About HP

Hewlett-Packard's interest in computation evolved as a natural extension of our traditional involvement in measurement problem solving. At an early date, HP recognized the growing need for a family of computational products designed to work easily and effectively with scientific instruments.

In 1966 we introduced the first digital minicomputer specifically designed to meet this need. Soon after, we followed up with our first programmable calculator. From these beginnings, HP has now become an acknowledged leader in the field of computational problem solving. More than 20,000 HP programmable calculators and digital computers are at work in a wide range of applications in science, industry, education, medicine, and business. Their effectiveness is further enhanced by a complete line of accessory devices, ranging from digital tape and disc drives to card and tape readers, printers, and plotters.

About The HP-45

To give you more computing power, your HP-45 works in a consistent and natural way that may be slightly different from previous calculators you have operated. Even though your new HP-45 is simple to operate, and you can start solving problems immediately by following the Quick Reference Guide accompanying the HP-45, you will find it worthwhile to read this handbook.
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Introduction

Little is understood about the methods used by calculating prodigies to perform their awesome feats. The method used by 10-year-old Truman Henry Safford in 1846 to calculate $365365365365365365^2$ (as described by the Rev. H. W. Adams) shows that difficult problems are difficult even for prodigies—"...he flew around the room like a top, pulled his pantaloons over the tops of his boots, bit his hands, rolled his eyes in their sockets, sometimes smiling and talking and then seeming to be in an agony, until, in not more than one minute said he, 133,491,850,208,566,925,016,658,299,941,583,225!"

Although your HP-45 might not be as much fun to watch, it makes calculating faster and less arduous, because the operational stack and the reverse "Polish" notation used in the HP-45 provide the most efficient way known to computer science for evaluating mathematical expressions.

The HP-45 has far more computing power than previous pocket calculators. Its accuracy exceeds the precision to which most of the physical constants of the universe are known. It will handle numbers as small as $10^{-99}$, as large as $10^{99}$, automatically places the decimal point, and allows 20 different options for rounding the display to provide greater flexibility and convenience in interpreting results. The HP-45 provides you with transcendental functions, such as logarithms, sines and cosines; polar/rectangular coordinate conversions for handling complex arithmetic, vectors; selective operating modes; and multiple storage registers. Additionally, constants for $\pi$ and $e$ are provided—as well as three metric/U.S. unit constants for conversions between centimeters/inches, kilograms/pounds, and liters/gallons. Furthermore, statistical capabilities for calculating the mean (arithmetic average) and standard deviation are incorporated in the HP-45.
To give you an idea of the scope and power of your HP-45, let’s convert rectangular x, y coordinates (3, 4) to polar form (magnitude and angle). To solve, simply enter the known values as follows:

Key in 4 (y-coordinate) and press ENTER, then key in 3 (x-coordinate) and press →P (to polar) to display the magnitude: 5.00. Press x:y to display the angle: 53.13.

If you want to see the angle with 8 decimal places, press FIX, then key in 8 and see displayed: 53.13010235.

To obtain the magnitude, press x:y and see displayed: 5.00000000.

Now press FIX 2 to get back to 2 decimal places in the display.

Note that the result is accurate to 9 significant digits. Now compare that with the slide rule solution (accurate to 3 significant digits).

<table>
<thead>
<tr>
<th>Slide Rule Method</th>
<th>HP-45 Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Magnitude</strong> = ( \sqrt{x^2 + y^2} )</td>
<td>Key in: 4 ENTER + 3</td>
</tr>
<tr>
<td><strong>Angle</strong> = ( \tan^{-1} \left( \frac{y}{x} \right) )</td>
<td>Display magnitude:</td>
</tr>
<tr>
<td>where: ( x = 3 )</td>
<td>( \rightarrow 5.00 )</td>
</tr>
<tr>
<td>( y = 4 )</td>
<td>Display angle:</td>
</tr>
<tr>
<td>Calculate magnitude: ( x^2 = 3 \times 3 = 9 )</td>
<td>( x:y )</td>
</tr>
<tr>
<td>( y^2 = 4 \times 4 = 16 )</td>
<td>( \rightarrow 53.13 )</td>
</tr>
<tr>
<td>( x^2 + y^2 = 9 + 16 = 25 )</td>
<td></td>
</tr>
<tr>
<td>( \sqrt{x^2 + y^2} = \sqrt{25} = 5.0 )</td>
<td></td>
</tr>
<tr>
<td>Calculate angle: ( \tan^{-1} \left( \frac{y}{x} \right) = \tan^{-1} \left( \frac{4}{3} \right) = \tan^{-1} \left( 1.3 \right) = 53.1 )</td>
<td></td>
</tr>
</tbody>
</table>

Incidentally, no calculator available today (including ours) can handle the problem given to our child prodigy. Isn’t it comforting to know that people can still do things machines can’t?
Fundamental Operations

Getting Started
Your HP-45 is shipped fully assembled with its battery pack in place. Before using the calculator for portable use, charge it for 14 hours as described in Appendix B. You may run the calculator on battery power alone or you may connect the battery charger and run while the battery is charging. Slide the power switch to ON. If anything other than 0.00 appears on the display, see Service, page 53.

The display blinks when an improper operation is made. The blinking will stop as soon as \( \text{CLX} \) is pressed and you may enter a new problem.

Keyboard
Figure 1 illustrates the keyboard layout. Almost every key performs two distinct functions. The symbol for the primary function appears on the key, and the symbol for the alternate function appears above the key like this \( \sqrt{x} \).

To use the primary function, merely press the selected key; to use the alternate function, press the gold key \( \text{ } \) (upper righthand corner) before pressing the associated key like this \( \text{ } \). Alternate functions are indicated like this \( \sqrt{x} \) throughout your handbook.

A summary of all keys and an index to where they are used are provided at the back of your Handbook.
Off-On Switch—Control Keys:

### Control Keys:
- \( x^y \)
- \( R \times \)
- \( \text{STO} \)
- \( \text{RCL} \)
- \( \text{ENTER} \)
- \( \text{CHS} \)
- \( \text{EEX} \)
- \( \text{CLx} \)

### Arithmetic Keys:
- \( - \)
- \( + \)
- \( \times \)
- \( \div \)
- \( \sqrt{x} \)
- \( x^2 \)
- \( \frac{1}{x} \)
- \( \log \)
- \( 10^x \)
- \( \text{SCI} \)

### Trigonometric Keys:
- \( \sin^{-1} \)
- \( \cos^{-1} \)
- \( \tan^{-1} \)
- \( \sin \)
- \( \cos \)
- \( \tan \)

### Other Functions:
- \( n! \)
- \( \bar{x}, s \)
- \( \rightarrow \text{DMS} \)
- \( \text{DMS} \rightarrow \)
- \( \Delta \% \)
- \( \text{DEG} \)
- \( \text{RAD} \)
- \( \text{GRD} \)
- \( \text{CLEAR} \)
- \( \text{cm/in} \)
- \( \text{kg/lb} \)
- \( \text{ltr/gal} \)

Gold Shift Key: [Image of gold shift key]

**Figure 1. Keyboard Layout**
Keying In and Entering Numbers

Each time a number key is pressed, that number appears left-justified on the display in the order as pressed. Note that a decimal point symbol is included with the number entry keys; it must be keyed in if it is part of the number. For example, 314.32 would be keyed as 3 1 4 • 3 2. To signal that the number string keyed in is complete, press ENTER . Now you may key in another number string.

If you make a mistake when keying in a number, clear the entire number string by pressing C L X . Then key in the correct number.

Performing Simple Arithmetic

In the HP-45, arithmetic answers appear on the display immediately after pressing an arithmetic key: + , − , • , ÷ . In an adding machine, the + key adds whatever is already in the machine to the last entry, and the − key subtracts this last entry. The HP-45 not only adds and subtracts the same way as the old familiar adding machine, it also multiplies and divides this way too—the • key multiplies whatever is already in the machine by the last entry, and the ÷ key divides by the last entry. For example, add 12 and 3.

Press: 12 ENTER 3 +  See displayed: 15.00

Did you notice that you calculated this sum in the same order in which you would ordinarily do it with pencil and paper? That’s right—you keyed in 12, terminated the number string and loaded the number by pressing ENTER . Then you pressed 3 followed by + to get the answer.

This same principle is used for calculating any arithmetic problem having two numbers and one arithmetic operator. For example, subtract 3 from 12.

Press: 12 ENTER 3 −  See displayed: 9.00
To multiply 12 by 3,

Press: 

12 \[\text{ENTER} \] 3 \[x\] \hfill \text{See displayed:} \quad 36.00

To divide 12 by 3,

Press: 

12 \[\text{ENTER} \] 3 \[\div\] \hfill \text{See displayed:} \quad 4.00

**Correcting Input Errors**

The HP-45 automatically stores the last number displayed (last input argument) that precedes the last function performed. For example, if you wanted to verify the last input argument from the example above,

Press: 

\[\text{LAST x} \] \hfill \text{See displayed:} \quad 3.00 \quad \text{last input argument}

A special storage register—Last x—is provided for this purpose. As each new function is keyed (executed), the contents of Last x are overwritten with the new value.

\[\text{LAST x} \] is a very useful feature for correcting errors, such as pressing the wrong arithmetic operator key or entering the wrong number. For example, if you were performing a long calculation where you meant to **subtract** 3 from 12 and **divided** instead, you could compensate as follows:

Press: 

12 \[\text{ENTER} \] 3 \[\div\] \hfill \text{See displayed:} \quad 4.00 \quad \text{oops—you wanted to subtract}

\[\text{LAST x} \] \hfill \text{See displayed:} \quad 3.00 \quad \text{retrieves last number displayed preceding operation (division)}

\[\times\] \hfill \text{See displayed:} \quad 12.00 \quad \text{reverses division operation; you’re back where you started}

\[\text{LAST x} \] \hfill \text{See displayed:} \quad 3.00 \quad \text{retrieves last number displayed before operation (multiplication)}

\[-\] \hfill \text{See displayed:} \quad 9.00 \quad \text{correct operation produces desired results}
If you want to correct a number in a long calculation, \( [\text{LAST x}] \) can save you from starting over. For example, divide 12 by 2.157 after you have divided by 3.157 in error.

**Press:**

\[
12 \ \text{ENTER} \ + \ 3.157 \ \div \ \rightarrow \ \boxed{3.80}
\]

you wanted to divide by 2.157 not 3.157

\[
\boxed{3.16}
\]

retrieves last number displayed preceding operation

\[
12.00
\]

you’re back at the beginning

\[
2.157 \ \div \ \rightarrow \ \boxed{5.56}
\]

Eureka!

### Clearing

To clear the display, press \( \text{CLx} \). To clear the entire calculator (except for certain data storage registers—more about that later), press \( \text{CLEAR} \). (Notice that it isn’t necessary—although it may be comforting—to clear the calculator when starting a new calculation.) To clear everything, including all data storage registers, turn the HP-45 off then on.

### Using Display And Rounding Options

Up to 15 characters can be displayed: mantissa sign, 10-digit mantissa, decimal point, exponent sign, and 2-digit exponent.

Two display modes (fixed decimal and scientific notation) and a variety of rounding options are provided. Rounding options affect the display only; the HP-45 always maintains full accuracy internally.

Fixed decimal notation is specified by pressing \( \text{FIX} \) followed by the appropriate number key to specify the number of decimal places (0–9) to which the display is to be rounded. The display is left-justified and includes trailing zeros within the setting specified. When the calculator is turned on it “defaults” to \( \text{FIX} \) 2; that is, the mode and decimal place settings revert to predesignated ones (\( \text{FIX} \) 2) automatically.
For example,

Press: See displayed:
123.456 123.456
FIX 4 123.4560
FIX 1 123.5
FIX 0 123.

Scientific notation is useful when you are working with very large or very small numbers. It is specified by pressing , followed by the appropriate number key to specify the number of decimal places (0–9) to be displayed. Again, the display is left-justified and includes trailing zeros. For example,

Press: See displayed:
SCI 6 1.234560 02
SCI 3 1.235 02

Now return to 2 decimal places in fixed decimal notation.

Press: See displayed:
FIX 2 123.46

Keying In Negative Numbers

To enter a negative number, key in the number, then press (change sign key). The number, preceded by a minus (—) sign, will appear on the display. For example,

Press: See displayed:
12 CHS -12.
ENTER 23 - -35.00

To change the sign of a negative or positive number on the display, press . For example, to change the sign of —35.00 now in the display,

Press: See displayed:
CHS 35.00
Keying In Exponents
You can key in numbers having exponents by pressing EEX (Enter Exponent). For example, key in 15.6 trillion \((15.6 \times 10^{12})\), and multiply it by 25.

Press: 
\[
15.6 \quad \text{EEX} \\
12 \quad \text{ENTER} \\
25 \quad \text{x}
\]
See displayed:
\[
15.6 \quad 00 \\
15.6 \quad 12 \\
1.560000000 \quad 13 \\
3.900000000 \quad 14
\]

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

Press: 
\[
\text{EEX} \quad 6 \quad \text{ENTER} \\
52 \quad \div
\]
See displayed:
\[
1. \quad 06 \\
1000000.00 \quad 00 \\
19230.77
\]

To key in negative exponents, key in the number, press EEX, key in the power of ten, then press CHS to make the exponent negative. For example, key in Planck’s constant \((h)\)—roughly, \(6.625 \times 10^{-27}\) erg. sec.—and multiply it by 50. (Since the problem deals with very small numbers, the keystrokes to reset the display to scientific notation showing six decimal places are included in the following example.)

Press: 
\[
6.625 \quad \text{EEX} \\
27 \quad \text{CHS} \\
6 \quad \text{SCI} \\
50 \quad \text{x}
\]
See displayed:
\[
6.625 \quad 00 \\
6.625 \quad 27 \\
6.625 \quad -27 \\
6.625000 \quad -27 \\
6.625000 \quad -27 \\
3.312500 \quad -25
\]

If you return to a FIX 2 setting, the result is rounded to zero. For example,

Press: 
\[
\text{FIX} \quad 2
\]
See displayed:
\[
0.00
\]
Performing Simple Functions

Finding Reciprocals
To calculate reciprocals of a displayed number, key in the number, then press $\frac{1}{x}$. For example, find the reciprocal of 25.

Press: $25 \frac{1}{x}$ \hspace{1cm} See displayed: $0.04$

You can also calculate the reciprocal of a value in a previous calculation without reentering the number. For example, calculate $\frac{1}{\frac{1}{3} + \frac{1}{6}}$.

Press: $3 \frac{1}{x}$ \hspace{1cm} See displayed: $0.33$ reciprocal of 3
6 $\frac{1}{x}$ \hspace{1cm} See displayed: $0.17$ reciprocal of 6
+ \hspace{1cm} See displayed: $0.50$ sum of reciprocals
$\frac{1}{x}$ \hspace{1cm} See displayed: $2.00$ reciprocal of sum

Finding Square Roots
To calculate the square root of any displayed value, press $\sqrt{\text{x}}$. For example, find the square root of 16.

Press: $16 \sqrt{\text{x}}$ \hspace{1cm} See displayed: $4.00$

Now find the square root of the result.

Press: $\sqrt{\text{x}}$ \hspace{1cm} See displayed: $2.00$

Squaring Numbers
$\sqrt{}$ permits you to square numbers with a single keystroke. For example, what is the square of the result in the previous example?

Press: $\sqrt{}$ \hspace{1cm} See displayed: $4.00$ 2 squared

Raising Numbers to Powers
$\sqrt[\text{x}]{\text{y}}$ permits you to raise a positive number (both integers and decimals) to any power. For example, calculate $2^6 (2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2)$.
Because a logarithmic routine is used internally to compute \( y^x \), the results may not be accurate to the last decimal place—as illustrated in the example above (see Accuracy, page 42).

Now change the decimal setting back to 2 places and find 8\(^{1.2567}\).

In conjunction with \( \sqrt{x} \), \( y^x \) provides a simple way to extract roots. For example, find the cube root of 5.

Sample Case: Assume that a body moves along a straight line according to the equation \( S = \frac{1}{2} t^6 - 4t \). Determine its velocity \( (V = 3t^5 - 4) \) and acceleration \( (A = 15t^4) \) at \( t = 2 \) seconds, where

\[
V = 3 \cdot 2^5 - 4 \\
A = 15 \cdot 2^4
\]

Solution:
Using $\pi$

$\pi$ is one of the fixed constants provided in the HP-45. Merely press $\boxed{\pi}$ whenever you need it in a calculation before executing the applicable operation. For example, calculate $3\pi$.

Press: 3 ENTER ↑ $\boxed{\pi}$ ×

See displayed: 9.42

Sample Case 1: Find the area $A$ of a circle with a 3-foot radius $r$, where

$$A = \pi r^2$$

$r = 3$

Solution:

Press: $\boxed{\pi}$ × 3 $\boxed{x^2}$ ×

See displayed: 3.14

Sample Case 2: Find the increase in the volume of a spherical balloon when its radius is increased from 2 to 3 inches. Volume of a sphere is equal to $\frac{4}{3} \pi r^3$. Therefore, $\frac{4}{3} \pi (3)^3$ minus $\frac{4}{3} \pi (2)^3$ is the increase in volume. The equation can be written

$$V = \frac{4}{3} \pi ((3)^3 - (2)^3)$$

Solution:

Press: 3 ENTER ↑ 3 $\boxed{y^x}$ 2 ENTER ↑ 3 $\boxed{y^x}$ − 4 × 3 $\div$ $\boxed{\pi}$ ×

See displayed: 27.00

Using Factorials

The $\boxed{n!}$ function permits you to handle combinations and permutations with ease. To calculate the factorial of a displayed number merely
press \( \text{[n!]} \). For example, find the factorial of 5.

**Press:** \( 5 \text{[n!]} \) \hspace{2cm} **See displayed:** \( 120.00 \)

Factorials can be calculated for positive integers from 0 through 69. Attempting to calculate the factorial of a fractional or negative value is an improper operation and will result in a blinking display.

**Sample Case 1, Permutations:** How many different ways may a coach assign players, from a squad of 12, to the 9 positions on a baseball lineup? The equation for permutations of 12 things taken 9 at a time is

\[
P(12, 9) = \frac{12!}{(12-9)!}
\]

**Solution:**

**Press:** \( 12 \text{[n!]} \) \hspace{2cm} **See displayed:** \( 4.79001600 \ 08 \) \( 12! \) value is retrieved from previous operation

\( 9 \) \hspace{2cm} **See displayed:** \( 12.00 \) \( 3! \) number of different lineups possible

**Sample Case 2, Combinations:** Let a fair die be tossed ten times. What is the probability that you will obtain the number 3 exactly 4 times in the 10 tosses? The required probability is given by the binomial law

\[
P = (1/6)^4 \ (5/6)^6 \ C_{10}^4
\]

\[
= (5^6/6^{10}) \ (10!/4! \ 6!)
\]

**Solution:**

**Press:** \( 5 \) \( \text{ENTER} \) \( 6 \text{[y^x]} \) \hspace{2cm} **See displayed:** \( 0.00 \) \( 5^6 \) displayed value rounded to zero

\( 6 \) \( \text{ENTER} \) \( 10 \text{[y^x]} \) \hspace{2cm} **See displayed:** \( 0.0003 \) \( 6^{10} \) value extended to 4 decimal places
Calculating Percentage Problems

The HP-45 simplifies the calculation of percentage problems because you don’t have to convert percents to their decimal equivalents before using them; just press the % key after keying in the percent value. Three types of percentage problems are handled:

- Finding percentage of number (base × rate)
- Finding net amount (base + or — percentage)
- Finding percent difference between a number and a base

\[
\text{percent difference} = \left( \frac{\text{number} - \text{base}}{\text{base}} \right).
\]

The equations used for percentage problems are included in Appendix D, Calculation Equations.

Finding Percentage: To find the percentage of a number, key in the base number and press ENTER+. Then key in the percent and press %. For example, to find 14% of 300,

Press: 300 ENTER+ 14 %  
See displayed: 42.00 percentage

Finding Net Amount: An additional feature is that after finding the percentage, the HP-45 still contains the original base number from which you may calculate the net amount by simply pressing + or —, respectively. For example,

Press: 300 ENTER+ 14 % +  
See displayed: 342.00 net amount (base plus percentage)
Press: See displayed:
300 ENTER + 14 % 42.00 percentage
- 258.00 net amount (base less percentage)

Finding Percent Difference Between Two Numbers: To find the percent difference between a number and the base, enter the base number and press ENTER +. Enter the second number, press ENTER =. For example, if you want to find the rate of increase of your current mortgage payment ($240/mo) over what you were paying in rent 15 years ago ($70/mo),

Press: See displayed:
70 ENTER + 240 $Δ% 242.86 % increase

Operational Stack

Stack Registers

The HP-45 uses the most efficient way known to computer science for evaluating mathematical expressions: the operational stack and reverse "Polish" (Lukasiewicz) notation.

The four temporary memory locations (number registers)—arranged in the form of a vertical stack—are called X (bottom register), Y, Z, and T (top register), respectively.

<table>
<thead>
<tr>
<th>Contents</th>
<th>Register Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>T</td>
</tr>
<tr>
<td>z</td>
<td>Z</td>
</tr>
<tr>
<td>y</td>
<td>Y</td>
</tr>
<tr>
<td>x</td>
<td>X</td>
</tr>
</tbody>
</table>

To avoid confusion between the name of a register and its contents, the register is designated by a capital letter and the contents by a small letter. Thus, x, y, z and t are the contents of X, Y, Z and T, respectively.

When you key in a number, it goes into the X-register—the bottom register and the only one displayed. When you press ENTER +, this number is duplicated into the Y-register. At the same time, y is moved up to Z and z is moved up to T like this:
When you press \(+\), x is added to y, and the entire stack drops to display the answer in X. The same thing happens for \(-\), \(\times\) and \(\div\). Whenever the stack drops, t is duplicated from T into Z, and z drops to Y, as follows:

<table>
<thead>
<tr>
<th>Press:</th>
<th>Contents</th>
<th>Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTER</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\begin{align*}
t & \rightarrow T \\
z & \rightarrow Z \\
y & \rightarrow Y \\
x & \rightarrow X
\end{align*}
\]

Look at the contents of the stack in Figure 2 as we calculate \((3 \times 4) + (5 \times 6)\). Directly above the keys pressed you see the information in X, Y, Z and T after the keystroke.

**Manipulating the Stack**

The \(\text{R}+\) key “rolls down” the stack and lets you review the contents (in last in-first out order) without losing data. It is also used to reposition data within the stack. Here is what happens each time you press \(\text{R}+\):

<table>
<thead>
<tr>
<th>Press</th>
<th>Contents</th>
<th>Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>R+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\begin{align*}
t & \rightarrow T \\
z & \rightarrow Z \\
y & \rightarrow Y \\
x & \rightarrow X
\end{align*}
\]

**Example:** Load the stack by pressing: 1 \(\text{ENTER} +\) 2 \(\text{ENTER} +\) 3 \(\text{ENTER} +\) 4. (The stack now contains \(x = 4, y = 3, z = 2,\) and \(t = 1\)).
3 is in X (display).
3 is duplicated into Y.
4 is in X (display).

Product (12) is formed in Y then drops into X.

Automatic ENTER pushes 12 into Y when 5 is keyed in; display shows 5.
ENTER pushes 12 into Z, duplicates 5 into Y, and leaves X unchanged.
6 in display overwrites 5 in X since it immediately follows ENTER.

Product (30) is formed in Y, then 12 drops into Y, 30 drops into X.

Sum (42) is formed in Y, then drops into X.

Figure 2. Stack Operations
To review the contents of the stack press \( \text{R+} \) four times. The fourth \( \text{R+} \) returns the stack to its original position \((x = 4, y = 3, z = 2, \text{ and } t = 1)\).

**Note:** The stack is raised and \( t \) is lost when a keyboard entry or \( \text{RCL} \) operation follows \( \text{R+} \), unless that entry follows \( \text{ENTER} \), \( \text{CLx} \), or \( \text{Σ+} \).

The \( x\bar{z}y \) key exchanges \( x \) and \( y \) as shown below.

<table>
<thead>
<tr>
<th>Press</th>
<th>Contents</th>
<th>Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x\bar{z}y )</td>
<td>( t \rightarrow T )</td>
<td>( z \rightarrow Z )</td>
</tr>
<tr>
<td></td>
<td>( y \rightarrow Y )</td>
<td>( x \rightarrow X )</td>
</tr>
</tbody>
</table>

You will often find that \( x \) and \( y \) should be exchanged before \( \div \), \( \times \), \( y^x \) operations.

**Example:** Find \( 2^9 \).

<table>
<thead>
<tr>
<th>Press</th>
<th>See</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 ( \text{ENTER} )</td>
<td>9. ( \rightarrow 9.00 )</td>
<td>( x ) and ( y ) are in wrong order.</td>
</tr>
<tr>
<td>2 ( x\bar{z}y )</td>
<td>2. ( \rightarrow 9.00 )</td>
<td>( x ) and ( y ) are in right order.</td>
</tr>
<tr>
<td>( y^x )</td>
<td>512.00</td>
<td></td>
</tr>
</tbody>
</table>

**Performing Combined Arithmetic Processes**

The HP-45 performs combined arithmetic operations—serial, mixed and chained calculations—with ease.

**Serial Calculation**

Any time a new number is entered after any calculation, the HP-45 performs an automatic \( \text{ENTER} \) on the result of the calculation. This feature permits a serial calculation without your having to write down or store any of the intermediate results. For example, find the sum of 4, 6, 8 and 10.

**Press:**

\[
\begin{align*}
4 & \quad \text{ENTER} \quad 6 + \rightarrow 10.00 \\
8 + & \quad \rightarrow 18.00 \\
10 + & \quad \rightarrow 28.00 
\end{align*}
\]
The same principle applies to serial multiplication, division and subtraction too. Note that an equals key (=) is not needed since results are displayed when a function key is pressed.

**Chained Calculation**

Chained calculations can be used to find the sums of products or the product of sums. For example, if you sold 12 items at $1.58 each, 8 items at $2.67 each and 16 items at $0.54 each, the total sale price is

\[(12 \times 1.58) + (8 \times 2.67) + (16 \times 0.54)\]

Press: See displayed:

12 \[\text{ENTER} \div 1.58 \times\] \$ 18.96
8 \[\text{ENTER} \div 2.67 \times\] \$ 21.36
$ \text{+}$ \$ 40.32
16 \[\text{ENTER} \div 0.54 \times\] \$ 8.64
$ \text{+}$ \$ 48.96 total sale price

**Mixed Chained Calculation**

A problem may also be calculated with any combination of arithmetic operators in both nested and linked operations. For example, to calculate

\[
[\{ (12 \times 5) - 2 \} + \{ (8 \div 2) + 10 \}] \times (213.08 \times 5 \div 1.33) \div 2
\]

Press: See displayed:

12 \[\text{ENTER} \div 5 \times\] \$ 60.00
2 $ 58.00
8 \[\text{ENTER} \div 2 \div\] \$ 4.00
10 \[\text{+}\] \$ 14.00
$ \text{+}$ \$ 72.00
213.08 \[\text{ENTER} \div 5 \times\] \$ 1065.40
1.33 $ 801.05
$ 57675.79
2 $ 28837.89

You may find the flow chart in Appendix A interesting. It describes a procedure (an algorithm) that will allow you to evaluate any expression on your HP-45 using the operational stack and reverse Polish notation.
**Last \(x\) Register**

The last input argument of a calculation is automatically stored in the Last \(x\) register when a function is executed. This feature provides a handy error correction device (see page 12 for examples)—as well as a facility for reusing the same argument in multiple calculations—since it allows recall of the argument by pressing \[\text{LAST } x\]. The register is cleared only when the calculator is turned off or when a new argument replaces (or overwrites) the previous one.

**Data Storage Registers**

In addition to the operational stack and Last \(x\) register, the HP-45 provides 9 registers for user storage.

**Unrestricted Storage**

**Registers \(R_1 - R_4\)**

Registers \(R_1 - R_4\) can be used for temporary storage without restriction. Values stored in these registers are not affected by calculations or by clearing operations. New values are entered by writing over the old contents; that is, by storing a new number. The contents are lost, however, when the HP-45 is turned off.

**Restricted Storage**

**Registers \(R_5 - R_8\)**

Registers \(R_5 - R_8\) are used internally when performing summations using \[\Sigma^+\] and \[\Sigma^-\]. When summations are not being performed, these registers may be used for general purpose storage. However, since registers \(R_5 - R_8\) are not overwritten by new values when using \[\Sigma^+\], they must be cleared of existing values by pressing \[\text{CLEAR}\] before they are used in summations.

**Register \(R_9\)**

Register \(R_9\) is required internally when performing trigonometric functions and polar/rectangular conversions; any values stored there will be lost. Otherwise, register \(R_9\) may be used for general purpose storage in the same manner as registers \(R_1 - R_4\).
**Storing and Recalling Data**

To store a value appearing on the display (whether the result of a calculation or a keyboard entry), press **STO**, then press the number key (1–9) specifying the storage register. To retrieve the value press **RCL**, then press the applicable number key. A copy of the recalled value appears on the display (X-register); the original value remains in the specified constant storage register. The number previously on the display is loaded into the Y-register unless the keystroke immediately preceding **RCL** was **ENTER** or **CLX** or **Σ+** (these keys do not cause the stack to be pushed up by the next data entry). For example, add 8, 20, 17, 43; store the result in R; and divide the individual numbers by the stored sum to find what part each is of the total.

**Press:**

<table>
<thead>
<tr>
<th>Operation</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 ENTER 20 + 17 + 43 +</td>
<td>88.00 total</td>
</tr>
<tr>
<td>STO 1</td>
<td>88.00</td>
</tr>
<tr>
<td>8 RCL</td>
<td>0.09 or 9% of total</td>
</tr>
<tr>
<td>20 RCL</td>
<td>0.23 or 23% of total</td>
</tr>
<tr>
<td>17 RCL</td>
<td>0.19 or 19% of total</td>
</tr>
<tr>
<td>43 RCL</td>
<td>0.49 or 49% of total</td>
</tr>
</tbody>
</table>

**Performing Register Arithmetic**

Arithmetic operations (+, −, ×, ÷) can be performed between a data storage register and the X-register (display). To modify the contents of the storage register, press **STO** followed by the applicable operator key (+, −, ×, ÷), then the number key specifying the storage register. For example, store 6 in register R, then increment it by 2.

**Press:**

<table>
<thead>
<tr>
<th>Operation</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 STO 1</td>
<td>6 → R₁</td>
</tr>
<tr>
<td>2 STO + 1</td>
<td>r₁ + 2 → R₁</td>
</tr>
</tbody>
</table>

To see what is now stored in Register R₁,

**Press:**

<table>
<thead>
<tr>
<th>Operation</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCL 1</td>
<td>r₁ → X (display)</td>
</tr>
</tbody>
</table>
Now subtract 3 from the contents of R₁ (8).

**Press:**

<table>
<thead>
<tr>
<th>3</th>
<th>STO</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCL</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**See displayed:**

<table>
<thead>
<tr>
<th>3.00</th>
<th>r₁ - 3 → R₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00</td>
<td>r₁ → X (display)</td>
</tr>
</tbody>
</table>

Conversely, to alter the X-Register (displayed value) without affecting the contents of the data storage register or the other stack registers, press **RCL**, the applicable operator, then the number key specifying the storage register. For example, add the current value stored in R₁ (5.00) to a new entry (2).

**Press:**

<table>
<thead>
<tr>
<th>2</th>
<th>RCL</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See displayed:**

<table>
<thead>
<tr>
<th>7.00</th>
<th>2 + r₁ → X (display)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00</td>
<td>r₁ → X (display)</td>
</tr>
</tbody>
</table>

Subtract the contents of register R₁ (5.00) from a new entry (11).

**Press:**

<table>
<thead>
<tr>
<th>11</th>
<th>RCL</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See displayed:**

<table>
<thead>
<tr>
<th>6.00</th>
<th>11 - r₁ → X (display)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00</td>
<td>r₁ → X (display)</td>
</tr>
</tbody>
</table>

Now combine several operations.

<table>
<thead>
<tr>
<th>3</th>
<th>STO</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>STO</td>
<td>1</td>
</tr>
<tr>
<td>.25</td>
<td>STO</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>RCL</td>
<td>1</td>
</tr>
</tbody>
</table>

**See displayed:**

<table>
<thead>
<tr>
<th>3.00</th>
<th>3 → R₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>r₁ + 2 → R₁</td>
</tr>
<tr>
<td>0.25</td>
<td>r₁ ÷ .25 → R₁</td>
</tr>
<tr>
<td>20.00</td>
<td>r₁ → X (display)</td>
</tr>
<tr>
<td>100.00</td>
<td>5 × r₁ → X (display)</td>
</tr>
</tbody>
</table>

To use a data storage register as a counter or tally register, you must set that register to zero—either by clearing or by storing 0. To increment the counter use a **STO +** sequence. To decrement use **STO -**. For example:

**Press:**

<table>
<thead>
<tr>
<th>0</th>
<th>STO</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>STO</td>
<td>+ 4</td>
</tr>
</tbody>
</table>

**See displayed:**

<table>
<thead>
<tr>
<th>0.00</th>
<th>0 → R₄; sets counter to 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>r₄ + 1 → R₄; increments counter</td>
</tr>
</tbody>
</table>
Sample Case: Hardhat Construction Company must file a quarterly report showing payroll information. Produce a report sorting the raw data (hours worked) according to four applicable rates: #1 = $6.735/hr. for straight time, #2 = $10.1025/hr. for 1.5 time, #3 = $13.47/hr. for double time, #4 = $1.75/hr. for showup-no work time. Calculate the hours and gross payroll by rate and craft; use the data from the abbreviated time card in Figure 2.

Hardhat Construction, Inc.

<table>
<thead>
<tr>
<th>Time Card Summary – Craft No. 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: July 3, 1973</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Hours</th>
<th>Rate</th>
<th>Rate Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Dickinson</td>
<td>2</td>
<td>1</td>
<td>(6.735/hr)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>(10.1025/hr)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
<td>(1.75/hr)</td>
</tr>
<tr>
<td>France Rode</td>
<td>6</td>
<td>1</td>
<td>(13.47/hr)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Arlin Laymon</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Time Card Data

Solution:

Press: See displayed:
OFF-ON (or store 0's in R_1, R_2, R_3, R_4)
6.735 STO 5
10.1025 STO 6
13.47 STO 7
1.75 STO 8
sorts and stores hours according to applicable rate—keeps running tally of hours

total craft hours

total hours, rate #1

total hours, rate #2

total hours, rate #3

total hours, rate #4

total, rate #1 (straight-time pay)

total, rate #2 (1.5-time pay)

total, rate #3 (double-time pay)

gross payroll subtotal

gross payroll subtotal

gross payroll for craft #7
Metric/U.S. Unit Conversion Constants

The HP-45 provides built-in conversion constants (accurate to 10 digits) for:

- Centimeters-to-inches and inches-to-centimeters (1 inch = 2.540000000 centimeters)
- Kilograms-to-pounds and pounds-to-kilograms (1 pound* = 0.453592370 kilograms)
- Liters-to-gallons and gallons-to-liters (1 gallon** = 3.785411784 liters)

To use these constants, key in the measure to be converted, press ENTER, then press the desired constant key followed by the applicable operator: × to obtain metric equivalents, ÷ to obtain U.S. equivalents.

Note that it isn’t necessary to press ENTER after keying in the initial value; the HP-45 performs an automatic ENTER when a preprogrammed constant key is pressed or when a user stored constant is recalled. For example,

Press: 
12 cm/in 
× 
See displayed: 
2.54
30.48

Sample Case 1: If an 8” x 10” drawing is to be reduced to 85% of its original size, what is the finished size in terms of centimeters?

Solution:

Press: 
8 ENTER 85 % 
10 ENTER 85 % 
See displayed: 
6.80 inches 
2.54 conversion constant 
17.27 centimeters 
8.50 inches 
2.54 conversion constant 
21.59 centimeters (the finished size is 17.27 cm × 21.59 cm)

† Ref: National Bureau of Standards, 1967
†† Changed in 1957 by international agreement
* Avoirdupois system
** U.S. liquid measure
Sample Case 2: If you needed a baby elephant for any reason (and could afford to maintain it), how much would shipping costs be in dollars if the baby weighs 500 kilograms and the shipping cost per pound were 23¢?

Solution:
Press: \[
\begin{align*}
500 & \quad \text{kg/lb} \\
\div & \\
.23 & \times
\end{align*}
\]
See displayed:
\[
\begin{align*}
0.45 & \quad \text{conversion constant} \\
1102.31 & \quad \text{pounds} \\
253.53 & \quad \text{total shipping cost}
\end{align*}
\]

Sample Case 3: An American in Germany purchases 16 liters of wine. Since the duty is figured on gallons, how many gallons does he have?

Solution:
Press: \[
\begin{align*}
16 & \quad \text{ltr/gal} \\
\div
\end{align*}
\]
See displayed:
\[
\begin{align*}
3.79 & \quad \text{conversion constant} \\
4.23 & \quad \text{gallons}
\end{align*}
\]

Sample Case 4: If you pick up a Mercedes Benz in Germany and the mileage is quoted at 7 kilometers per liter, would this car be expensive to run by U.S. standards?

Solution:
Press: \[
\begin{align*}
7 & \quad \text{ltr/gal} \\
\times \\
20 & \quad \text{cm/in} \\
\times \\
5280 & \quad \text{x}
\end{align*}
\]
See displayed:
\[
\begin{align*}
3.79 & \quad \text{conversion constant} \\
26.50 & \quad \text{kilometers/gallon} \\
2.54 & \quad \text{conversion constant} \\
30.48 & \quad \text{cm/ft} \\
160934.40 & \quad \text{cm/mile} \\
5 & \quad \div \\
\div
\end{align*}
\]
See displayed:
\[
\begin{align*}
1.61 & \quad \text{km/mile} \\
16.47 & \quad \text{miles/gallon}
\end{align*}
\]

Logarithmic and Exponential Functions

The HP-45 computes both natural and common logarithms as well as their inverse functions (antilogarithms):
\( \ln \) is \( \log_e \) (natural log); takes log of value in \( X \)-register to base \( e \) (2.718 \ldots).

\( e^x \) is \( \text{antilog}_e \) (natural antilog); raises \( e \) (\( e = 2.718 \ldots \)) to the power of value in \( X \)-register. (To display the value of \( e \), press 1 \( e^x \).)

\( \log \) is \( \log_{10} \) (common log); takes log of value in \( X \)-register to base 10.

\( 10^x \) is \( \text{antilog}_{10} \) (common antilog); raises 10 to the power of value in \( X \)-register.

**Sample Case 1:** Suppose you wish to use an ordinary barometer as an altimeter. After measuring the sea level pressure (30 inches of mercury) you climb until the barometer indicates 9.4 inches of mercury. How high are you? Although the exact relationship of pressure and altitude is a function of many factors, an approximation is given by

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

Solution:

<table>
<thead>
<tr>
<th>Press:</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>25000 ENTER ( \frac{\text{30 \ ENTER ( \text{\text{#}} ) \ ENTER ( \text{\text{#}} )}}{\ln} ) ( \times )</td>
<td>( \frac{30}{\text{Pressure}} ) = 3.19</td>
</tr>
<tr>
<td>( \frac{9.4 \ \text{\text{#}}}{\ln} ) ( \times )</td>
<td>1.16</td>
</tr>
<tr>
<td>( \frac{29012.19 \ \text{\text{#}}}{\ln} ) ( \times )</td>
<td>feet altitude</td>
</tr>
<tr>
<td>( \text{we suspect you are on Mt. Everest} )</td>
<td>(we suspect you are on Mt. Everest —29,028 feet)</td>
</tr>
</tbody>
</table>

**Sample Case 2:** 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

\[
\text{Magnitude} = 8.25 - \log 105
\]

Solution:

<table>
<thead>
<tr>
<th>Press:</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.25 ENTER ( \frac{\text{105 \ \text{\text{#}} \ \text{\text{#}}}}{\log} ) ( - )</td>
<td>2.02</td>
</tr>
<tr>
<td>( \frac{6.23 \ \text{\text{#}}}{\log} ) ( - )</td>
<td>rating on Richter Scale</td>
</tr>
</tbody>
</table>
Statistical Functions

The statistical function is used to find the mean (arithmetic average) and standard deviation (measure of dispersion around the mean) of data entered and summed. Options are provided to enable you to interact with and modify results by adding new data or correcting errors. Also, the number of entries and sum of the squares—as well as the sum of entries in two dimensions—can be obtained. Summation/averaging calculations also use the (sigma) key to sum the numbers used in calculating means and standard deviations. Because the function uses storage registers R₆-R₈, these registers must be cleared with before pressing or errors could result.

Mean and Standard Deviation

Information is entered as follows:

1. Press to assure that registers R₆-R₈ are clear of previous data.
2. Key in each value and sum with key. To correct an incorrect value before it is loaded with the keystroke, press . After the value is summed, correct by (a) reentering incorrect value, then (b) pressing , followed by (c) entering correct value, and finally (d) pressing ; then continue entering values. The last pressed provides the number of entries.
3. Press to obtain mean.
4. Press to obtain standard deviation.
5. If there are more values to be included—say if you want to add to the data sample and modify results—key in and press after each.

Additional information is also available by performing steps 6–10 (in any order).

6. Press to obtain number of entries.
7. Press to obtain sum of squares for X-register entries.
8. Press to obtain sum of X-register entries.

*A Y-register entry is any value residing in the Y-register at the time is pressed; e.g., if the entry sequence is \( n_1 \text{ ENTER } n_2 \Sigma^+ \) where: \( n_1 = y\text{-value} \) \( n_2 = x\text{-value} \)
Alternatively, press RCL Σ+ to obtain sum of X-register entries, and X²Y to obtain sum of Y-register entries.

**Statistical Formulas and Data Flow**

The formula used for calculating the mean is:

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

The formulas used for calculating the sample standard deviation is:

$$s = \sqrt{\frac{1}{n-1} \left( \sum_{i=1}^{n} x_i^2 - \frac{1}{n} \left( \sum_{i=1}^{n} x_i \right)^2 \right)}$$

To obtain the standard deviation of a population, multiply the sample standard deviation by the following conversion factor as shown below:

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

When you press Σ+ the following data is stored in registers R₅–R₈:

- \(n + 1 \rightarrow R_5 \rightarrow X\)
- \(\sum x^2 + x^2 \rightarrow R_6\)
- \(\sum x + x \rightarrow R_7\)
- \(\sum y + y \rightarrow R_8\)

When you press Σ− the data in registers R₅–R₈ is altered like this:

- \(n - 1 \rightarrow R_5 \rightarrow X\)
- \(\sum x^2 - x^2 \rightarrow R_6\)
- \(\sum x - x \rightarrow R_7\)
- \(\sum y - y \rightarrow R_8\)

**Sample Case 1:** In a recent survey to determine the average age of 10 of the wealthiest people in the U.S., the following data were obtained:

62 84 47 58 68 60 62 59 71 73

Of the ages given, what is the mean; the standard deviation?
Add two more ages (87 and 49) after the initial calculation. What is the new mean and standard deviation?

**Solution:**

**Press:**  
\[ 87 \Sigma+ 49 \Sigma+ \]  
\[ \bar{x}, s \]  
**See displayed:**  
\[ 12.00 \] number of entries  
\[ 65.00 \] new mean  
\[ 12.29 \] new standard deviation

**Sample Case 2:** Perform error recovery after entering the second value in error.

**Solution:**

**Press:**  
\[ \text{CLEAR} \]  
\[ 62 \Sigma+ 44 \Sigma+ \]  
\[ 44 \Sigma+ 84 \Sigma+ \]  
\[ 47 \Sigma+ 58 \Sigma+ \]  
\[ 68 \Sigma+ 60 \Sigma+ 62 \Sigma+ \]  
\[ 59 \Sigma+ 71 \Sigma+ 73 \Sigma+ \]  
\[ \bar{x}, s \]  
**See displayed:**  
\[ 0.00 \] number of entries  
\[ 10.00 \] number of entries  
\[ 64.40 \] mean  
\[ 10.10 \] standard deviation

**Sample Case 3:** Find the sum of the ages entered, sum of the squares, and the number of entries as well as the mean and standard deviation.

**Solution:**

**Press:**  
\[ \text{CLEAR} \]  
\[ 62 \Sigma+ 84 \Sigma+ 47 \Sigma+ 58 \Sigma+ 68 \Sigma+ \]  
\[ 60 \Sigma+ 62 \Sigma+ 59 \Sigma+ 71 \Sigma+ 73 \Sigma+ \]  
**See displayed:**  
\[ 0.00 \] number of entries  
\[ 10.00 \] number of entries
Sample Case 4: Assuming that every member of the sample over 65 is a female, calculate the mean, standard deviation, and the sum of ages—as well as the total number of females. Enter a 1 for female and 0 for male before keying in each value.

Solution:

Press:

See displayed:

<table>
<thead>
<tr>
<th>Number of Entries</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sum of Ages</th>
<th>Number of Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>64.40</td>
<td>10.10</td>
<td>644.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>
To use the **SIN**, **COS** and **TAN** functions, key in the number and press the appropriate function key. To use the arc functions, press **M-**, then press the associated function key. For example, find $\text{SIN}^{-1}(0.866)$.

**Press:**

$.866$ **M-**

See displayed:

$60.00$ degrees

Note that trigonometric functions use storage register 9; any value stored there will be overwritten during a trigonometric calculation.

**Angular Modes**

Trigonometric functions can be performed in any one of three angular modes: decimal degrees, decimal radians and decimal grads—the latter being a 100th part of a right angle in the centesimal system of measuring angles. Note that trigonometric functions assume decimal angles regardless of angular mode. To select a mode, press **M-**, then press the associated key: **DEG** or **RAD** or **GRD**.

The mode selected will remain operative until a different mode is selected, or until the calculator is turned off; when turned back on, the HP-45 automatically defaults to decimal degrees mode.

**Sample Case 1:** Find the cosine of $35^\circ$. If the HP-45 is not already in degrees mode, press **DEG** before performing the calculation.

Solution:

**Press:**

$35$ **COS**

See displayed:

$0.82$

**Sample Case 2:** Find the tangent of 6 radians.

Solution:

**Press:**

**RAD** $6$ **TAN**

See displayed:

$-0.29$

**Sample Case 3:** Find the arc sine of .5 in grads.

Solution:

**Press:**

**GRD** $0.5$ **SIN**

See displayed:

$33.33$
Degrees-Minutes-Seconds Conversion

Displayed angles can be converted from any decimal angular mode to degrees-minutes-seconds, in the format dd.mmss, by pressing \[ \text{DMS} \rightarrow \text{DMS} \]. Conversely, to convert an angle displayed in degrees-minutes-seconds to the decimal equivalent in the specified angular mode, press \[ \text{DMS} \rightarrow \text{DMS} \].

This feature is also useful in calculating problems dealing with time (hours-minutes-seconds) too.

Note that conversions involving angles \( \geq 10 \) degrees are improper operations.

**Sample Case 1:** Assume a surveyor wants to add 2 angles: \( 10° 8’ 56” \) and \( 2° 17’ 42” \). These must first be converted to decimal degrees before adding and then converted back to degrees-minutes-seconds.

**Solution:**

<table>
<thead>
<tr>
<th>Press:</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 10.0856</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 10.15 decimal degrees</td>
</tr>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 2.1742</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 2.30 decimal degrees</td>
</tr>
<tr>
<td>+</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 12.44 decimal degrees</td>
</tr>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ]</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] 12.2638 ( 12° 26’ 38” )</td>
</tr>
</tbody>
</table>

**Sample Case 2:** Find the arc sine of \( .55 \) in degrees mode and convert to degrees-minutes-seconds.

**Solution:**

<table>
<thead>
<tr>
<th>Press:</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( .55 )</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( 33.37 ) decimal degrees</td>
</tr>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ]</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( 33.2201 ) ( 33° 22’ 01” )</td>
</tr>
</tbody>
</table>

**Sample Case 3:** Using the data from Sample Case 2, above, calculate the arc sine of \( .55 \) in radians mode and convert the result to degrees-minutes-seconds.

**Solution:**

<table>
<thead>
<tr>
<th>Press:</th>
<th>See displayed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( .55 )</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( 0.58 ) radians</td>
</tr>
<tr>
<td>[ \text{DMS} \rightarrow \text{DMS} ]</td>
<td>[ \text{DMS} \rightarrow \text{DMS} ] ( 33.2201 ) ( 33° 22’ 01” )</td>
</tr>
</tbody>
</table>
Polar/Rectangular Coordinate Conversion

Two functions are provided for polar/rectangular coordinate conversion. To convert values in X and Y-registers, (representing rectangular x, y coordinates, respectively) to polar r, \( \theta \) coordinates (magnitude and angle, respectively), press \( \rightarrow \mathrm{P} \).

Conversely, to convert values in X and Y-registers representing polar (r, \( \theta \), respectively) to rectangular coordinates (x, y, respectively), press \( \rightarrow \mathrm{R} \).

Because polar/rectangular conversions involve trigonometry, storage register 9 is used. Thus, any values previously stored in this register will be overwritten when coordinate conversions are performed.

Sample Case 1: Convert rectangular coordinates (4, 3) to polar form with the angle expressed in degrees.

Solution:

Press: \[ \text{See displayed:} \]

- [DEG] 3 ENTER \( \hat{\beta} \) 4 \( \rightarrow \mathrm{P} \) ->R

- \( \hat{\beta} \) 4 \( \rightarrow \mathrm{P} \) ->R

- \( \hat{\beta} \) 4 \( \rightarrow \mathrm{P} \) ->R

magnitude

angle in degrees
Sample Case 2: Convert polar coordinates \((8, 120^\circ)\) to rectangular coordinates.

Solution:

Press:  

See displayed:

By combining the polar/rectangular function with the accumulation function, \(\sum\), you can add and subtract vector components. The sum of these are contained in storage registers \(R_7\) and \(R_8\):

\[
\begin{align*}
    r_7 &= x_1 \pm x_2 \pm \ldots \pm x_n = \Sigma x \\
    r_8 &= y_1 \pm y_2 \pm \ldots \pm y_n = \Sigma y
\end{align*}
\]

To display the contents of registers \(R_7\) and \(R_8\), press \(\text{RCL} \ \Sigma\) to obtain the sum of x-coordinates (register \(R_7\)); then press \(\times \Sigma y\) to obtain the sum of y-coordinates (register \(R_8\)).
**Sample Case 3:** Sum 2 vectors $V_1$, $V_2$ having polar coordinates $(8, 30^\circ)$, $(12, 60^\circ)$, respectively. Represent the sum $V$ in terms of polar coordinates $(r, \theta)$.

**Solution:**

Press:

- Press: CLEAR
- Press: 60 ENTER + 12
- Press: \(\Sigma+\)
- Press: 30 ENTER + 8
- Press: \(\Sigma+\)
- Press: RCL \(\Sigma+\)
- Press: \(\rightarrow P\)
- Press: \(\times 2\ y\)

See displayed:

- 0.00
- 6.00
- 1.00
- 6.93
- 2.00
- 12.93
- 19.35
- 48.07

magnitude $r$

\(\circ\) angle $\theta$
Operating Limits

Underflow and Overflow Display Formats
To ensure greater accuracy, the HP-45 performs all calculations by using a ten-digit number and a power of ten. This abbreviated form of expressing numbers is called scientific notation; i.e., \(23712.45 = 2.371245 \times 10^4\) in scientific notation.

If a number is too large for the display format specified, the HP-45 automatically displays the number in scientific notation. For example, if you keyed in 100, and pressed \(\text{FIX} \ 8\), the calculator will display the number in scientific notation because there isn’t enough room to display 8 digits after the decimal point.

Press: \(\text{FIX} \ 8\)  
100 ENTER \(\rightarrow\) See displayed: \(1.00000000 \ 02\)

Numbers whose magnitude is less than 1, and are too small to be displayed in the specified \(\text{FIX}\) format, are displayed as zero. For example, the number \(.000396\) is displayed in \(\text{FIX} \ 3\) format as follows:

Press: \(\text{FIX} \ 3\)  
.000396 ENTER \(\rightarrow\) See displayed: \(0.000\)

When a \(\text{SCI}\) setting is used, values are displayed rounded to the number of decimal places specified. Values having a magnitude of \(\geq 10^{100}\) are displayed as \(\pm 9.999999999 \ 99\). Values having a magnitude of \(< 10^{-69}\) are displayed as zero.

Improper Operations
If you attempt a calculation containing an improper operation—say division by zero—an error signal is triggered and a blinking display appears. To clear, press \(\text{CLX}\), or any other key that doesn’t trigger another error.
The following are examples of improper operations:

\[ \frac{a}{b} \] , where \( x = 0 \)

\[ y^x \] , where \( y \leq 0 \)

\[ \sqrt{x} \] , where \( x < 0 \)

\[ \sqrt[3]{x} \] , where \( x = 0 \)

\[ n! \] , where \( x < 0 \) or is not an integer

\[ \bar{x}, \bar{s} \] , where number of entries is < 2

\[ \rightarrow \text{DMS} \] , where angle converted \( \geq 100,000^\circ (\geq 10^\circ) \)

\[ \text{DMS} \rightarrow \] , where angle converted \( \geq 100,000^\circ (\geq 10^\circ) \)

\[ \log \] , where \( x \leq 0 \)

\[ \ln \] , where \( x \leq 0 \)

\[ \sin^{-1} \] , where \( |x| \) is \( \geq 1 \)

\[ \cos^{-1} \] , where \( |x| \) is \( \geq 1 \)
The flow chart in Figure 3 allows you to evaluate any expression on a calculator using an operational stack and reverse Polish (Lukasiewicz) notation. Although the general solution requires an operational stack of unlimited length, the four-register stack in your HP-45 is adequate for most practical problems. Before using the algorithm, write your expression in serial form. All expressions can be written in serial form. For example, $\frac{2}{3 + (1/2)}$ becomes $2/(3 + (1/2))$.

According to our algorithm, the solution can be obtained for any expression by entering the numbers in the order in which they occur. Use the algorithm to solve $(3 + 4) \left[ \log \left( \frac{25\sqrt{7} + 9}{45} \right) + 6 \right]$.

<table>
<thead>
<tr>
<th>Press</th>
<th>See Displayed</th>
<th>Flow Chart Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3.</td>
<td>A</td>
</tr>
<tr>
<td>ENTER ‡</td>
<td>3.00</td>
<td>D</td>
</tr>
<tr>
<td>4</td>
<td>4.</td>
<td>A</td>
</tr>
<tr>
<td>+</td>
<td>7.00</td>
<td>C</td>
</tr>
<tr>
<td>ENTER ‡</td>
<td>7.00</td>
<td>D</td>
</tr>
<tr>
<td>25</td>
<td>25.00</td>
<td>A</td>
</tr>
<tr>
<td>ENTER ‡</td>
<td>25.00</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>7.00</td>
<td>A</td>
</tr>
<tr>
<td>ENTER ‡</td>
<td>7.00</td>
<td>D</td>
</tr>
<tr>
<td>9</td>
<td>9.</td>
<td>A</td>
</tr>
<tr>
<td>+</td>
<td>16.00</td>
<td>C</td>
</tr>
<tr>
<td>$\sqrt{x}$</td>
<td>4.00</td>
<td>B</td>
</tr>
<tr>
<td>$\times$</td>
<td>100.00</td>
<td>C</td>
</tr>
<tr>
<td>log</td>
<td>2.00</td>
<td>B</td>
</tr>
<tr>
<td>ENTER ‡</td>
<td>2.00</td>
<td>D</td>
</tr>
<tr>
<td>6</td>
<td>6.</td>
<td>A</td>
</tr>
<tr>
<td>+</td>
<td>8.00</td>
<td>C</td>
</tr>
<tr>
<td>$\times$</td>
<td>56.00</td>
<td>C</td>
</tr>
</tbody>
</table>

* You may omit these steps because your HP-45 performs an automatic ENTER ‡ for you.
Legend:
- One number (monadic) operations are things like $\sqrt{x}$, $\ln$, etc.
- Two number (dyadic) operations are things like $+$, $-$, $\times$, $\div$.
* You may omit this step if you’ve done any operation on the last number entered.

Figure 4. Stack Flow Chart

Note that the expression could have been written:
$$(\log \left[ \sqrt{(7 + 9) 25} \right] + 6) \cdot (3 + 4).$$
Also, it could have been evaluated—using the algorithm—in fewer steps:

Press

7 ENTER + 9 +

$\sqrt{x}$ 25 \times

log 6 + 3

ENTER + 4 + \times

Try it.
Appendix B
Hardware Specifications

Temperature Range

<table>
<thead>
<tr>
<th>Mode</th>
<th>Temperature °C</th>
<th>Temperature °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating</td>
<td>0°C to 50°C</td>
<td>32°F to 122°F</td>
</tr>
<tr>
<td>Charging</td>
<td>10°C to 40°C</td>
<td>50°F to 104°F</td>
</tr>
<tr>
<td>Storage</td>
<td>–40°C to 55°C</td>
<td>–40°F to 131°F</td>
</tr>
</tbody>
</table>

Battery Operation
The battery provides three to five hours of continuous operation. By turning off the power when the calculator is not in use, the HP-45 battery power will last easily throughout a normal working day.

CAUTION
To avoid damage to the calculator use only the HP 82001A Rechargeable Battery Pack which is warranted for one year.

All decimal points but one light in the display when 2 to 5 minutes of operation time remain in the battery pack. Even when all decimal points are turned on, the true decimal position is known because an entire digit position is allocated to it.

Example: 

```
.80.35...........
```

Operating the calculator for more than 2 to 5 minutes after this low power indication first occurs may result in calculation errors. The battery pack must be recharged by connecting the HP-45 to its battery charger (HP Model 82002A).

Recharging and AC Line Operation
The HP-45 should be turned off before plugging in the charger. It can be turned on again after the charger is plugged into the power outlet and can be used during the charging cycle. The HP-45 can be operated continuously from the AC line if desired. There is no danger of overcharging the battery.
CAUTION
To prevent damage to the recharger, use only with HP calculators and battery holder.

After 14 hours, a completely discharged battery will be fully charged. Shorter charge periods will allow reduced battery operating time. For convenience, overnight charging is recommended.

CAUTION
To prevent damage to the calculator, the position of the line voltage select switch on the battery charger must be set to the proper line voltage.

1. Turn the HP-45 power switch to OFF.
2. Insert battery charger plug into the rear connector of the HP-45 and insert power plug of battery charger into the power outlet. The HP-45 will not operate when connected to the recharger unless the recharger is connected to a live power outlet.
3. Slide the power switch to ON, see that 0.00 is displayed.
4. Slide power switch to OFF if you don’t want to use the calculator while it is charging.
5. At end of the charging period, you may continue using your HP-45 with AC power or proceed to next step for battery operation.
6. With the power switch at OFF, disconnect battery charger from power receptacle and the battery charger from HP-45.

Temporary degradation, peculiar to nickel-cadmium batteries, may cause a decrease in the operating period of the battery pack. Should this happen turn the HP-45 on for at least five hours to discharge the batteries completely. Then put it on charge for at least 14 hours. This should correct the temporary degradation.

If the battery pack won’t hold a charge, it may be defective. If the warranty is in effect, return the pack to Hewlett-Packard according to the instructions on page . . . If the battery pack is out of warranty, use the accessory, order card, provided with your HP-45, to order a new battery. Remember, you can use your HP-45 on AC power until the replacement battery pack arrives.
Battery Pack Replacement

1. Turn power switch to **OFF** and disconnect the battery charger.

2. Slide the two battery-door latches (the top feet) toward middle of calculator.

3. Let battery door and battery-pack fall into palm of hand.

4. See if the battery connector springs on the calculator have been inadvertently flattened inward. If so, bend them out and try the battery again.

5. Insert the battery pack so that its contacts face the calculator and contact is made with battery connectors.
6. Insert the bottom of the battery door behind the retaining groove and close the door.

7. Close the battery door by pressing it gently while sliding the two battery-door latches outward.

NOTE: If you use your HP-45 extensively in field work or during travel, you may want to order the Model 82004A Battery Holder and Pack, consisting of battery charging attachment and spare battery pack. This enables you to charge one pack while using the other.

WARNING
Do not try to burn old batteries. They may EXPLODE!
Appendix C

Accessories

The list below shows standard accessories included with the HP-45. All items were checked at our factory prior to shipment. Please notify Advanced Products Customer Service of any irregularities by returning a copy of the packing slip with your comments or by telephoning (408) 996-0100. If outside the U.S., please contact the Hewlett-Packard Sales and Service Office nearest you.

<table>
<thead>
<tr>
<th>Standard Accessories</th>
<th>Model/Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP-45 Quick Reference Guide</td>
<td>00045-90300</td>
</tr>
<tr>
<td>Battery Pack</td>
<td>82001A</td>
</tr>
<tr>
<td>Battery Charger/AC Adapter</td>
<td>82002A</td>
</tr>
<tr>
<td>Soft Carrying Case</td>
<td>82021A</td>
</tr>
<tr>
<td>HP-45 Owner’s Handbook</td>
<td>00045-90300</td>
</tr>
<tr>
<td>Personalizing Labels (4 each)</td>
<td>7120-2946</td>
</tr>
</tbody>
</table>

If outside the U.S., you may require a different version of the Battery Charger/AC Adapter. Please contact the Hewlett-Packard Sales and Service Office nearest you for the recommended model.

Optional accessories for the HP-45 can be ordered by completing and mailing the order card provided. We will send you additional order cards as new optional accessories are added to our product line.

<table>
<thead>
<tr>
<th>Optional Accessories</th>
<th>Model/Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Holder and Pack</td>
<td>82004A</td>
</tr>
<tr>
<td>Security Cradle</td>
<td>82007A</td>
</tr>
<tr>
<td>Hard Field Case</td>
<td>82006A</td>
</tr>
</tbody>
</table>
# Appendix D

## Calculation Equations

The following table shows the data flow and equations used in those calculations where the formula is not self-evident.

<table>
<thead>
<tr>
<th>Function</th>
<th>Formula</th>
</tr>
</thead>
</table>
| %        | \[
\frac{x \cdot y}{100} \rightarrow X; \ y \rightarrow Y
\] |
| \(\Delta\%\) | \[
100 \cdot \frac{x - y}{y} \rightarrow X; \ y \rightarrow Y
\] |
| \(\rightarrow p\) | \[
\sqrt{x^2 + y^2} \rightarrow X
\] \[
\tan \frac{y}{x} \rightarrow Y
\] |
| \(\rightarrow R\) | \[
x \cos y \rightarrow X
\] \[
x \sin y \rightarrow Y
\] |
| \(\Sigma +\) | \[
n + 1 \rightarrow R_5 \rightarrow X
\] \[
\Sigma x^2 + x^2 \rightarrow R_6
\] \[
\Sigma x + x \rightarrow R_7
\] \[
\Sigma y + y \rightarrow R_8
\] |
| \(\Sigma -\) | \[
n - 1 \rightarrow R_5 \rightarrow X
\] \[
\Sigma x^2 - x^2 \rightarrow R_6
\] \[
\Sigma x - x \rightarrow R_7
\] \[
\Sigma y - y \rightarrow R_8
\] |
| \(\bar{x}, s\) | \[
\frac{1}{n} \sum_{i=1}^{n} x_i \rightarrow X
\] \[
\sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \frac{1}{n} \left( \sum_{i=1}^{n} x_i \right)^2}{n - 1}} \rightarrow Y
\] |
Appendix E
Service and Warranty

Servicing

**CAUTION**
Calculator can be damaged by strong static charge.

**Low Power**
All decimal points light to warn you that you have 2 to 5 minutes of operating time left. You must then either:
- Operate from AC power
- Charge the battery pack
- Insert a fully charged battery pack

**Blank Display**
If the display blanks out, turn the HP-45 off then on. If 0.00 does not appear on the display, check the following:
1. If battery charger is attached to HP-45, make sure it is plugged into outlet.
2. Examine battery pack to see if it is discharged or is not making contact.
3. If display is still blank, try operating the HP-45 from the AC line.
4. If, after step 3, display is still blank, the HP-45 is defective (see warranty section).

**Warranty**

**In Warranty**
The HP-45 is warranted against defects in materials and workmanship for one (1) year from date of delivery. During the warranty period, Hewlett-Packard will repair or, at its option, replace components that prove to be defective when the calculator is returned, shipping prepaid, to a Hewlett-Packard Customer Service Facility (see 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 any person other than at an authorized Hewlett-Packard Customer Service Facility.
No other warranty is expressed or implied. Hewlett-Packard is not liable for consequential damages.

**Out of Warranty**

Beyond the one-year warranty period, your calculator will be repaired for a moderate charge. Return the HP-45 along with all standard accessories (see *Shipping Instructions*). If only the battery pack is defective, simply order a replacement on the Order Card provided.

**Shipping Instructions**

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

- Your HP-45 with all standard accessories in their travel safety case
- A completed Service Card (from back cover pocket of this manual)

If a battery pack is defective and within warranty, return the following to us:

- Only the defective battery pack
- A completed Service Card (from back cover pocket of this manual)

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

**Note:** The serial number of your calculator may be found by removing the battery pack.

Under normal conditions, your calculator will be repaired and re-shipped within two days of receipt at this address. Should other problems or questions arise regarding service, please call the applicable service telephone number on the Service Card, or call Advanced Products Division, Customer Service, at (408) 996-0100.
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This addendum contains updating information for the HP-45 Owner's Handbook, manual part number 00045-90300, printed November 1974.

**Page 53.** Change the In Warranty paragraph to read as follows:

**Full One-Year Warranty**
The HP-45 is warranted against defects in materials and workmanship for one year from the date of delivery. During the warranty period, Hewlett-Packard will repair or, at its option, replace at no charge components that prove to be defective, provided the calculator is returned, shipping prepaid, to Hewlett-Packard's Customer Service facility.

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 express warranty is given by Hewlett-Packard. **HEWLETT-PACKARD SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES.**

**Page 54, Shipping Instructions.** Delete reference to "travel safety case" in the first step.