-25
Applications
Programs



Pause to display 2
Halt to display 3
Halt to display 4
Branch back for next



Programming

As we briefly explained in the introduction, calculator programming is as simple as pressing the keys you would manually press to solve your problem. But even though HP-25 calculator programming is simple to understand and use, it is very powerful, featuring:

- An obvious programming language.
- 49 usable steps of program memory.
- The ability to combine several keystrokes into each step.
- Decision-making capability for sophisticated routines.
- Several editing operations to facilitate corrections.

Together these features provide you with the tools necessary to tackle complex problems with unabashed confidence.

What is a Program?

A program is nothing more than a sequence of manual keystrokes that is remembered by the calculator. You can then execute the program as often as you like with less chance of error. The answer displayed at the end of execution is the same one you would have obtained by pressing the keys one at a time manually. No prior programming experience is necessary for HP-25 calculator programming.

Why Write Programs?

Programs are written to save you time on repetitive calculations. Once you have written the keystroke procedure for solving a particular problem and recorded it in the calculator, you need no longer devote attention to the individual keystrokes that make up the procedure. You can let the calculator solve each problem for you. And because you can easily check the procedure in your program, you have more confidence in your final answer since you don't have to worry each time about whether or not you have pressed an incorrect key. The calculator performs the drudgery, leaving your mind free for more creative work.

Three Modes of Operation

There are three ways to use your HP-25 calculator:

1. Manual RUN mode
2. PRGM mode
3. Automatic RUN mode

PRGM  RUN

PRGM  RUN

PRGM  RUN

Manual RUN Mode

The functions and operations you have learned about in the first four sections of this handbook are performed manually one at a time with the PRGM-RUN switch set to RUN  RUN. These functions combined with the automatic memory stack enable you to calculate any problem with ease.

PRGM Mode

In PRGM (*program*) mode the functions and operations you have learned about are not executed, but instead are recorded in a part of the calculator called *program memory* for later execution. All operations on the keyboard except three can be recorded for later execution with the PRGM-RUN switch set to PRGM  RUN. The three operations that cannot be recorded are:

SST

BST

f PRGM

These three operations work in PRGM mode to help you write and record your programs.

Automatic RUN Mode

The HP-25 can also be used to automatically execute a list of operations with the PRGM-RUN switch set to RUN  RUN if they have previously been recorded in program memory. Instead of your having to press each key manually, the recorded operations are executed sequentially in automatic RUN mode when you press  (*run/stop*). You press only one key and the entire list of recorded operations is executed much more quickly than you could have executed them yourself.

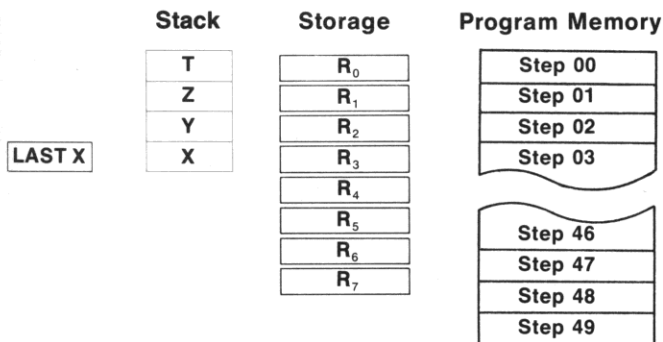
Introductory Program

The area of a sphere program you wrote, recorded, and executed in the introduction showed you that the sequence of keystrokes used to solve a problem manually is the same sequence used in a program. Now let's return our attention to that program to explain the information displayed in PRGM mode.

First, set the PRGM-RUN switch to PRGM  RUN so that the sequence of keystrokes will be recorded for later execution. Second, press   to clear the calculator of previous programs. The display will show:

00

This tells you that you are at the beginning of program memory. Step 00 contains an automatic stop instruction and cannot be used to record your program keystrokes. Program keystrokes are recorded in steps 01 through 49. (See figure below.)



As you can see, the program memory for the HP-25 is separate from the four stack registers, the LAST X register, and the eight storage registers.

With 00 displayed in PRGM mode, you are ready to key in your program. Surface area of a sphere is calculated using the formula $A = \pi d^2$. The short list of keys for the area of a sphere program is shown below:

Keys Comments

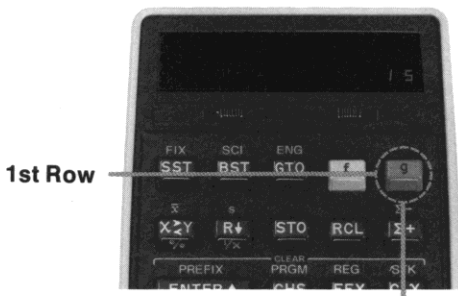
g	}	These keys square the diameter.
x^2		
g	}	These keys place π in the X-register.
π		
$\times$		This key multiplies d^2 by π .

Keycodes

Press the first key of the program and the display will change to:

15

The two numbers on the right of the display designate the key stored in that step. Each key on the keyboard has a two-digit keycode. For convenience, the digit keys are coded 00 through 09. All other keys are coded by their position on the keyboard. The first digit denotes the row of the key and the second digit the number of the key in that row. So 15 tells you that the key is in the first row on the calculator and that it is the fifth key in that row, the g key.



5th Key

This handy matrix system allows you to easily determine the code for each instruction without using a reference table.

Merged Keycodes

To conserve program memory when using prefixed functions, the keycodes for the prefix and the function are merged into one step. For an example of this press the second key of the program, x^2 , and the display will change to:

01	15 02
----	-------

The two-number code 01 that has appeared on the left side of the display designates the step number of program memory that is being displayed. The two pairs of numbers on the right side of the display indicate that the function $g \ x^2$ has been recorded in that step (01) of program memory. Digits 1 and 5 denote the g key. Digits 0 and 2 denote the 2 key. The operation stored then, is $g \ 2$ which is the x^2 function. In every case, a single operation (e.g., $f \ \sin$, $STO \ + \ 1$, $x \rightarrow y$) uses only one step of program memory.

Each operation, prefixed or not, requires only one step of program memory.

The keys for finding the area of a sphere and their corresponding displays are shown below. Press each key in turn and verify the keycode shown in the display.

Key	Display
$g \ x^2$	01 15 02
$g \ \pi$	02 15 73
$\times$	03 61

In this case, a program consisting of five keystrokes takes only three steps of program memory.

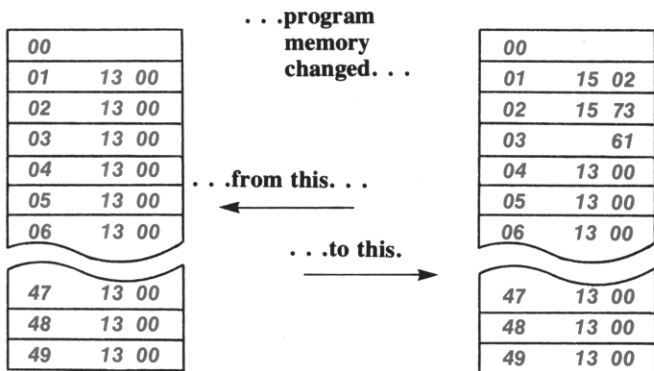
Running a Program

Programs are executed in automatic RUN mode. So first set the PRGM-RUN switch to RUN  RUN. Next press **GTO** **0** **0**. This operation resets the calculator so that program execution will begin from step 00 (Pressing **f** **PRGM** in RUN mode accomplishes the same thing.) Then, key in a value for a diameter and press **R/S** in RUN mode to run your program. The operations stored in program memory are executed sequentially downward from step 00. First step 01 is executed, then step 02, then step 03, and then step 04, which now contains a special instruction, **GTO** **0** **0**.

GTO 00

The **GTO** **0** **0** instruction in step 04 is not an instruction you keyed in yourself. It was already there. If you press **f** **PRGM** in PRGM mode or if you switch the calculator OFF and ON again, program memory is *filled* with **GTO** **0** **0** instructions. The three-step program you keyed in replaced three of these instructions. Program memory was changed as shown in the following illustration.

When you keyed in your program. . .



The illustration on the left shows program memory immediately after pressing **f** **PRGM** in PRGM mode or turning the HP-25 ON. The illustration on the right shows program memory after recording the three-step example program.

A **GTO** **0** **0** instruction in the program tells the calculator to go to step 00 and execute the automatic stop instruction there next. If **R/S** is pressed again in automatic RUN mode, the calculator will begin executing instructions from step 00 as it did the first time. Each time the calculator executes the program, it ends execution at step 00, ready to begin again.

If you had recorded a 49-step program, after executing step 49 the calculator would execute the automatic stop instruction stored in step 00. Then you would have to press **R/S** to execute the program again.

Now try an example.

Example. Calculate the surface area of a spherical “cat’s-eye” (marble) with a diameter of 1.3 centimeters. Then calculate the surface area of a baseball with a diameter of 2.5 inches.

Press	Display	
1.3 R/S	5.31	Area of the marble in square centimeters.
2.5 R/S	19.63	Area of the baseball in square inches.

Each time you press **R/S** the calculator executes the sequence of keystrokes you have recorded. You calculate the same answers you would obtain if you did each problem manually, but without the time or the tedium.

Writing a Second Program

Now let’s write a second program and use it to further explore the programming capability of your HP-25 calculator. Suppose you want to write a program that will calculate the increase in

volume of a spherical balloon as its diameter increases using the formula:

$$\text{Increase in volume} = 1/6 \pi (d_1^3 - d_0^3),$$

where d_0 is the original diameter of the balloon and d_1 is the new diameter. If d_0 were entered in the Y-register and d_1 were keyed into the X-register, the problem could be solved manually by pressing the keys shown in the left-hand column that follows.

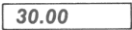
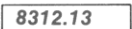
Keys	Display	
ENTER ↵	01 31	
3	02 03	
f y^x	03 14 03	Cube the new diameter.
x↔y	04 21	
3	05 03	
f y^x	06 14 03	Cube the original diameter.
-	07 41	Subtract the cubes.
9 π	08 15 73	
$\times$	09 61	Multiply by π .
6	10 06	
$\div$	11 71	Divide by 6.

The program keystrokes for this problem are the same. Simply switch to PRGM mode **PRGM**  **RUN** and press **f** **PRGM** to clear program memory and display step 00. Then key in the list of keys above. The keys are not executed, but are recorded in program memory steps 01 through 11. Verify that each key-code is correct as you key in each instruction by checking the displays shown.

(Notice that you had to record the **ENTER**↵ key as an instruction in this program. The **ENTER**↵ instruction here separates the number 3 that is the second step of the program from the digits for the new diameter that you will key in later.)

To run the program switch to automatic RUN mode  RUN and press   (or   ) so that the calculator will begin execution from step 00. Then try the following example.

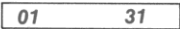
Example. Find the increase in volume of a spherical balloon if the diameter changes from 30 feet to 35 feet.

Press	Display	
30 		Enter the original diameter into Y.
35 		Key the new diameter into X and run the program. The answer, in cubic feet, is displayed.

Displaying Each Step

In order to look at this program, you need to be able to display each step. Two operations allow you to do this:  (*single step*) and  (*back step*).

With the increase in sphere volume program still recorded in the calculator set the PRGM-RUN switch to RUN  RUN and press   to reset the calculator to step 00. Then switch to PRGM mode  RUN and press  once. The display will change to:



Press  again and the display will change to:



Now press . You can see what has happened. You are back at program memory step 01. Press  again and step 00 is displayed. Pressing  again does nothing.

 displays the contents of the *next* step of program memory.

 displays the contents of the *previous* step of program memory.

Of course, because these two keys work in PRGM mode, neither can be stored in program memory.

Displaying a Particular Step

If you want to see one of the later steps of your program, **SST** is not convenient. To display a particular step of program memory use the **GTO** key with the PRGM-RUN switch set to RUN . Simply press **GTO** and then key in the desired two-digit step number. Then set the PRGM-RUN switch to PRGM  and the contents of the specified step will be displayed.

For example, to see step 10 in the previous program, set the PRGM-RUN switch to RUN  and press **GTO** **1** **0**. Then switch back to PRGM mode . The display will show:

10	06
----	----

When using the **GTO** key in this way, always use two digits for designating step numbers. For instance, to see step 6 you must press **GTO** **0** **6** in RUN mode and then switch back to PRGM mode.

If the first digit key following **GTO** is greater than four, the **GTO** key is ignored and the number is keyed into the X-register. Similarly, if one of the two keys following **GTO** is not a digit key, the **GTO** key is ignored and the operation associated with the invalid key is performed.

Interrupting Program Execution

From time to time you will want to program to stop execution by itself so that you can enter new data or view an intermediate result. There are two operations on your HP-25 calculator that will automatically interrupt program execution when they are encountered as program instructions: **R/S** and  **PAUSE**.

Stopping Program Execution

R/S works differently as an executed instruction in a program than it does when pressed from the keyboard. As an executed instruction, **R/S** stops program execution, allowing you to key in new data or to write down an intermediate result.

When **R/S** is then pressed from the keyboard in automatic RUN mode, the calculator continues execution sequentially downward.

Example Program. Universal Tins, a canning company, needs to calculate the volumes of various cylindrically-shaped cans. Universal would also like to be able to record the area of the base of each can before the volume is calculated. One program to solve this problem follows.

This program calculates the area of the base of each can and then stops. When after you have written down that result, the program can be restarted to calculate the final volume. The formula used is:

$$\text{Volume} = \text{base area} \times \text{height} = \pi r^2 \times h$$

The radius (r) and the height (h) of the can are keyed into the X- and Y-registers, respectively, before the program is run.

To record this program, set the PRGM-RUN switch to PRGM  and press **f** **PRGM** to clear program memory and display step 00. Then key in the following list of keys.

Press	Display	
9 x²	01 15 02	Square the radius.
9 π	02 15 73	Place π in X.
x	03 61	Calculate the area of the base.
R/S	04 74	Stop to record the area.
x	05 61	Calculate the final volume.

In order to run this program set the PRGM-RUN switch to RUN  and press **f** **PRGM** so that the calculator

will begin execution from step 00. Then use the program to complete the table below:

Height	Radius	Area of Base	Volume
25	10	?	?
8	4.5	?	?

Press Display

25 **ENTER↑** 25.00

Enter the height into the Y-register.

10 **R/S** 314.16

Program stops to display the area.

R/S 7853.98

Volume of first can is calculated.

8 8.00

Enter the height into the Y-register.

ENTER↑

4.5 **R/S** 63.62

Program stops to display the area.

R/S 508.94

Second volume is calculated.

With the height in the Y-register and the radius in the X-register, pressing **R/S** in automatic RUN mode calculates the area of the can's base; the program stops at the first **R/S** instruction encountered. Pressing **R/S** again calculates the volume of the can and program execution stops at step 00, ready to run again.

In general, **R/S** is recorded into a program when you need to display *more* than one answer. To display *only one* answer or the final answer of a series, the **GTO 0 0** instruction in a program is more convenient since the calculator ends execution at step 00, ready to begin again.

Pausing During Program Execution

An **f PAUSE** instruction executed in a program momentarily interrupts program execution to display intermediate results that do not have to be written down. The length of the pause is about one second, although more than one **f PAUSE** instruction can be used to lengthen the time if desired.

To see how **f** **PAUSE** can be used in a program, we'll modify the cylinder volume program in the previous example. In the new program the area of the base will only be briefly displayed before the volume is calculated. This example will also show how different programming approaches can be taken to solve the same problem.

To key in the program, set the PRGM-RUN switch to PRGM **PRGM**  **RUN** and press **f** **PRGM** to clear program memory and display step 00. Then key in the following list of keys.

Press	Display	
g x²	01 15 02	Squares the radius in X.
g π	02 15 73	Places π in X.
x	03 61	Calculates the area of the base.
f PAUSE	04 14 74	Pauses to show the base area for one second.
x	05 61	Calculates final volume of can.

This program also assumes the height has been entered into the Y-register and the radius has been keyed into the X-register. If you have stored the instructions, set the PRGM-RUN switch to RUN **PRGM**  **RUN** and press **f** **PRGM** so that the calculator will begin execution from step 00. Now complete the table below using the new program.

Height	Radius	Area of Base	Volume
20	15	?	?
10	5	?	?

Press	Display	
20 ENTER	20.00	Enter the height into the Y-register.
15 R/S	706.86	Area of base is displayed for one second.
	14137.17	Program stops, displaying the volume.
10 ENTER	10.00	Enter the second height into Y.

5 **R/S****78.54**

Area of base is displayed for one second.

785.40

Program stops, displaying the volume.

Program Stops

At times a mistake of some kind in your program will stop program execution. To help you identify why the calculator stopped in the middle of your program, possible reasons are listed below.

Executing a R/S. The execution of a **R/S** instruction in a program halts program execution at the step following the **R/S**.

Executing Step 00. Whenever step 00 is executed in a program, program execution stops at step 00.

Pressing Any Key. Pressing any key halts program execution. Be careful to avoid pressing keys during program execution. If a program has been stopped by pressing a key, be careful not to restart program execution in the middle of a digit entry key sequence within the program. For example in the section of a program shown below, if program execution halted at step 23, the number 13 would appear in the display. If **R/S** is pressed, the number 13 would be automatically pushed up into the stack and the number 4.7 would be keyed into the X-register.

19	61
20	14 03
21	01
22	03
23	04
24	73
25	07
26	15 22

Digit entry

Digit entry

Digit entry

Digit entry

Digit entry

To avoid problems like this, you should switch to PRGM mode to see whether or not you are in the middle of a digit entry key sequence. If you are, you should use **SST** or **BST** to correct the situation. In this case, you should press **SST** twice in PRGM mode, then switch back to RUN mode and press **CLX**. Finally you can press **R/S** to resume program execution.

BST

Overflow Calculations. Your HP-25 has been designed so that by looking at the display you can always tell why the calculator stops. If program execution stops because the result of a calculation in the X-register is a number with a magnitude greater than $9.999999999 \times 10^{99}$, all 9's are displayed with appropriate sign. It is then easy to determine the operation that caused the overflow by switching to PRGM mode and identifying the keycode in the display.

If the overflow occurs in one of the storage registers, possibly the result of storage register arithmetic or the summations with $\Sigma+$, the calculator will display **OF** to inform you of the overflow. Check the storage registers to see in which register the overflow has occurred.

If the result of a calculation is a number with a magnitude less than 10^{-99} , zero will be substituted for the number and a running program will continue to execute normally.

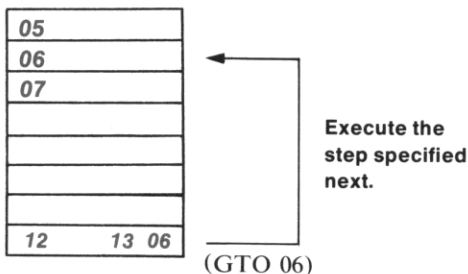
Improper Operation Stops. Calculations that cause the word **Error** to be displayed also stop program execution. You can identify the reason for the stop by switching momentarily to PRGM mode to see the keycode of the improper operation. A list of improper operations can be found in appendix B.

Branching

Although program execution is normally sequential, with one step executed after another, execution can be transferred or "branched" to any step in program memory. The "branch" can be made unconditionally or it can be made dependent on the outcome of a comparison of data values.

Unconditional Branching

You have seen how **GTO** is used in manual RUN mode to help you display any step in program memory. As an instruction executed in a program **GTO** is used to branch program execution to the step number specified. It can tell the calculator to execute step 00 next, as we have already seen, or to execute any other step in program memory.

Unconditional Branching

When recording an unconditional branch always follow the **GTO** key with two digit keys to designate the step number. For instance, to branch to step 6 the program instruction must be **GTO** **0** **6**.

If the first digit key following **GTO** is greater than four, the **GTO** key is ignored and the number is stored in that step of program memory. Similarly, if one of the two keys following **GTO** is not a digit key, the **GTO** key is ignored and the invalid key is stored in program memory.

Example Program. The following program is an interesting one to show your friends. It calculates the squares of consecutive whole numbers beginning with zero. The calculator continues to compute the square of the next consecutive whole number until you press **R/S** to stop program execution (or until the calculation overflows). The simple formula used is: $x \times n^2$ where n is continually incremented by one.

To key in the program set the mode switch to **PRGM**  **RUN** and press **f** **PRGM** to clear program memory and display step 00. Then key in the list of keys shown below.

Press	Display	
0	01 00	
STO 1	02 23 01	Store zero in R_1 .
RCL 1	03 24 01	Recall the current number for squaring.
9 x²	04 15 02	Square the number.
f PAUSE	05 14 74	Display the square briefly.
1	06 01	
STO + 1	07 23 51 01	Increment the number in R_1 by one.
GTO 0 3	08 13 03	Transfer program execution to calculate the next square.

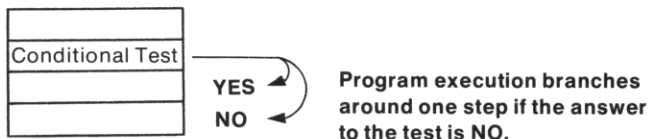
The program calculates the square of the number in storage register R_1 , starting with zero. It pauses to show the answer and then increments the contents of the register by one. The unconditional branch at the end of the program is used to transfer program execution back to step 03 so that the calculation can be repeated with the new value in register R_1 .

To run the program set the **PRGM-RUN** switch to **RUN**  **RUN** and press **f** **PRGM** so that the calculator will begin execution from step 00. Then simply press **R/S**. The squares of consecutive whole numbers will be shown one by one in the display. Press **R/S** again to stop execution whenever you wish.

Conditional Branching

Eight different program instructions give the HP-25 the ability to make decisions within a program depending on the outcome of a comparison of data values. These “conditionals” transfer program execution based on the outcome of the test. If the answer is YES, program execution continues sequentially downward. If the answer is NO, the calculator branches

around the following step, which can contain an unconditional branch or a simpler instruction (**CHS**, for example). The program makes a decision for you!



The eight different conditionals in your HP-25 are shown here. In each case, the tests are made on the 10-digit numbers and two-digit exponents actually stored in the stack registers, not on the displayed values.

- f** $x < y$ tests to see if the value in the X-register is less than the value in the Y-register.
- f** $x \geq y$ tests to see if the value in the X-register is greater than or equal to the value in the Y-register.
- f** $x \neq y$ tests to see if the value in the X-register is not equal to the value in the Y-register.
- f** $x = y$ tests to see if the value in the X-register is equal to the value in the Y-register.
- g** $x < 0$ tests to see if the value in the X-register is less than zero.
- g** $x \geq 0$ tests to see if the value in the X-register is greater than or equal to zero.
- g** $x \neq 0$ tests to see if the value in the X-register is not equal to zero.
- g** $x = 0$ tests to see if the value in the X-register is equal to zero.

Example Program. This program calculates the arc sine of an input value x (x must be within the limits of -1 and $+1$). The program tests the resulting angle, and if it is not greater than zero, adds 360 degrees to it. The angle displayed by the program, then, is always positive.

To key in the program set the mode switch to **PRGM**  **RUN** and press **f** **PRGM** to clear program memory and display step 00. Then key in the following list of keys.

Press	Display	
9 sin⁻¹	01 15 04	Calculates the arc sine.
9 x≥0	02 15 51	Compares the result to zero.
GTO 0 0	03 13 00	If greater than zero, display arc sine.
3	04 03	} Otherwise add 360 degrees to the arc sine.
6	05 06	
0	06 00	
+	07 51	

To run the program set the PRGM-RUN switch back to RUN and press **f** **PRGM** so that the calculator will begin execution from step 00. Then key in positive or negative values for x . The resultant arc sine will always be positive.

Press	Display	
9 DEG	0.00	Set degrees mode.
.5 R/S	30.00	Arc sine of .5 equals 30 degrees.
.5 CHS	-0.5	Key in negative value for x .
R/S	330.00	360 is added to the arc sine to give a positive angle.

Editing a Program

Even the most experienced programmer finds errors in his programs. These errors range from mistakes in the original equations to mistakes in recording the program. Wherever they occur they need to be found and corrected, and the HP-25 is designed to make this error-checking process as easy as possible.

Finding the Error

One of the easiest ways to find out if your program is working properly is to work a test case in which you either know the answer or the answer can be easily determined. For example, if you have a program that calculates the area of a circle using the formula $area = \pi \times r^2$, you can easily determine that an input value of 1 for r will give an answer of π .

SST Execution. In longer programs a wrong test-case answer will seldom pinpoint the mistake. For these cases, you can slow down program execution by using the **SST** key in RUN mode. In RUN mode, the **SST** key will execute your program instruc-

tions one at a time. When you hold the **SST** key down in RUN mode, the program step number and keycode are displayed. When you release the **SST** key, the instruction is executed. Use **SST** on the simple area of a circle program shown below to familiarize yourself with its operation.

Example Program. This program calculates the area of a circle using the formula: $A = \pi r^2$ where r is the radius. Set the PRGM-RUN switch to PRGM  and press **f**  to clear program memory and display step 00. Then key in the list of keys shown below.

Press	Display
g 	01 15 02
g 	02 15 73
x 	03 61

The program assumes that a value for r has been keyed into the X-register. To run the program, set the PRGM-RUN switch back to RUN  and press **f** . Now step through the program in slow motion using a value of 10 for r .

Press	Display
10	10.
SST	01 15 02
	100.00
SST	02 15 03
	3.14
SST	03 61
	314.16

When you hold **SST** down, the first instruction is displayed.

When you release **SST**, the first instruction is executed.

Again holding **SST** down displays the second instruction.

Again releasing **SST** executes the second instruction.

Holding **SST** down displays the third instruction this time.

And releasing **SST** executes the third instruction.

You can see that it would be easy to spot a mistake in your program using the **SST** key.

When you hold the **BST** key down in RUN mode, the program step number and keycode for the previous step are displayed. When you release **BST**, the X-register is again displayed. However if you switch back to PRGM mode, you will find that the previous step is now displayed. And if you press **R/S** in RUN mode after pressing **BST**, the calculator will begin execution from the previous step in program memory. Now press **BST** in RUN mode to review the program instructions of the above program.

Press	Display	
BST	03 61	Holding BST down in RUN mode displays the previous instruction.
	314.16	Releasing the BST key displays the original contents of the X-register.
BST	02 15 73	Again holding BST down displays the previous step in program memory.
	314.16	And releasing BST displays the original contents of the X-register again.

If you now switch to PRGM mode the second step will be displayed:

02 15 73

One caution should be observed when using **SST** in RUN mode. The **SST** key does not terminate data entries. Therefore you must be careful when keying in data at a **R/S** instruction if you plan to continue execution with **SST**. If you have data in program memory directly following the **R/S** instruction, the calculator will add-on the number in memory to the data entry. To prevent this from happening, press **ENTER** following your data entries whenever you plan to continue execution with **SST**.

Cued Stops. If you have a program that is halted several times during execution for data entries, you may want to "identify" each stop by recording a familiar number into the program just before each **R/S** instruction. Then when the calculator stops

execution because of the **R/S** instruction in the program, you can look at the displayed X-register to see the “identification number” for the required input. For example if your program contains eight steps for data inputs, it may be helpful to have the numbers 1 through 8 appear so you know which input is required each time.

Changing One Instruction

Changing or correcting one step of your program is easy with your HP-25 calculator because of the features built into it. Once the error has been found, use **SST** or **BST** in PRGM mode or **GTO** in RUN mode to display the step *preceding* the step to be changed. For example, to change the instruction in step 06, you need to display step 05. If you wish to change the step, simply press the correct key or keys for step 06. They will write over and replace the incorrect information already stored in that step.

If step 06 is an extra step in your program, press **g** **NOP** (*no operation*). This instruction tells the calculator not to perform any operation here.

Example Program. The program represented below is designed to take the cube root of a number.

Press	Display
ENTER ↵	01 31
3	02 03
g $\frac{1}{x}$	03 15 22
f y^x	04 14 03

Suppose that upon reviewing the program with the **SST** key, however, you discover you have keyed in the following mistake-ridden program :

Press	Display
ENTER ↵	01 31
3	02 03
g %	03 15 21
x↔y	04 21
f y^x	05 14 03

Oops! You pressed the wrong key.

And you pressed it again by mistake.

Set the PRGM-RUN switch to PRGM , press **f** , and key in this mistake-ridden second program now.

To correct the program, press **BS** three times to display step 02. Then correct the first mistake by keying in the correct keys for step 03.

Press **Display**

g 

02 03
03 15 22

First display this step.

Then press the correct keys for step 03.

With step 03 displayed you are ready now to correct step 04. Since this is an unwanted extra step, use the **g**  function to replace its contents.

Press **Display**

g 

03 15 22
04 15 74

Display step 03 to correct step 04.

Press **g**  so that the calculator will not perform an operation here.

Now set the PRGM-RUN switch back to RUN , and press **f**  to reset the calculator to step 00. The example below will help you determine whether or not you have corrected the program.

Example. Find the cube root of 8 and then of 125.

Press **Display**

8 

2.00

125 

5.00

Adding Instructions

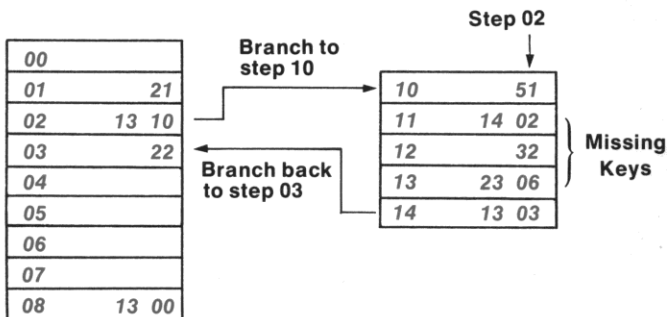
If you have recorded a medium-sized program and have left out a crucial sequence of keystrokes right in the middle, you do not have to start over. The missing sequence of keystrokes can be recorded in the available steps following your program. You can then use the **GTO** key to make an unconditional branch to the sequence when it is needed and then make a second unconditional branch back to the main part of your program at the end of the sequence.

The program segment shown below should make this more clear. Three keys are missing between steps 02 and 03.

00	
01	21
02	51
03	22
04	
05	
06	
07	
08	13 00

← Missing three steps (**f** **√x** , **CHS** and **STO** **6**) here.

In order to add the missing steps we need to branch to one of the available program steps in program memory. The corrected program is shown below.



Notice in particular that the instruction originally stored in step 02 is now stored in step 10. Step 02 now contains an unconditional branch instruction to step 10. The missing keys are stored in steps 11 through 13 and the instruction stored in step 14 is an unconditional branch back to step 03 in the main program.

Program Applications

The following two programs are provided as additional examples to test your programming skills. Only the purpose of each program is explained. See if you can figure out how each program works on your own.

Factorial

This program calculates the factorial of an input value “ n ” [$n(n-1)(n-2) \dots 3 \times 2 \times 1$]. (For the special case where $n = 0$, $0! = 1$.) Switch to PRGM mode  RUN and press 

 before keying in the following list of keys.

Keys



Display

01	15	03
02	14	01
03	23	01
04	15	71
05	13	14
06		01
07	14	71
08	13	16
09		21
10		01
11		41
12	23	61 01
13	13	06
14		01
15	13	00
16	24	01

Now switch back to RUN mode  RUN and press   so you can try the following example.

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

Method: $P_6 = 6!$

Press

6 

Display

720.00	($6 \times 5 \times 4 \times 3 \times 2 \times 1$)
--------	--

Converging Series

This program uses the following series to approximate the value of “ e ” ($e = 1/0! + 1/1! + 1/2! + \dots + 1/n!$). It then tests each approximation against the value for “ e ” generated by the calculator by pressing **1** **g** **e^x** . Each approximation is displayed, then the difference between the approximation and the calculator’s value for “ e ” is displayed. When the two values are equal, the program stops and displays the number of terms it took for the series to converge.

Switch to PRGM mode **PRGM**  **RUN** and press **f** **PRGM** before keying in the following list of keys.

Keys	Display
1	01 01
STO 0	02 23 00
STO 1	03 23 01
ENTER ↑	04 31
g $1/x$	05 15 22
RCL 0	06 24 00
+	07 51
STO 0	08 23 00
1	09 01
g e^x	10 15 07
f $x=y$	11 14 71
GTO 2 6	12 13 26
$x \leftrightarrow y$	13 21
f FIX 9	14 14 11 09
f PAUSE	15 14 74
f PAUSE	16 14 74
—	17 41
f PAUSE	18 14 74
R↓	19 22
RCL 1	20 24 01
1	21 01
+	22 51

STO	1	23	23	01
X		24	61	
GTO	0	4	25	13 04
RCL	1	26	24	01
f	FIX	2	27	14 11 02

Switch back to RUN mode  RUN and press   before trying the program yourself by pressing .

Your series should converge after 11.00 terms.

Afterword

If you have worked completely through this handbook, you should have a very good knowledge of all of the basic functions of the HP-25. But in fact you've only begun to see the power of the calculator. You'll come to understand it better and appreciate it more as you use the HP-25 daily to solve even the most complex mathematical expressions. At your fingertips you have a tool that was unavailable to Archimedes, Galileo, or Einstein. The only limits to the flexibility of the HP-25 are the limits of your own mind.

Accessories, Service and Maintenance

Standard Accessories

Your HP-25 comes complete with one each of the following standard accessories:

Battery Pack (installed in calculator before packaging)
Soft Carrying Case
HP-25 Owner's Handbook
HP-25 Applications Programs
Battery Charger/AC Adapter
HP-25 Quick Reference Guide

Optional Accessories

Other accessories are specified on the Accessory Order Form.

To order additional standard or optional accessories for your HP-25 see your nearest dealer or fill out an Accessory Order Form and return it with check or money order to:

Hewlett-Packard
Advanced Products Division
19310 Pruneridge Avenue
Cupertino, CA 95014

If you are outside the U.S., please contact the Hewlett-Packard Office nearest you.

AC Line Operation

Your calculator contains a rechargeable battery pack that includes two nickel-cadmium batteries. When you receive your calculator, the battery pack inside may be discharged, but you

can operate the calculator immediately by using the battery charger/ac adapter. Even though you are using the battery charger/ac adapter, *the batteries must remain in the calculator whenever the calculator is used.*

CAUTION

Attempting to operate the HP-25 from the ac line with the battery pack removed may result in damage to your calculator.

The procedure for using the battery charger/ac adapter is as follows:

1. If your charger has a line voltage select switch, make sure it is set to the proper voltage. The two line voltage ranges are 100 to 127 volts and 200 to 254 volts.

CAUTION

Your HP-25 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-25 power switch to OFF.
3. Insert the female battery charger/ac adapter plug into the rear connector of the HP-25 and insert the power plug into a live ac power outlet.

CAUTION

The use of a charger other than the HP battery charger supplied with the calculator may result in damage to your calculator.

Battery Charging

The rechargeable batteries in the battery pack are being charged when you are operating the calculator from the battery charger/ac adapter. With the batteries in the calculator and the battery

charger connected, the batteries will charge with the calculator OFF or ON. Normal charging times from fully discharged battery pack to full charge are:

Calculator OFF: 6 hours

Calculator ON: 17 hours

Shorter charging periods will reduce the operating time you can expect from a single battery charge. Whether the calculator is OFF or ON, the HP-25 battery pack is never in danger of becoming overcharged.

Note: It is normal for the battery charger/ac adapter to be warm to the touch when it is plugged into an ac outlet. It is also normal for the HP-25 calculator itself to be warm to the touch with the ac adapter/battery charger connected for battery charging and the HP-25 ON-OFF switch set to OFF.

Battery Operation

To operate the HP-25 from battery power alone, simply turn the calculator OFF, disconnect the female battery charger plug from the rear of the calculator, and turn the calculator ON again. (Even when not connected to the calculator, the battery charger/ac adapter may be left plugged into the ac outlet.)

Using the HP-25 on battery power gives the calculator full portability, allowing you to carry it nearly anywhere. A fully charged battery pack provides approximately 2 to 5 hours of continuous operation. By turning the power OFF when the calculator is not in use, the charge on the HP-25 battery pack should easily last throughout a normal working day.

Most of the battery power consumed by the calculator is used to light the display, so you can maximize battery operating time by displaying the minimum number of digits necessary while calculating. If the HP-25 must be left ON between calculations,

1. is the display that consumes the least power.

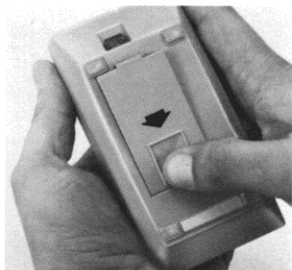
Battery Pack Replacement

If it becomes necessary to replace the battery pack, use only another Hewlett-Packard battery pack like the one shipped with your calculator.

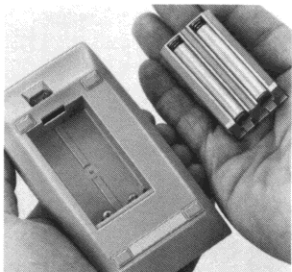
CAUTION

Use of any batteries other than the Hewlett-Packard battery pack may result in damage to your calculator.

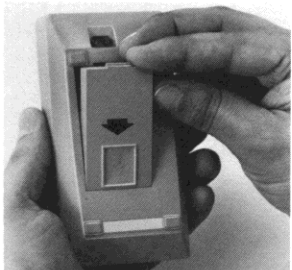
To replace the battery pack, use the following procedure:



1. Set the calculator ON-OFF switch to OFF and disconnect the battery charger/ac adapter from the calculator.
2. Press down on the thumbset at the rear of the calculator and slide the battery pack in the direction of the arrow.



3. When the key on the battery pack becomes visible, lever that end of the pack up and permit the battery pack to fall into the palm of your hand.



4. Insert the new battery pack in the direction of the arrow. Slant the leading edge of the pack into the edge of the doorway.
5. Snap the battery pack into place by pressing it gently.

If you use your HP-25 extensively in field work or during travel, you may want to order the optional Reserve Power Pack, consisting of a battery charging attachment and a spare battery pack. The Reserve Power Pack enables you to charge one battery pack while using the other in the calculator. See the Accessory Brochure shipped with the calculator for details.

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 along with your HP-25 and battery charger/ac adapter to Hewlett-Packard according to the shipping instructions. If the battery pack is out of warranty, see your nearest dealer or use the Accessory Order Form provided with your HP-25 to order a replacement.

Service

Low Power

When you are operating from battery power in RUN mode, all decimal points except the true one light to warn you that you have a minimum of 1 minute of operating time left.

6 0.2. 23

Low Power Display

True Decimal Point

You must then either operate the calculator from the battery charger/ac adapter as described under AC Line Operation, or you can substitute a fully charged battery pack for the one in the calculator.

Blank Display

If the display blanks out, turn the HP-25 OFF, then ON. If **0.00** does not appear in the display in RUN mode, check the following:

1. If battery charger is attached to the HP-25, make sure it is plugged into an ac outlet. If not, turn the calculator OFF before plugging the charger 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-25 using the charger (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 stored program, the display continuously changes and is purposely illegible to indicate that the program is running. When the program stops, the display is steady.

Temperature Range

Temperature ranges for the calculator are:

Operating	0° to 45°C	32° to 113°F
Charging	15° to 40°C	59° to 104°F
Storage	-40° to +55°C	-40° to +131°F

Warranty

Full One-Year Warranty

The HP-25 is warranted against defects in materials and workmanship for one (1) year from date of delivery to the original purchaser. 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 is returned, shipping prepaid, to Hewlett-Packard's Customer Service Facility. (Refer to Shipping Instructions.)

This warranty does not apply if the calculator 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 warranty is expressed by Hewlett-Packard. **Hewlett-Packard shall not be liable for consequential damage.**

Out-of-Warranty

Beyond the one-year warranty period, calculators will be repaired for a moderate charge. *All* repair work performed beyond the warranty period is warranted for a 90-day period.

Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of sale. Hewlett-Packard shall have no obligation to modify or update products once sold.

Shipping Instructions

Whether the unit is in-warranty or out-of-warranty, it is the customer's responsibility to pay charges for shipping to the

applicable service facility listed on the *Service Card*. During warranty, the service facility will, in turn, ship the unit back to the customer prepaid, via the fastest economical means.

On out-of-warranty repairs, the customer will pay shipping charges both ways.

Malfunctions traced to the calculator, batteries, or battery charger require that you return the following to us:

Calculator with all standard accessories.

Completed *Service Card*.

Send returned items safely packaged to the address shown on the *Service Card*.

Under normal conditions, calculators will be repaired and re-shipped within five (5) working days of receipt at any Hewlett-Packard Service Facility listed on the *Service Card*.

Should other problems or questions arise regarding service, please call your nearest Hewlett-Packard sales or service facility.

Improper Operations

If you attempt a calculation containing an improper operation—say, division by zero—the display will show **Error**. To clear, press **CLX**.

The following are improper operations:

$\div$, where $x = 0$

y^x , where $y \leq 0$

$\sqrt{x}$, where $x < 0$

$1/x$, where $x = 0$

$\log$, where $x \leq 0$

$\ln$, where $x \leq 0$

$\sin^{-1}$, where $|x|$ is > 1

$\cos^{-1}$, where $|x|$ is > 1

STO $\div$, where $x = 0$

$\bar{x}$, where $n \leq 0$

S , where $n \leq 1$

Stack Lift and LAST X

Stack Lift

A number keyed in following one of these operations lifts the stack:

$-$	COS	$\rightarrow$ H.MS	SCI
$+$	$\cos^{-1}$	$\rightarrow$ H	ENG
$\times$	tan	ABS	STO n
$\div$	$\tan^{-1}$	$\frac{1}{x}$	RCL n
e^x	INT	%	STO $-$ n
$\ln$	FRAC	$\bar{x}$	STO $+$ n
log	$\sqrt{x}$	S	STO $\times$ n
10^x	x^2	$x \rightarrow y$	STO $\div$ n
sin	π	$R \rightarrow$	$\rightarrow$ R
$\sin^{-1}$	y^x	FIX	$\rightarrow$ P

A number keyed in following one of these keys does not affect the stack:

f	g	STO	0 thru 9
CHS	EEX	$\bullet$	

A number keyed in following one of these operations writes over the number in the X-register and the stack does not lift:

CLX	ENTER $\uparrow$	$\Sigma +$	$\Sigma -$
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LAST X

The following operations save x in LAST X:

$-$	FRAC	COS	$\frac{1}{x}$
$+$	INT	$\cos^{-1}$	y^x
$\times$	$\ln$	tan	e^x
$\div$	log	$\tan^{-1}$	10^x
$\rightarrow$ H.MS	sin	$\sqrt{x}$	$\rightarrow$ R
$\rightarrow$ H	$\sin^{-1}$	x^2	$\rightarrow$ P
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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 (statute)†	= 1.150 779 448 miles (nautical)†

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*
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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.



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